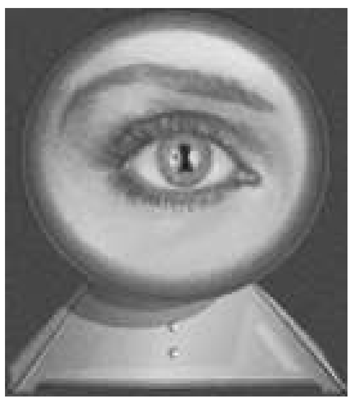
Electromagnetic Surveillance

8

Visual



1. Introduction

Our eyesight contributes greatly to our survival, the quality of our lives, and our cultural pursuits. For these reasons, much research has focused on developing technologies that correct, enhance, and supplement our visual skills and many of these have been further adapted to aid in surveillance activities. Spectacles improve our eyesight, telescopes allow us to see farther, night-vision devices help us to see in low-light conditions, cameras help to monitor activities in locations we cannot easily or quickly reach, and protective suits and vehicles allow us to move about and observe in hazardous areas. To supplement this 'enhanced vision' we have also developed recording devices that allow us to view or review monitored activities at a later time.

Magnifiers, scopes, and cameras are installed in many settings including space probes, Earth-orbiting satellites, unstaffed air vehicles, submarines, ATM machines, personal cam-

A conceptual drawing of computer 'cams' that allow users to videoconference in realtime over the Internet. These cameras are now available for less than $150 and the resolution and speed of the videocams continue to improve. [Classic Concepts ©1999, used with permission.]

corders, and more. Special suits and accessories allow us to enter radiation areas, chemical environments, and underwater habitats. Visual surveillance technologies help us organize our lives, ensure our safety, and understand the greater cosmos. Devices range in size from equipment weighing many tons to 'pinhole' video cameras so small they can be hidden in a tie clip. In fact, spy cameras have become so tiny and inexpensive, people have been unable to resist the temptation to use them in unethical and unsettling ways that are discussed in more detail later.

Visual technologies encompass a very broad category of strategies and devices that are used by professionals and amateurs in all walks of life. Consequently, this is one of the longer chapters in this book and could easily be expanded to fill ten books, but it is hoped that the brief history and sampling of devices and applications included here can provide a good introduction that conveys the breadth and scope of the topic.

Cameras and scopes are the most common visual surveillance products so much of this chapter focuses on these devices, but there is also information on suits and craft that enable people to observe and photograph in hazardous environments. Audio surveillance is built into most visual surveillance systems so the reader is encouraged to consult the Acoustic Surveillance chapters to learn more about the theory and application of sound.

1.a. The Prevalence of Visual Surveillance

In 1949, George Orwell published "1984," a classic novel describing a chillingly repressive society in which a person's every move was monitored by cameras, both inside and outside of the home. Even though there were no pinhole cameras, personal computers, or Internet links in 1949 when Orwell wrote "1984," his description of a surveillance society was remarkably prophetic. People in free societies recoiled when they read this outrageous and dehumanizing government control scenario. On their guard because the story had the ring of truth, many looked to the future with suspicion and anxiety.

The year "1984" came and went without Orwell's predictions coming true and there was a collective sigh of relief from many individuals who thought society was 'out of the woods' and the loss of privacy and freedom was not inevitable after all. It now appears that Orwell was mostly right, except that the people wielding the cameras are not always Big Brother, but a great number of Little Brothers.

In Orwell's scenario, Big Brother (government) commandeered surveillance equipment to limit freedom of movement and expression. While it is true that government surveillance is increasing as the technology becomes cheaper and easier to use, and should always be monitored and regulated, government efforts have focused primarily on law enforcement and national security, not on the lives of law-abiding individuals.

To illustrate the trends in consumer access to technology and the Little Brother scenario, commercial services now offer satellite pictures of one-meter resolution (fine enough to distinguish a hot tub from a car) for less than $25 per square mile to almost anyone who wants to buy them. Yet, even greater incursions into personal privacy are coming from unregulated individuals who disregard fair ethical principles. Internet voyeur-site managers plant tiny cameras in extremely personal and compromising locations and sell images of unaware victims for large sums of money. 'Free enterprise' isn't supposed to include free exploitation of innocent victims and such blatant exploitation will probably result in restrictions being put into place, since these entrepreneurs have failed to practice ethical self-restraint. Examples of these activities will be discussed in more detail later in this chapter.

Government and nongovernment surveillants alike now make extensive use of visual surveillance devices. Major users include

- local and federal law enforcement agents (traffic control, stake-outs, patrols, prison management)
- federal military defense agents (aerial, orbital, and marine surveillance)
- private citizens and aspiring entrepreneurs (home security, nanny cams, voyeur products)
- public and private businesses (business security, employee monitoring, industrial safety, private detectives, salvage companies, insurance adjustors)
- papparazzi and the media in general (investigative reporting, news and weather reporting, celebrity stalking)

The following examples of applications make it easier to understand the variety of visual surveillance activities and the tremendous proliferation of visual surveillance products. The first examples include many legitimate uses, whereas some of the latter examples are questionable in terms of their overall benefit and high in their potential for abuse.

- Quality assurance personnel and quality control inspectors use surveillance devices to detect and monitor production quality and to aid in maintenance and repair activities.
- Salvage operators use surveillance technologies to locate wrecks and objects of value that may be lost on land or at sea. They often use cameras and display devices in conjunction with sonar, metal detectors, and magnetic detectors.
- Construction contractors use surveillance to monitor progress and safety, to check structural integrity, and to limit access to hazardous areas, especially by unauthorized personnel.
- Employers monitor traffic in and out and through their facilities to ensure public and employee safety, to safeguard investments, and to reduce employee theft.
- Prisons and jails utilize cameras to monitor the movement of prisoners, to protect guards, to protect prisoners from one another, and to protect prisoners from undue use of force or abuse by prison guards, especially in women's prisons.
- Banks and retail stores monitor not just the inside of their business premises, but the outside as well. Some cities have as many as 2,000 of these cameras aimed at streets, sidewalks, and back alleys.
- Customs and immigration officials use surveillance products to detect and locate contraband goods, illegal immigrants, stowaways, and smugglers.
- Armed forces strategists, intelligence officers, and commanders use visual surveillance technologies to monitor borders, national security, economic trends, military activities of foreign nations, battlefields, and to engage in national search and rescue and disaster relief operations.
- Businesses can issue badges that track employee movements within the workplace and install motion detectors that trigger hallway cameras. Some have installed two-way mirrors and hidden cameras in washrooms and change rooms.
- Video cameras are mounted in law enforcement vehicles and on street corners and in some countries (e.g., Britain) the recordings are sold to educational and commercial

buyers for distribution and sale. They can be previewed on the World Wide Web.

- Thousands of newscams are mounted on helicopters and highrises which indirectly record and broadcast the activities of citizens almost every moment of the day.
- Camera-equipped papparazzi surveil celebrities 24 hours a day (many of them living in their cars or vans) in order to capture images to sell to publishers.
- Entrepreneurs have hired youth on skateboards to go around cities and college campuses with cameras hidden in small backpacks. These backpacks can be 'innocently' set down almost anywhere to tape footage that can be sold on tape or on the Internet. The images more often than not end up being balcony views of women's cleavage, or up-skirt shots from grates, basement staircases, and other creative vantage points. In the spring of 2000, one Internet entrepreneur who had installed hidden 'peep' cameras throughout women's private areas (including one inside a toilet) at a California university was broadcasting the images on the Web without the knowledge of the women being photographed.

1.b. Potential for Abuse

Most private citizens think they are protected from illicit video recording by existing Peeping Tom laws. A surprising fact is that many of the people taping them without their knowledge or consent may *not* be breaking existing laws (some states don't have Peeping Tom laws and others don't cover visual surveillance if the sound recording mechanisms are turned off) and, in the case of many businesses, do not even have to inform their employees or customers that they are being observed.

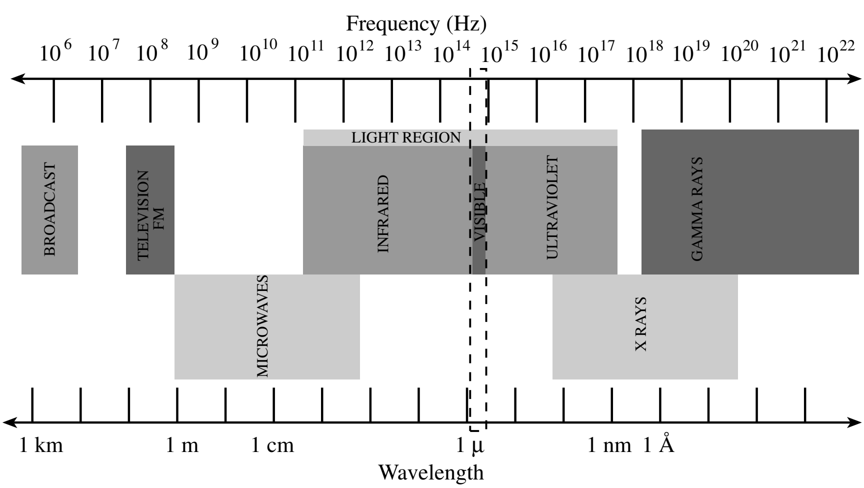
There are currently hundreds of Web sites on the Internet in which personal, private, and even sexually explicit video images from hidden cameras are being distributed. Some people are willing to be photographed because it is prestigious or profitable; voyeurism is big business on the Internet, with many voyeur adult sites earning large sums. There are other instances where people have consented to being taped, but are unaware that their images are being distributed to the public (until it's too late). Finally, there are thousands of people being recorded, sometimes in very compromising situations or states of undress, without their knowledge or consent.

Should we be worried about the increase in video surveillance or is it just harmless fun? Given the amount of nonconsenting exploitation that exists at the present time, there is reason for concern. Do surveillance videos make the streets safer; do they aid in criminal arrests? Apparently not in all circumstances. There is a general perception that video surveillance is more objective and fairer than eyewitness reports, and that may be true in ideal situations, but recent research on cameras with remote swivel and zoom capabilities indicates that a disproportionate number of women and minorities are being observed and recorded by white males. This raises a warning flag that suggests that *a recording is only as objective as the person controlling the camera*. There have also been conflicting reports about whether cameras stop crime. Some opponents argue that the costs don't justify the results, or that crime is, in some instances, only being displaced to other areas. These controversial research findings are also discussed in more detail later.

Not all visual surveillance is of questionable benefit. Many video cameras are installed to provide safety, security, quality assurance, and other positive benefits. When cameras are installed in hazardous industrial areas or dark, vulnerable public areas, they may protect employees and the general public.

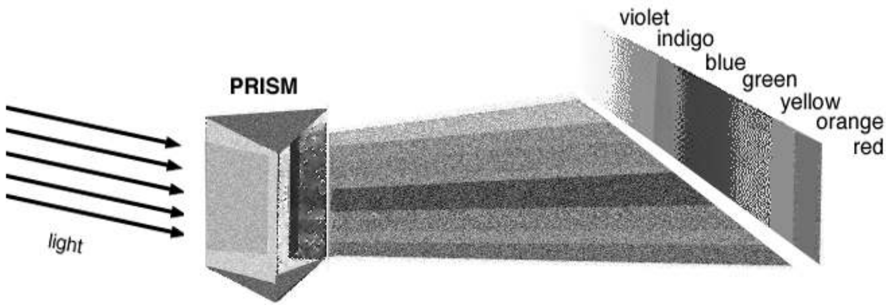
- Subways and train stations are monitored for breakdowns and rider safety. Dark parking lots and tunnels are monitored to protect lone pedestrians.
- Bridges are monitored for traffic accidents, suicide attempts, and accidental falls.
- Amusement parks monitor machinery and the safety of patrons.
- Convenience stores videotape cashiers and cash.
- Parents monitor children and their caregivers, grown children monitor aging parents with neurological illnesses that might cause them to harm themselves if left unattended.
- Detectives track people and their activities, law enforcement agents monitor traffic and suspected criminal activities.
- Environmental scientists track land use and ecosystem damage, meteorologists track weather.
- Event planners surveil for crowd control and safety at dances, sports events, and rock concerts.
- The military monitors the economic and political activities of other nations for national security.

1.c. Basics of Visual Perception

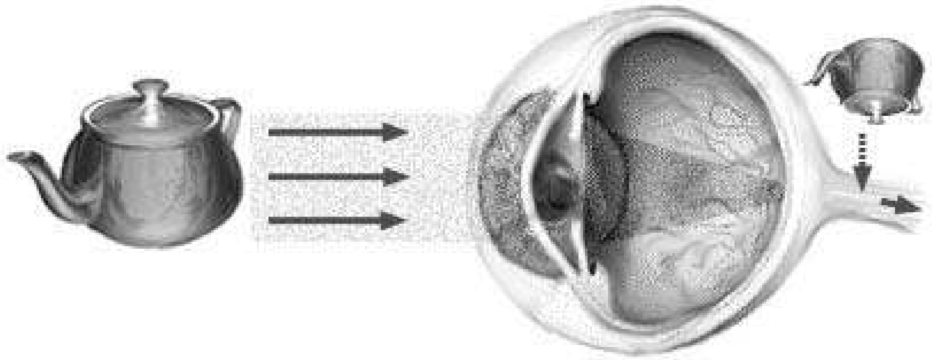


The visible spectrum is a narrow band of radiation between infrared and ultraviolet, ranging from about 390 to 770 nanometers. We perceive specific regions within the visible spectrum as different colors, with green being the dominant reflected radiation, approximately midpoint in the visible spectrum. Our visual senses, our eyes and brains working together, are well-developed to perceive and interpret these wavelengths to aid us in survival.

Visual surveillance technologies rely primarily on energy in the visible spectrum. *Visible* radiation is a type of electromagnetic energy in the *light spectrum,* sometimes called the *optical spectrum* (which also includes infrared and ultraviolet energy). The visible spectrum is a surprisingly narrow band sandwiched in the middle of the optical spectrum. The wavelengths associated with visible radiation are longer than ultraviolet and shorter than infrared. Sensing devices that operate in these frequencies are called *photodetectors* and some broadband devices that detect radiation in the visible spectrum also detect infrared and ultraviolet frequencies.



When light from our Sun is undifferentiated, we call it *white light*. A prism can be used to distinguish the basic colors that are combined to make white light. This is similar to the phenomenon of a rainbow in which atmospheric moisture disperses the light into its different wavelengths. The colors are not limited to those labelled here, but blend from one to the next. The prism makes it possible to do much the same thing, without the rain. Color imaging devices are designed to display or sense these wavelengths and sometimes wavelengths beyond what we can see. Printers are designed to reproduce the colors as closely as possible with various pigments. Grayscale imaging devices are sensitive to values (the amount of light) in terms of brightness and contrast, but do not reproduce pigments or light as color. [Classic Concepts diagram ©2000, used with permission.]



Vision is a complex interaction of 1) light energy that reaches our eyes after reflecting off objects in the path of vision; 2) physical sensing by the various structures in the eye, particularly the cornea, lens, and retina; and 3) interpretive neural processing that occurs in our brains. Since the curved shape of our eye and the way in which the light waves reach the retina on the back of our eyes cause the image to be inverted, we actually 'see' upside-down (as do many optical devices). However, our brains have adapted so well to this inversion that we are not consciously aware that we are looking at the world upside-down. [Classic Concepts ©2000, used with permission.]

We designate the visible spectrum as those wavelengths that are visible to *human* eyes. Some creatures may perceive some or all of this spectrum plus wavelengths outside those that are visible to humans. The visible spectrum includes wavelengths from about 390 nanometers (violet) to about 770 nanometers (red). Green is toward the middle of the spectrum from about 492 to 577 nanometers. The distinctions are not clearcut. The colors, as we perceive them, blend gradually from one to the next. The colors that we see are the ones that are reflected off the object that we are viewing. Thus, plants, which we perceive as predominantly green, are actually not green in the sense of 'being green,' but rather are green in the sense that they absorb the other colors and *reflect back* the green light that stimulates our visual senses.

Sight, the ability to perceive energy in the visible spectrum, is one of our most important and best-developed senses. With the exception of birds of prey that have better visual acuity and possibly better color vision, very few creatures on the planet see as well as people. Consequently, many common professional and consumer surveillance devices operate with visible light. Cameras are the predominant visible light technology and the primary topic of this chapter. Scopes and magnifying glasses are also discussed, as are recording devices for storing visual images.

Film, video, and digital devices that can 'capture' and record light are now so common, that there are usually several in almost every home within developed nations. 'Disposable' cameras can be purchased for under $8, film cameras typically run from $20 to $600, camcorders and digital still cameras are available for under $1,000 and even fairly sophisticated professional cameras are under $5,000. Visual surveillance technologies are plentiful, affordable, and versatile. These devices range in size from tiny pinhole video cameras the size of a dime, to broadcast cameras that weigh 40 or 60 pounds, and telescopes that weigh several tons.

2. Types and Variations

Visual surveillance devices can be categorized into those that help us perceive images, those that process or encode the images, those that allow us to record them for delayed viewing, and those that aid us in visually assessing environments that are hazardous to unprotected humans. Often these various functions will be combined inside one housing (e.g., a camera and a recorder are combined into a *camcorder*), or closely linked by a cable or transmissions device. Often they can be subdivided into color or black and white technologies with some capable of functioning in both modes.

Imaging Devices - Imaging devices all have one thing in common, they are designed to enhance human vision to allow us to see beyond our basic physiological capabilities. They help us see smaller objects, more distant objects, and enhance our vision in low-light conditions. Magnifiers enlarge and sometimes illuminate an image so we can study it in more detail. Various types of scopes make distant objects appear closer and more sharply defined. Cameras allow events and objects to be seen, processed, or recorded as still or moving images.

Processing Devices - These are built-in or stand-alone components which convert or modify the visual images. They include analog/digital converters, multiplexing and splitting devices, database managers, and image processors. There are many types of image processors; they can be used to colorize, compare, recognize, title or date- and time-stamp, and to trigger alarms, recording devices, and playback systems.

Recording Devices - Recording devices allow a record of an event or object to be created and stored so that it can be reviewed at a later time. The record may be transient, available only for an instant or onetime review, or it may be semipermanent, stored on tape or another recording medium. Common recording media include film, magnetic tapes, paper, hard drives, and memory cards. Many visual recording devices simultaneously record audio.

Probes, Robots, Remote-Controlled, and Autonomous Craft - Humans are sometimes too large, too small, too weak, too busy, or too limited in lifespan to be able to see and monitor everything that is going on. For this reason, we have developed a wide variety of mechanical and electronic aids to probe into activities and environments on our behalf. Most of these devices send back information in realtime, as recordings, or on delayed schedules, so that what they have 'seen' can be vicariously viewed at a later time.

Vehicles and Environmental Suits and Gear - There are places that humans can't go without technology. They are either beyond our physical capabilities or hazardous without protection. To aid us in surveilling from new heights, depths, or in hostile environments, we have developed a great variety of technologies including underwater and radiation suits, air- and spacecraft, armored vehicles, and protective accessories.

2.a. Vision Enhancement

There are a number of types of devices that allow us to see better. They may magnify, alter, highlight, or brighten the visual landscape so that we can see details, motions, or colors that are otherwise difficult to see.

Magnifiers

Magnifiers are devices that make small objects appear larger so that they are easier to see. *Magnifying glasses* (handheld or worn on the face) and *microscopes* are designed to enlarge objects that are nearby. They are extremely useful in forensic and other investigative sciences. They can aid in identifying forgeries (money, signatures, photographs, stock certificates, etc.), fingerprints, blood and other tissue traces, powder burns, bullet grooves, hairs, and fibers. There is a limit to the size of objects that can be seen with optical microscopes. Generally the better the optics and the higher the magnification, the higher the price. Beyond a certain microscopic level, it is necessary to use devices other than optical microscopes. Electron microscopes, in which electrons are fired at an object and imaged as they reflect from that object, permit extremely tiny objects to be imaged. Since electrons are not color sensors in the sense that light reflects color, electron microscope images are not colored. However, false color may be applied to make the images easier to interpret and more interesting to view. Color may also be used as markers or identifiers to call attention to relevant details in an electron microscope image.

Scopes/Binoculars

Scopes are similar to magnifiers, except they are intended to make distant rather than near objects appear larger. Devices to aid in seeing over distances are some of the oldest surveillance devices developed by humans. Telescopes have been used by pirates, Peeping Toms, spies, and detectives since they first became widespread during the Renaissance. When two scopes are combined in one housing, to make them easier to handle, they are called binoculars. Specialized telescopes for seeing great distances or imaging parts of the spectrum beyond the visible range are often used by astronomers to surveil the galaxy and beyond.

Night vision

Scopes are based on using available light, which means that they become more difficult to use as it gets darker. For this reason, some are equipped with image intensifiers. These are electronics that take the low light and amplify it to make it easier to see. Some night vision devices are further designed to sense infrared radiation, wavelengths that are not normally visible to humans. Most infrared night vision devices require supplemental illumination from an infrared light, though some have this built in. The less expensive night vision devices typically don't have infrared capabilities.

The image intensifier component uses photoemissive cathodes for the sensor surface. This amplifies the *incident light* image; in other words, the image brightness of the available light is increased and is typically displayed on a charge-storing target (or on film) rather than on a phosphor-coated screen. An image intensifier can also be used in conjunction with the following three types of imaging systems

vidicon - An early type of tube common on closed circuit TV which consists essentially of an electron gun and a photoconductive target for detection. Less sensitive than the orthicon, but smaller and simpler and possibly more reliable. Smearing of moving images can result from lag and the photoconductive surface is nonuniform.

image orthicon - The sensitive surface is photoemissive rather than photoconductive. The system includes amplification through internal electron multiplication. More sensitive than the vidicon, it uses a low-velocity beam, photoemissive cathodes for the sensor surface, and displays the image on a phosphor-coated mosaic.

image isocon - An older display system that is similar to the orthicon except for the optics and the way in which only scattered portions of the signal are used.

2.b. Imaging

The most common visual imaging devices are cameras. Some of them record the images as they are displayed and some must be hooked into recording devices to store the images. Cameras can be categorized in a number of ways, and the groups represented here have been chosen for ease of explanation and illustration. It is easier to describe technologies that use the visual spectrum than say, the infrared spectrum, because nature has equipped us with excellent visual sensing equipment that helps us to see phenomena that respond to this part of the spectrum. In contrast, with infrared technologies, what you see isn't necessarily what you get; a lot of interpretation and target-background analysis is usually necessary to understand infrared images. With visible spectrum information, what we see is pretty close to what we're used to seeing and we can easily distinguish a person from a car or a building, or a person exhibiting unusual behaviors from others who are just standing around.

Still-image technologies and moving-image technologies are not as distinct from one another as some might think. Most moving-image technologies are actually a series of still images presented in sequence so quickly that our minds are fooled into thinking we are observing natural movement. A series of still photos of a horse running, when presented at a speed of about 24 to 30 frames per second, looks like a moving picture. Our senses cannot process the information fast enough to perceive the movement as a series of still pictures presented one after the other. Through a phenomenon called *persistence of vision* our eye/brain 'blends' the still images together into one sensory perception that assumes it is seeing natural motion. There isn't much advantage in presenting animation frames more than about 30 or 40 frames per second, and certainly no advantage to more than 60 frames per second as far as the human nervous system is concerned. Thus, movie cameras for most purposes don't need to be able to shoot frames at very high speeds. However, if you hook a camera to a very fast plane, high frame rates are needed to compensate for the fast movement of the plane. Note that the frame rates discussed here are not the same as the *frame refresh* rates on monitors. Raster monitors that are used for television and computer view screens will refresh the screen at the rate of about 50 or 60 frames per second and there is a perceptual difference between the two speeds. However, the refresh rate is distinct from animation frames and affects the clarity of the image more than the perception of movement.

Film Cameras

Film Cameras are usually designed specifically for taking individual still frames or for taking a series of frames intended to be replayed as a movie or animation. The film must be handled in darkness and put through a chemical process before the pictures can be viewed. The most common film sizes are 8 mm, 16 mm, and 35 mm. For high quality photography, bigger film sizes are available as sheets. The common sizes for high quality photography are 4" *x* 5" and 8" *x* 10".

Handheld covert cameras are those that are easily hidden, and thus are often very small, about the size of a pack of cigarettes or smaller. There are even cameras the size of a thumbnail that can take tiny pictures. Very high-grain film is necessary for very small cameras as the surface area of the film is limited by the size of the camera. As the grain gets finer, usually the film requires more light exposure. Thus, there is a trade-off; very tiny cameras often don't work well in very low light conditions such as theaters, corridors, and back alleys.

Film cameras usually have the optics and the imaging surface (the film) in the same container. Digital and video cameras may have the optics and the imaging surface (memory cards and tape decks) in a separate container linked by a communications cable. This enables the production of larger units with longer recording times while still keeping the optics small and easier to hide. Camcorders have the camera and the recorder housed in one unit. High-resolution cameras for broadcast-quality telecasts sometimes have separate camera and film recorder units.

In some cases the camera may be linked to the imaging device (usually a monitor or tape deck or both) through a wireless transmitter rather than a cable. The wireless link can use radio or infrared frequencies.

In terms of how they image a scene, most camera systems fit in two basic categories:

- *frame* or *staring* camera - A 'staring' technology images the entire 'frame' or scene at one time. Most consumer and commercial photography cameras are frame cameras. Neither the lens nor the film is moved at the moment the image is taken. Frame cameras can be adapted for stereographic images by using two cameras slightly offset or by overlapping the individual frames. When mounted on high-flying craft, the camera is usually pointed down. When mounted on low-flying craft, there may be one camera on a pivot designed to shoot images at different angles, or there may be more than one camera.

  Frame cameras designed to take in a wider field of view result in longer, narrower images called *panoramic* images. Wider panoramas are possible by mounting two or more cameras in line with one another.

- *strip* or *scanning* cameras - A specialized 'scanning' camera advances the film while exposing it, usually as the camera moves along a scene. Synchronization of the movement of the film and the movement of the mounted camera is important to prevent or minimize image blur. This is called *motion compensation.* Strip cameras usually have a narrower field of view than frame cameras. Strip cameras are particularly useful for aerial mapping projects. Strip cameras can be used in tandem to create stereographic images.

Panoramic photography can be accomplished with frame cameras, but the width of the image is limited by the optics and distance to the film associated with the camera. Wider images are made possible by mounting two or more frame cameras side-by-side, or by using a strip camera. With strip cameras, wider panoramic images can be creating by scanning back and forth while moving the camera optics. Different types of panoramic images are possible, depending on the speed of the host craft and the direction of the scanning, whether perpendicular or at right angles to the direction of motion.

There is more information about cameras, infrared film, and aerial photography in the Infrared and Ultraviolet chapters that may be of interest.

Movie Cameras

Sometimes it is important in surveillance applications to record actions rather than objects. The subject of the investigation might be someone hiding stolen items or dumping hazardous wastes into a local watershed. These actions can often be more clearly documented with moving images. Moving pictures can be captured with film, video, or digital cameras.

Film cameras aren't usually the most suitable type of camera for this type of surveillance. Film cartridges for small, unobtrusive movie cameras usually only record about 3 minutes of action before another cartridge is needed. Video cameras, on the other hand, can typically shoot from 20 minutes to two hours of footage per cassette, depending on the type of camera. Another advantage is that they are generally quieter than film cameras. Digital moving cameras are becoming more popular, but they still have two disadvantages for surveillance activities. Recording times for most digital movie cameras are still somewhat short, although they are longer than film cameras. This will probably improve as memory and cartridge technologies improve. The second disadvantage is that it is easy to alter the images. Digital footage can readily be changed on a computer without overt signs of tampering. This makes digital imagery questionable as courtroom evidence.*

For surveillance activities, compact, long-play, high-resolution camcorders are usually preferred. This makes Hi-8 mm and 8 mm video cameras suitable. Hi-8 has the advantages of higher image quality, more compact cassettes, and two-hour recording times. Super-VHS-C is a compact camera format with good image quality, but the tapes typically don't record for as long as Hi-8 tapes, and Super-VHS-C is not as widely available as Hi-8. Regular VHS is sometimes used, but the cameras are bulky and the image quality is not nearly as good as the image quality of Hi-8.

Instant Cameras

For surveillance, it is sometimes important to process the pictures immediately. For these applications, instant cameras, particularly the Polaroid cameras, have been popular. Instant cameras are designed to take still pictures. They use multilayer film sheets that include the chemicals to develop the image inside the package for each image. To stabilize the image for permanent storage, a chemical fixer is included in a little tube applicator with the film pack. This allows the fixer to be rubbed across the surface of the image to protect it from fading.

Instant camera images are generally not as sharp and clear as film images, and the sheets are sometimes awkward to handle, but for many applications the speed of imaging takes precedence over the sharpness of the image.

Instant cameras that use film packs are gradually being superseded by digital cameras as the quality of digital images improves.

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*There is a potential market for developers to design compression schemes or hardware tamper schemes for digital images that could reveal whether the images have been altered. This would allow surveillance professionals to use new digital technologies for the presentation of forensic evidence.

Digital Cameras

Digital cameras record information bit by bit on electronic storage media rather than in analog format on film or tape. This means that they are not inherently still or moving image technologies. A series of digital still frames can readily be replayed as an animation. By 1998, primarily due to falling costs and the ease of uploading the images to the Web, digital cameras became 'hot' consumer items.

Digital cameras have many advantages for surveillance work, including small size, 'instant' pictures, and good sensitivity in low light conditions. No space is needed for film cassettes and the flash cards used to store images are tiny. They are easy to load; flipping in a memory card is easier than loading film. The pictures are almost instantly available, since there is no need to take film to a lab for processing. Thus, the pictures can be viewed and retaken if they didn't work the first time, and they can be viewed in private without going through a public film lab. They are also easy to upload to a computer network, since no scanning or conversion is usually necessary.

The technology for digital photography has improved dramatically in the last decade and so has the demand. The resolution of digital cameras has improved about 16-fold since 1990. Whereas five years ago, most consumer cameras could image only about 640 *x* 320 pixels at a cost of about $800, now cameras in the $500 range can image 1024 *x* 768 and higher. While this still doesn't equal the resolution of film, it is suitable for many applications.

To the trained eye, digital images don't start to resemble film images until they are about 4,000 *x* 4,000 pixels. However, it has been found that most laypeople don't see much of a difference between digital and film images, if the digital images have a resolution of 2,000 *x* 2,000 pixels or higher. Since the consumer market is driven by people who are not graphics professionals, it may be a while before there is enough demand for high-quality professional cameras to drop below $1,000.

For surveillance professionals, a difference in picture quality can be important. A distant picture of a driver's license or license plate can't be enlarged to read the number unless the resolution of the original image is high enough to resolve the data. No amount of computer processing can reveal details on a license plate if the original image is a fuzzy video shot at 640 *x* 320 pixels resolution.

The chief disadvantages of digital cameras are slower 'shutter' speeds, limited viewfinders, and limited resolutions. Low-end digital cameras typically use a liquid crystal display (LCD) to frame a shot. This can be hard to see in bright light or low light conditions. Higher-end (usually $900 and up) single-lens-reflex digital cameras have optics similar to traditional 35 mm cameras for framing a shot. This provides a clearer, crisper image, but may also be difficult to view in low light conditions.

By the end of the 1990s, very-high-density digital chips were being developed that began to rival the resolution of film. Image capture was also becoming faster, making it possible to design digital cameras that could shoot moving images.

It is not known how long it will take for these improved technologies to be incorporated into consumer products (perhaps two or three years), but they are likely to have a dramatic impact on photography in general. It may become difficult to find film-based resources. As the demand for chemical processing of photos decreases, photography stores and photofinishing labs may not have enough clients to stay in business. Thus, the availability of consumer photofinishing services will likely decrease except for specialty enlargement, art photography, and advertising needs (e.g., billboard photography and reproductions). At the same time, the prices of chemical processing may increase.

2.c. Specialized Photography and Accessories

High-Speed Photography

In surveillance, it is sometimes necessary to record images at high speeds. Fast actions such as speeding vehicles, running wildlife, fast-moving weather systems, or fleeing suspects may require specialized equipment. High-speed photography is usually defined for still images as shutter speeds of 1/1000 of a second or faster or as moving image frame rates of hundreds of times per second or faster. High frame rates of millions of frames per second are used in scientific research and in high-speed aerial imaging, in order to capture fast-moving objects or compensate for the forward motion of the aircraft.

Forensic researchers often use high-speed photography to study bullet trajectories, blood spatter patterns, and other aspects of physics that cannot be readily seen with the unaided eye. This information in turn provides a knowledge base from which crime scene activities can be reconstructed.

Wildlife surveillance often depends on high-speed photography. There are fish that can snatch prey out of the water so quickly that a human can't see more than a momentary rustle and the prey is gone. Similarly, frogs and lizards can move their legs and tongues so fast that the only way to empirically study the actions is to photographically record them.

Lenses

Lenses are a very important aspect of photography. Clear, crisp, well-focused images are usually desired for surveillance and better lenses tend to result in better images. Since lens-switching is often impractical in surveillance situations, time-consuming, and sometimes even dangerous, multi-setting zoom lenses are often used. Lenses for imaging more distant objects that are compact (short in the barrel) tend to be more expensive than longer lenses with the same zoom factor. Lenses with wider aperture settings that let in more light (important for low light conditions), that is *f*-stops of *f*10 and lower, tend to cost more as well.

Very large lenses, including small telescopes that can be attached to a camera, often need a tripod. This not only distributes the weight, but helps keep the image steady. When distant objects are greatly magnified, the slightest tremor of the hand causes the image to shake. If light conditions are low and the shutter speed is slow, this results in blurred images.

News photographers, wildlife photographers, private investigators, and astronomers are some of the people who frequently use high-magnification lenses.

Lenses typically come in bayonet-mount and screw-mount varieties. Bayonet-mount lenses are now more common and are quick to exchange. Screw-mount lenses tend to stay on more securely, but take a little longer to change. If you rarely change lenses, the distinction isn't important.

2.d. Image Processing

Splitters/Multiplexers

Surveillance systems will usually consist of several imaging cameras feeding into one monitoring center or processing device. For example, in aerial photography systems, where size and weight need to be minimized, infrared imaging and visible-light imaging often are captured and processed through some of the same equipment and may even be sent to the same viewing screen or recording device.

Businesses and large apartment complexes often put cameras in their hallways and parking lots for security. Their systems often include dozens of cameras feeding into a single ‘command center’ with viewing consoles that are staffed by one or two people. Sometimes the systems are organized so that each monitor can display *split-screen images,* that is, images from more than one camera. The typical 16” monitor usually can display about four images per screen for comfortable viewing. Sometimes six or eight images will be displayed, but beyond this, larger monitors are needed or the images are so small it’s difficult to see if anything unusual is happening.

The splitting and combining of images are done with specialized peripheral equipment called *splitters* and *multiplexers* which are hooked up between the cameras and the viewing or recording mechanisms (or sometimes built into the recording devices).

- A splitter can take the signal from a camera and send it to more than one destination. For example, a video doorway intercom might display on two different consoles, one in the kitchen and one in the garage.
- A multiplexer can take signals from several cameras, let’s say four or six, and display them on a single screen in a 2 *x* 2 or 3 *x* 2 grid. A common type of multiplexer allows the user to view four images on a ‘split screen’ and then poll through the individual screens in full screen mode before going back to the split screen. The more sophisticated of these can be computer controlled to perform these functions at the touch of a key, on a set schedule, or if triggered by detectors near the cameras.

Date/Time Stampers/Titlers

Many still and video recording systems now have time- and date-stamping features that allow stamping right on the image at the time of the recording, or retroactive stamping of log information, including date/time and comments or names.

The date/time stamp is only as good as the person who sets it. Many systems come factory set to 00:00:00 or simply have an incorrect setting. It is important to set and occasionally double-check the date/time settings, especially if there is a possibility that the footage might be needed in court as evidence.

Image Processing

Image processing is becoming an important aspect of surveillance display technologies. Computers can be used to extract remarkable amounts of information from fuzzy video images. Since many of the less expensive time-lapse and consumer video surveillance devices provide rather low-quality images, computer processing is sometimes the only way to extract critical information such as facial features, the writing on labels and bags, license plate numbers, and other important data.

There are now software programs which can examine a frame in relation to a few preceding and succeeding frames and calculate ‘missing’ information in order to sharpen an image. This works because the portion of an image that is fuzzy in one frame might be clear in the next frame, even if all of the information isn’t clear in any one particular frame. By combining the good data from a series of frames into one image, the image can be ‘cleaned up.’ This is useful with low-resolution systems optimized for long recordings. Image processing shouldn’t be substituted for good initial images, as the cost of getting a better quality camera and/or VCR is far less than the cost of trying to clean up poor video images.

Image processing is being used in another way in visual surveillance. It can now be used to track the motion of a specific person (e.g., movement through a hallway or parking lot). Software programs have been developed to recognize a human form and follow it (controlling swiveling cameras along the way) and sound an alarm in case odd behavior is noted (access to restricted areas, zig-zagging in a parking lot to check cars for valuables, etc.). Other programs can isolate a person's face on a video and automatically check the features against a visual database.

Databases

Databases are powerful storage and retrieval tools and with powerful tools come more ways to use and abuse the information that they contain. With image processors able to track movement, faces, identities, and other categorizable information, databases have become an important component of many surveillance systems. Law enforcement agencies, in particular, use many visual matching tools with online databanks, systems which are gradually superseding paper files and books full of 'mug shots.'

Search and retrieval systems for databases are becoming faster and more powerful and digital processing of imagery from video cameras is now so sophisticated that a camera can be remotely controlled by a computer to seek out, identify, and track a specific person from a database (or add each person who appears on camera) as the person moves through a hallway, parking lot, or office complex. Side views, hats, and beards are no longer a deterrent to computer algorithms. Celebrities, ex-employees, suspected criminals, disgruntled spouses, and other people can be singled out and tracked without their knowledge or consent.

2.e. Recording Devices

Some of the technologies mentioned so far, such as cameras, are designed to image and record at the same time. Others are designed to record to separate units.

Recording mechanisms are sometimes built into imaging devices, rather than being housed as separate components. Film cameras and video camcorders are the two most common types of imaging and recording systems. Video cameras are sometimes separate from the recording devices, linked through a cable or radio transmitter.

There are many types of recording media: tapes, diskettes, CD-ROMs, DVDs, PCMCIA cards, proprietary memory cards, hard drives, etc. All of these are used in various types of surveillance devices and each has advantages and disadvantages. One of the dilemmas facing surveillance professionals, especially those doing forensic work, is that courtroom evidence must be considered to be free of tampering. Images captured with digital devices can readily be changed with computer software. Until tamperproof products are developed for forensics work, it may be necessary to capture some types of evidence with traditional photographic film.

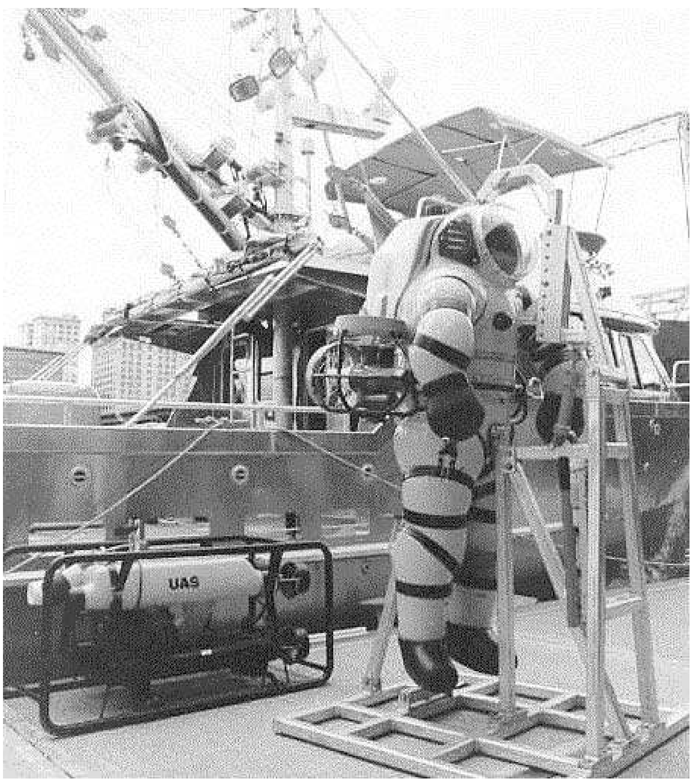
Since recording devices are important to surveillance activities, and covert cameras often have to be small, with the recording device located away from the camera, a number of types of remote recording systems are used:

continuous recorders - Short-duration recording devices usually perform continuous recording at about 20 to 30 frames per second (and much faster for slow motion photography and high-speed photography such as aerial photography). Most analog recorders record to tape or film, but it is impractical to have tape or film that is longer than a few hundred feet, so many continuous recorders are not practical for 24-hour surveillance. Most analog continuous recorders can record from 20 minutes to about 6 hours. Digital continuous recorders and portable models usually have recording limits of a few minutes up to about 20 minutes (this is increasing as the size and cost of digital memory decreases). Some continuous digital recorders may record for hours or days if they are linked to very large hard drives with compression designed into the system.

time-lapse recorders - A long-duration recording device usually uses a time-lapse system which records a 'frame' every few seconds or minutes. If you've seen video images of a flower blooming in a few seconds or clouds rapidly scudding across the sky, you were probably watching time-lapse photography. The biggest advantage of time-lapse recording is that long durations can be captured on limited-length recording media. The biggest disadvantage is that an important event might occur during one of the 'blank' moments between individual frames.

2.f. Environmental Vehicles, Suits, and Gear

Environmental Suits



This unique hardsuit from Underwater Atmospheric Systems (UAS) enables divers to dive deeper and longer than in scuba suits, due the built-in pressurized 'atmospheric' life support systems (which prevent 'the bends'). The suit allows divers to enter depths of 1250 feet for up to 48 hours, with typical operating times of 6 to 8 hours. The umbilical provides electrical connections and communications are hardwired with acoustic through-water backup system. Thruster packs can be attached to the suit to increase mobility. The suit is constructed mainly of T6061 cast aluminum, designed and developed by the Ceanic Corporation. In the background is an Underwater Atmospheric Systems boat equipped with several surveillance systems including sonar and radar. The hardsuit can be used for underwater observation, salvage, insurance and maintenance inspections, appraisals, damage assessment, and video recording. [Photo © 2000 UAS by Robert Mester, used with permission.]

Environmental suits are often used to allow people to enter hazardous environments in order to carry out visual surveillance activities. Most people are familiar with *scuba* (self-contained underwater breathing apparatus). Divers use scuba systems to stay underwater for extended periods of time, sometimes in the cold temperatures found at higher latitudes or greater depths. Wreck divers use scuba gear to enable them to find and salvage airline or marine wrecks. It is common for these divers to take along handheld, chest-worn, or helmet-worn video and still cameras to record the wrecks and their activities while diving.

Water is hazardous to most types of precision instruments and detection devices. For this reason, divers have to use special underwater cameras and other recording devices or waterproof containers to protect conventional cameras. Underwater video cameras may be self-contained or may connect, via an 'umbilical cord' to a recording console at the surface.

Diving bells or remote-controlled undersea vessels are often used to reach greater depths or to supplement the work of divers. *Hardsuits*, specialized diving suits that contain their own pressure systems, can be used for activities at depths that are too great for a soft-suited diver to access. Thus, they can be used for platform and vessel inspection (quality assurance, insurance claims, appraisals), maintenance, repair, salvage, rigging, testing, and other deep-water applications.

Goggles, masks, helmets, gloves, boots, and other accessories are typically incorporated into environmental suits and are, at times, used individually. Communications links are sometimes established through tethers and cables. The tethers may be attached to the host vessel on the water's surface or may attach to a communications buoy which uses radio waves to link with the host.

Left: When TWA Flight 800 crashed off Long Island, New York, U.S. Naval divers assisted in search and recovery operations. Brad Fleming dons a Mark-21 diving helmet. Right: A U.S. Navy Commander uses a camera 240 feet below the surface of the ocean as he inspects and photographs an artifact on a sunken U.S. Civil War ship. The vessel was lost in a battle in March 1862, the first battle fought by iron armored vessels. [U.S. DoD 1996 news photo by Charles L. Withrow; 1999 news photo by Eric J. Tilford, released.]

Gas masks and radiation suits have been regularly issued by the armed forces to surveil areas in which there have been chemical spills or radiation leaks or where it is suspected that chemicals or radiation might be used against them by other forces. With the development of new synthetic materials, the technology for these has considerably improved. Protective suits are much lighter and more flexible than those that were in use during and immediately after World War II.

Left: Sgt. Putnam in a gas mask and permeable cloth helmet during a chemical warfare decontamination demonstration in 1944. Right: Airborne Corps historian wearing M-17A1 protective mask during an Iraqi scud attack in January 1991. Protective gear allows people to work, scout, and patrol in hazardous environments. Cameras will sometimes also be equipped with housing to protect from chemical, water, and radiation exposure. [U.S. Army 1944 Signal Corps photo by Sgt. Bradt and U.S. Army 1991 Airborne Corps archive by John F. Freund, released.]

Protective Vehicles and Stations

Sometimes a protective suit is not sufficient protection. Humans are still vulnerable to explosives, radiation, and gunfire. Vehicles that allow visual surveillance in environmentally or socially hostile environments range widely in form and function and include aircraft, spacecraft, diving bells, submarines, amphibious vehicles, and large armored tanks. They allow people to enter, view, and record in environments that lack air, that may be too hot or to cold, that may contain nuclear fallout, or that may be subject to hostile fire. They may also enable workers to access more territory in a shorter period of time than is possible on foot. One example of vehicle-facilitated surveillance is the lunar rover used by the Apollo 15 astronauts to investigate and photograph about 17 miles of the Moon's surface in the early 1970s.

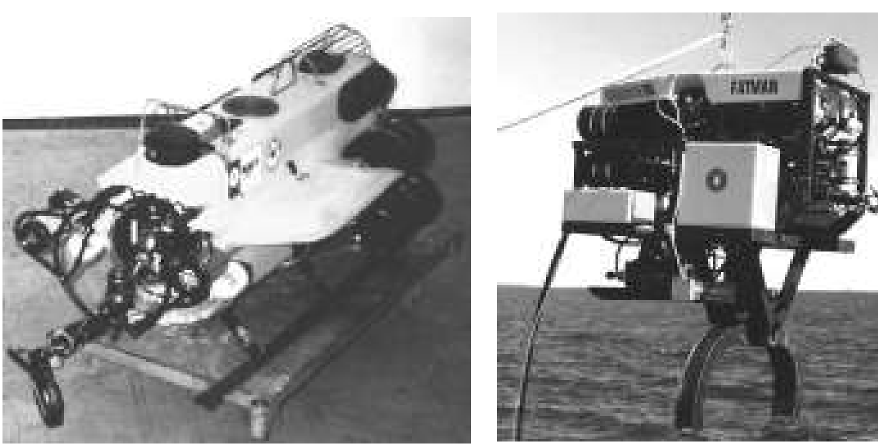
This is a Light Armored Reconnaissance Vehicle which is part of the Strategic Reserve Force of the Stabilization Force of the U.S. Marines shown (left) in a 1998 training exercise. In 1999, the vehicles were used for urban patrol in Kosovo (right). [U.S. DoD 1998 news photos by Steve Briggs and C. J. Shell, released.]

In the early 1970s Skylab, an 89-foot Earth-orbit workshop, provided a means for people to work and observe from above the Earth's atmosphere. Skylab enabled a new level of astronomical observations and Earth resources observations.

Left: A U.S. Marine Assault Amphibious Vehicle coming ashore in Croatia during a training exercise. Right: Amphibious Vehicle coming ashore during maritime combined operational training exercises among NATO nations to improve skills valuable in NATO-led peacekeeping support operations. [U.S. DoD 1998 news photo by Steve Briggs, U.S. Navy and Timothy A. Pope, released.]

2.g. Probes, Robots, Remote-Controlled and Autonomous Craft

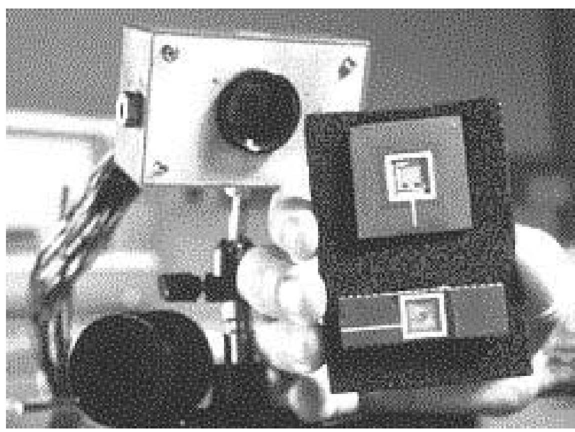
Many technologies have been developed to allow people to enter and surveil environments that could be hazardous or lethal to humans. These include the deep sea, the upper atmosphere and space, deep underground caverns, radiation areas, and small or confined structures. Sometimes, however, it is safer or more efficient to send in a robotic vessel rather than a human in a protective suit or vehicle.



The Mini-Remote Vehicle 1 (MR1) (left) and MR2 (right) are used by the U.S. Navy to probe hazardous deep sea environments. They are self-propelled and equipped with lights, still and live video cameras, and rotating-head sonar to survey marine environments to depths of about 1000 feet. The Navy used this technology in 1996 to aid in the search and recovery of data flight recorders from the TWA 800 airliner that crashed off Long Island, New York. [U.S. DoD 1996 news photo, released.]

To aid us in maneuvering or peering in unfriendly regions, scientists have developed not only special suits and a variety of piloted and unpiloted vessels and probes, but also special radiation-proof or waterproof camera housings, and an extraordinary variety of robots designed to search, detect, respond, or send information back to a communications station. Often specialized cameras and other surveillance devices are used in conjunction with these environmental suits, vehicles, and robots.

Most autonomous vehicles, probes, and robots have video vision systems incorporated into their design. Many remote-controlled vehicles are also equipped with cameras. The vision systems are sometimes intended to allow the device to navigate and find its way around its environment. At other times the vision systems are designed to allow the pilot to control the device from a distance. Many are equipped with more than one vision system to serve more than one purpose, navigation and surveillance, and sometimes visual measurement.



Ralph Etienne-Cummings and a robot which can follow a line on the ground and avoid obstacles. Two vision sensors are mounted as 'eyes' on the front of the little vehicle-shaped robot. The system has learning algorithms that allow it to remember how it avoided a previous obstacle. These microchips give the robot the vision capabilities it needs to navigate and carry out its tasks. [Johns Hopkins 1999 news photo by Mike McGovern, released.]

Robots are even more diverse than the people who invent them. They range from huge industrial production robots to miniature robots the size of an insect. There are also ideas for microscopic robots, called *nanites* described in science fiction literature that may one day be a reality. There is only room here for a small selection of robot examples, but at least it can provide a taste of the utility and diversity of robots designed to aid in surveillance tasks.

Robots use many different types of locomotion systems. Some roll, others bounce, still others fly, wiggle, or slither along. Each of these types of movements lends itself to navigating a different type of terrain.

A 'slithering' robot that mimics the movement patterns of snakes has been developed by a California animator, Gavin Miller. The shape and movement of the robot allow it to enter and traverse environments that might be difficult for other types of robots. Slithering robots are not common. It is a challenge to control and articulate a large number of 'limbs' even if those limbs don't have any legs.

At Johns Hopkins University, Ralph Etienne-Cummings, an electrical engineer, has developed a robotic vision system on a microchip that aids in navigation and in avoiding obstacles. The single chip design, also known as a *computation sensor,* handles analog and digital processing functions, extracts relevant visual information, and then processes the data and responds accordingly. If it 'sees' an obstacle, it will move around it. If used in a surveillance system, it can follow a moving target such as a person. This could also have applications for hands-free videoconferencing.

The advantages of having the basic functions on a single electronic chip are speed, portability, and lower power consumption. Smaller systems typically require less power to operate. Thus, chip-based robots could be used on boats, airplanes, and autonomous vehicles.

Sometimes robots need to be able to jump up stairs or through holes. They may even need to jump and move to evade projectiles.

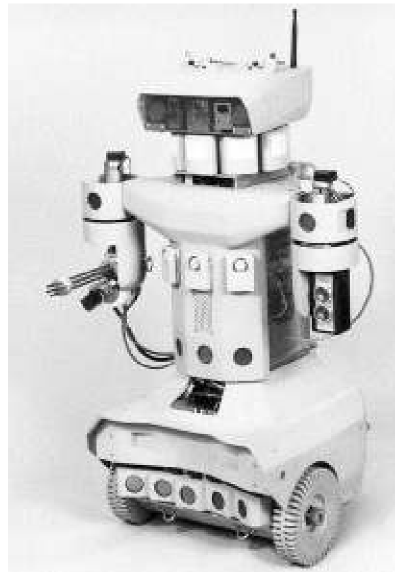
Jumping robots equipped with tiny pan and tilt cameras have been developed by Nikolaos Papanikolopoulos at the University of Minnesota in Minneapolis. These nine-ounce, sugar-tin-sized robots provide a way to send in a 'scouting party' in situations that might be hazardous to humans. Equipped with a spring-controlled 'bounce reflex' they can hop up and down stairs and over obstacles to survey the area and radio back visual and auditory information as well as other information such as the presence of dangerous chemicals or gases. Support scouts with sound/vibration sensors rather than video cameras have also been developed. Both variations can radio information to a mobile radio repeater and from there to a surveillance console at a safe distance from any hostile activities. The robots could be used for rescue operations, military activities, minesweeping, hazardous environment inspection, and investigative reporting.

At the U.S. Space and Naval Warfare Systems, robots are researched and developed in two divisions, Advanced Systems and Ocean Systems. One of the more recent projects, the ROBART III robot, is equipped with a wide variety of sensors and autonomous systems for intrusion detection and response. It has further been developed so that it can be used in conjunction with a system of 'slave' robots (essentially a distributed network system) that accompanies ROBART III for deployment onsite.

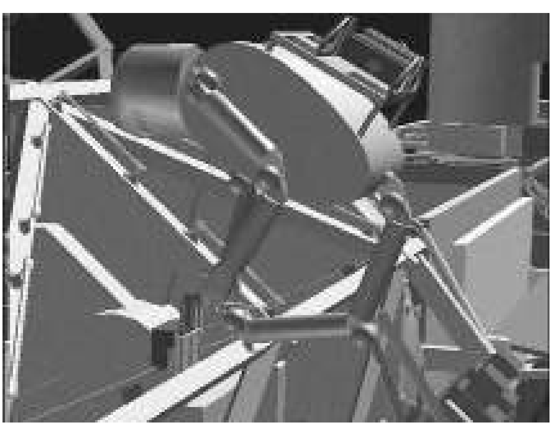
ROBART III's head-mounted sensors include two Polaroid sonar transducers, a Banner near-infrared proximity sensor, an AM Sensor microwave motion detector, and a video surveillance camera. The output of the CCD camera is broadcast to the operator over an analog radio-frequency (RF) link and simultaneously fed to an onboard video motion detector that provides azimuthal data, allowing the head pan-axis controller to automatically track a moving target. Azimuthal and elevation information from the motion detector will be similarly fed to the pan-and-tilt controller for the six-barrel pneumatically fired dart gun for purposes of automated weapon positioning.

Additional Polaroid sensors and near-infrared proximity detectors are strategically located on the system to provide full collision-avoidance coverage in support of the advanced teleoperation features.

At NASA and its various associated space centers, robotics and vision systems that can be used in space missions are the subject of continuing research and development. Autonomous robots that can explore planetary environments, robot simulators that can be used to train astronauts, and remote-controlled robots that can be operated by astronauts from a distance have all been used in one way or another to enhance space exploration and the collection of samples to bring back to Earth. Many of these robotic systems are enhanced with one or more vision systems or visual recording devices.



Left: Purdue Doctoral students DeSouza and Jones work with “Peter” a mobile robot equipped with a number of types of sensors. Peter can navigate by converting images to 3D measurement grids and comparing the surroundings with a pre-programmed destination. The robot has cameras and ultrasonic detectors to enable it to carry out its tasks. Right: ROBART III, evolved from Bart Everett’s original Robart I, was developed in 1992 as part of the U.S. Naval *Mobile Detection, Assessment, and Response System* (MDARS) program. [Purdue 2000 news photo; U.S. Space and Naval Warfare Systems Center news photo, released.]



Left: An artist’s rendering of Robonaut at work while being guided by an astronaut inside the space vessel. Robonaut is sufficiently human in form and movement that you could almost call it an android (humanoid robot), but it is actually a robotic ‘surrogate.’ Developed by NASA at the Johnson Space Center, this robot has an unusual control system by which it can mimic the movements of the astronaut wearing a controlling suit at a distance. Right: Astronaut Jeffrey Hoffman is shown in 1993 wearing a special helmet and gloves that allow him to remotely view and position a robot arm, the Remote Manipulator Systems (RMS) that can be used to manipulate equipment from a distance, such as parts of a telescope. [NASA/JSC news photos, released.]

Developed by NASA at the Johnson Space Center, the Robonaut android-like mechanism has an unusual control system. Most robots are either autonomous, following programming algorithms or artificial intelligence heuristic problem-solving methods, or remote-controlled, relying on the commands from the operator to determine their actions. Robonaut stands out for its ability to mimic the movements of a nearby human wearing a motion-sensitive body suit. The person controlling the robot can be safe behind a protective barrier as in a spacecraft, laboratory, or nuclear installation, watching what the robot sees with its vision system on a display system. Robonaut is remarkably dexterous, with over 100 sensors and controllers in the arm alone. Special materials protect the robot from damage from projectiles and fire.

The concept behind Robonaut has been used on other types of devices that mimic portions of the human body rather than the whole body. Devices that mimic the functions of the head and hands are especially useful as they can 'see,' 'hear,' and collect things on our behalf. Gripper arms on diving vehicles, for example, have been developed so that they follow the movements of an operator in a nearby marine vessel. This allows the operator to remotely move, inspect, and pick up objects for collection from a safe distance. This is particularly useful for deep sea exploration and explosives handling.

3. Context

Visual surveillance technologies are used in many different settings, in laboratories, businesses, toll booths, city streets, submarines, aircraft, cars, bedrooms, day care facilities, schools, shopping malls, subways, ferries, change rooms, space probes, military installations, wilderness areas, wildlife preserves, forensic laboratories, and observatories. It's difficult to think of a context in which a camera, telescope, or microscope isn't useful in some way.

Cameras are the most familiar type of surveillance device. They are used by photographers, detectives, and automated satellites and robots to document crimes, news, people's activities, and workplace environments. In summary, the most common settings and applications for film and video photography include the following:

- *Safety and security systems* are installed in homes, offices, parking lots, industrial complexes, bridges, research laboratories, schools, detention facilities, trains, malls, prisons, and financial institutions.
- *Forensic photography* is used to snap 'mug shots' of convicted criminals, and to record crime scenes, establish evidence, examine details that might be difficult to see under normal circumstances, and to record the activities of persons under suspicion in the process of building a case for arrest and prosecution.
- *Investigative surveillance* is routinely practiced with cameras by detectives, journalists, news crews, divers, spies, wildlife conservationists, environmental engineering and cleanup crews, customs and immigration officials, reconnaissance specialists, and search and rescue teams.
- *Routine visual recording* of activities is practiced by professions in which accountability is important, including medicine, law enforcement, large-scale construction and engineering, archaeology, political and environmental advocacy, and armed forces operations and exercises.

4. Origins and Evolution

4.a. Human Aspects

The evolution of visual surveillance devices is intrinsically linked to human needs and impulses. Humans are highly motivated to know what others are doing. We develop and commandeer various types of technology to achieve our desire for information and confirmation and to foster a feeling of security and control within our lives. Visual surveillance technologies have arisen primarily through the evolution of optics, photography, vacuum tubes, and recording devices. In less than 200 years, these devices have gone from being in the hands of only a few to being within the budget of any consumer with moderate financial resources.

The Impulse to Observe

Humans have been naturally curious for a very long time. The impulse to observe is strongly tied to our biological origins as predators and gatherers. A predator needs to be curious about movement, form, or smell, and to be able to locate and recognize the source of the movement in order to procure food. The same observational skills can be important in recognizing and gathering food, sensing dangers, procreating, and caring for offspring. Curiosity, jealousy, and competition for resources and mates may account for the earliest incidences of spying in human history. There are many stories of spying and the covert transmission of information that predate visual surveillance technologies as we know them, so it is not surprising that new technologies are regularly exploited for their surveillance potential even if they were originally invented for some other purpose.

The impulse to observe is counterbalanced with a human need for privacy. By the 1500s, the citizenry in Europe had implemented some of the early "Peeping Tom" laws to prevent people from being spied upon through windows and doorways.

In the United States, the Constitution and Bill of Rights of 1789 and 1791 formalized many of the basic aspects of freedom and privacy that underlie our present social framework and system of government. This foundation and the subsequent legislative amendments that have followed were designed to safeguard our most basic needs, some of which are the needs for trust, security, and the opportunity to be alone and uncensored.

In 1890, Warren and Brandeis wrote an article that was published in the Harvard Law Review that referred to Cooley's definition of privacy as the "right to be left alone" and argued that this was "the most comprehensive of rights, and the right most valued by a free people." This implied that there was a need to establish a boundary between the desire to observe and the need to not be observed.

The Impulse to Exchange Information

People relate strongly to their visual senses. They enjoy seeing, recording what they see, and conveying their visual experiences to others. There are many motivations for sharing information and images. People share images of special moments, things they want to remember. They exchange pictures of family members that document important events, animals, and beautiful scenery. Businesses exchange information for developing projects, communicating goals, marketing, and otherwise carrying on business. Governments share images to carry out their responsibilities on behalf of their constituents. They use pictures to monitor trade, to carry out defensive actions, to curtail criminal actions, and to keep abreast of the activities of other nations.

The Impulse to Record

The most ancient and primitive 'recording devices' were fingers or sticks that people used to make paintings in sand or on rock (e.g., cave paintings). This desire to record images and events later evolved into more portable forms of pictures and pictograms inscribed on papyrus. The history of art includes many examples of historical records of events. Artists were once employed to visually record important transactions and occasions such as weddings, the rise of a new monarch, the outcome of a significant battle, or the death of a hero. Accuracy was dependent on the skill and point of view of the artist creating the record. This desire to record and preserve information more quickly and accurately than an artist could render with paint and canvas was at the heart of the development of photography.

4.b. Technological Aspects

The Evolution of Optics

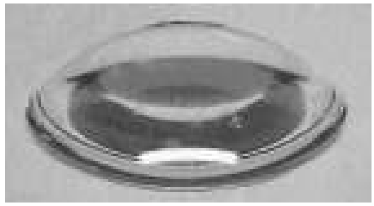
The field of optics probably began with water rather than glass. People saw that water could reflect images and eventually noticed that a piece of contoured ice or droplet of water could 'display' or 'project' an image of objects behind it on its upper surface. You can observe this basic phenomenon by placing a large drop of water on a laminated document, like a driver's license, and looking at it from the side. The document will be clearly visible on the curved upper surface of the water drop. Aristophanes (ca. 450 B.C.-ca. 388 B.C.) apparently demonstrated various refractive characteristics of water (and possibly also glass) in ancient Greece. About 400 years later, Lucius Annæus Seneca (ca. 4 B.C.-65 A.D.) recorded his observations on the magnifying properties of liquids.

Almost all visual surveillance devices exploit the reflective and refractive properties of transparent materials in the form of lenses. Lenses provide a way to control the direction of light. They are extensively used in cameras, scopes, and illuminators. Lenses and the properties of light have been of interest for at least 2,000 years; Claudius Ptolemæus (85-165) apparently authored five volumes on optics, though only one survives. Another great scholar, Abu Ali Hasan (sometimes written Al-Hazen) Ibn al-Haitham (965-ca. 1040), created hundreds of scientific documents, including critical reviews of Ptolemy's writings along with his own theories about optics, the nature of light, light passing through water-filled vessels, and the reflection of light from variously shaped surfaces (*"Kitab-al-Manadhir"*). His theories strongly influenced western thought through Latin translations of his documents about 200 years later, including *"Opticae Thesaurus."*

The Development of Lenses

Water may have made humans aware of the magnifying properties of curved surfaces, but it wasn't a very practical material for making lenses. To create solid lenses that embodied the optical properties of water, it was necessary to develop skills in handling appropriate transparent materials, especially glass and quartz. Anecdotal histories by writers like Pliny (*"Naturalis Historica,"* 77 A.D.) suggest that the ancient Phoenicians discovered glass several thousand years before biblical times. Egyptian glass beads and Babylonian glass rods from about 2500 B.C. and earlier have been found and artifacts that may be glass lenses date back as far as 2000 B.C.

Many early lenses were made from blown glass. Glass-blowing houses appear to have been established in Greece before 5 B.C. However, it was another 200 years before pioneer artisans and scientists developed ways to systematically harness the light-influencing principles of the curved water droplet in glass and gems.



From a basic ground lens inventors developed spectacles, spyglasses, microscopes and many other essential tools that enabled them to more easily surveil their environment.

Optical glass and gems probably existed in Asia in antiquity, though we do not have many historic details in the English language. Occasional references to the magnifying properties of curved glass can be found in European documents from about the third century onward, but melting, shaping, and grinding skills and tools were not widespread until around the 1200s in Europe, when the commercial manufacture of window glass was established. Quartz and beryl were used in early lenses and are still important in optics manufacturing, especially for scientific applications or specialized photography.

Practical Viewing Devices

Lenses with various concave, convex, and flat surfaces are widely used in microscopes, telescopes, cameras, and eyeglasses. Through history, the development of lenses for one application often improved the technology for related applications. Mirrors are used with many viewing devices, sometimes in combination with one or more lenses, and the improved manufacture of mirrors during and after the Renaissance aided in the development of many surveillance technologies.

Ground crystalline substances known as 'reading stones' were used by monks in the Middle Ages around 1000. Over the next several centuries, as reading spread from the cloisters to the general population, the demand for reading stones increased. The problem with reading stones was that the reader couldn't comfortably hold a book with both hands and use a stone at the same time. It had to be continuously moved across the text. Roger Bacon was interested in finding better ways to improve vision. Sometime around 1250, he demonstrated that ground lenses could improve eyesight and recorded this use of crystal or glass in his *"Opus Majus"* in 1268. As the craft of writing and publishing evolved, so did the craft of developing stones, spectacles, and other instruments to make the writing clearer. Eyeglasses that could rest on the head, thus leaving the hands free, were soon to become popular.

Alessandro di Spina is credited with inventing the first eyeglasses, in 1280, though it is possible that monocles may have been used in ancient Greece and there are some written references to eyeglasses a few years earlier than the attribution to di Spina. Sofronius Eusebius Hieronymus (340-420) is depicted in portraits with eyeglasses. Eyeglasses with colored glass also existed in earlier times in Asia, though their design suggests they may have been used for religious or aesthetic rather than utilitarian purposes. In 1289, di Popozo referred to spectacles for older, failing eyes in his manuscript *"Traite de con uite de la famille."*

A glass industry emerged in Constantinople. The refinement of lenses and the combining of lenses led to important magnifying tools like telescopes and microscopes.

Leonardo da Vinci may have been working on the invention of magnifiers or telescopes in the early 1500s, but no actual models survive. He is said to have had disagreements with German glassmakers and to be working in secrecy. Perhaps he was developing telescopes as a tool of warfare, an activity that may have demanded a certain amount of secrecy at the time.

Going Beyond the Basics

The evolution from spectacles to more sophisticated imaging devices was a natural development. By combining two lenses, you could create a basic refracting telescope or compound microscope. German-born Hans Lippershey (ca. 1570-1619) of The Netherlands applied for a patent for a dual-lens telescope in the early 1600s (which was denied) and developed several telescopes for the government.

In about 1590 in The Netherlands, Hans Janssen, apparently aided by his son Zacharias Janssen, a youth at the time, created drawings for lens configurations that could be considered rudimentary compound microscopes. Zacharias built a telescope-like three-tube microscope around 1595 which could magnify from 3 to 10 times by extending the tubes. The eyepiece was bi-convex and the objective lens plano-convex [Davidson and Abramowitz, 1999]. Practical microscopes emerged about half a century later.

Though it was apparently not the first such instrument, Galileo Galilei (1564-ca. 1642) had developed a telescope by 1609. He then improved upon it and helped to popularize the invention. The use of telescopes to observe the heavens was somewhat suppressed in the west by religious superstitions and taboos. In many western religions, it was considered audacious and sinful to examine the heavens, as it implied peering into the affairs of God. This is perhaps one of the reasons why optics developed earlier in the east than in the west up to the time of the Renaissance. In some eastern areas, it was considered socially acceptable to determine the exact location of God, in order to find the right orientation in which to pray. In the west, however, early telescopes were primarily used for navigation and the surveillance of animals and people. In spite of various restrictions and religious doctrines that hampered western science, Galileo dared to stare into the heavens and chart the skies with his new instruments, publishing his astronomical observations in *"Siderius Nucius"* in 1610.

It is not uncommon for practical inventions to come into use before the theory of how they work is well understood. Johannes Kepler (1571-1630) made important theoretical observations about light transmission and applied his ideas as practical improvements to the telescope by describing different combinations of convex and concave lenses. The technology was further developed by Robert Hooke who published *"Micrographia"* in 1665.

Around the same time as the theory and practical application of microscopes became important, the construction of these devices began to evolve in two general directions. English designers created tripod microscopes of turned wood, pasteboard, and leather, while Italian designers favored turned wood and brass.

New Forms of Optical Enhancements

As was mentioned earlier, reading stones were somewhat awkward to use, as they required a hand to be constantly moving over the text. Spectacles were better, but even they had some disadvantages, since prescription lenses had not yet evolved into a science. The idea of enhancing or altering human vision by direct contact with the eye, as in contact lenses, may have been foreshadowed by some sketches of the cornea drawn by Leonardo da Vinci in the early 1500s (Codex D), but he doesn't appear to have been designing a way to correct vision or to have produced any working models.

By the 1600s, however, inventors were trying to find a way to directly enhance vision, without stems or handheld impediments. A *contact tube* was described by René Descartes (1596-1650) in *"La Doptrique"* in 1636 and by Philippe de la Hire (1640-1718) half a century later. Thomas Young (1773-1829), a British physician, tried placing microscope lenses directly on his eyes in 1801.

For many centuries, gems and minerals have been important components in the manufacture of many types of lenses. Sunglasses in the mid-1700s were made with slightly opaque quartz lenses. Quartz is still used in a variety of scientific optics and for infrared and ultraviolet photography.

Usable contacts were developed in the late 1800s by F. E. Muller, Adolf Eugene Flick, Eugene Kalt, and others, but could not be worn by many people because they irritated the eyes. Most early contact lenses were made of blown glass.

Mirrors are integral to many optical devices. Metal mirrors were available in the Renaissance, but modern glass mirrors weren't used regularly until the 1800s. Isaac Newton (1642-1727) solved some of the problems of color aberration associated with refracting lenses by using a polished metal mirror instead of curved glass as part of a telescope assembly, thus creating a reflecting component. James Gregory (1638-1675), in 1663, and N. Cassegrain, in 1672, developed variations on this mirrored telescope. Mirrors constructed of polished metal tended to scratch and corrode. Léon Foucault (1819-1868) created modern mirrors by binding silver to glass, producing clearer images and longer-lasting mirrors.

Evolutionary Improvements

Technology and science were at a stage in the 1600s where many discoveries were made and communicated among scientists and inventors. The pace of evolution in optics increased at this time.

Very long telescopes were developed by Christiaan (1629-1695) and Constantijn Huygens. By 1655, Christiaan had made some important astronomical studies of Saturn with a telescope of his own design. He is also credited with having discovered the phenomenon of polarization. Jean Dominique Cassini (1625-1712) used longer and longer telescopes to probe the skies, discovering many attributes of the planets in our solar system.

Robert Hooke (1635-1792) was an important inventor of telescopic and microscopic devices, as well as thin films. One of his contemporaries, Antonie van Leeuwenhoek, (1632-1723) made advancements in lens grinding and microscopy. He invented and manufactured many devices to improve upon the compound microscopes of the time.

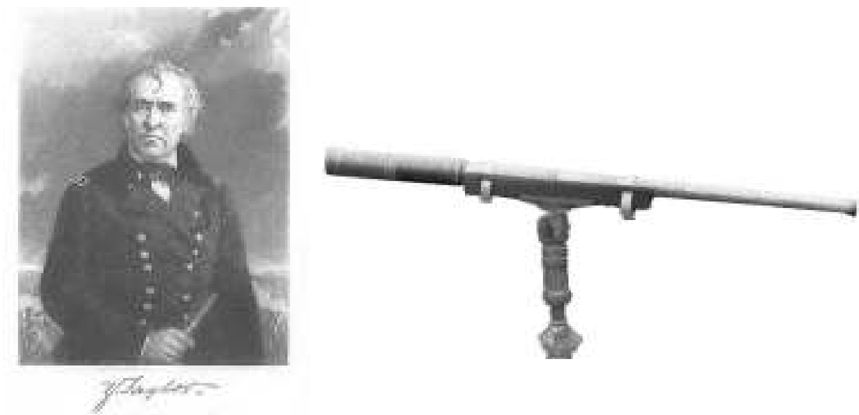
Eyeglasses and contact lenses improved and were produced in increasing numbers. John F. William Herschel (1738-1822) described a contact lens in *"Encyclopedia Metropolitana."* In 1784, Benjamin Franklin (1706-1790), scientist and statesman, combined two types of lenses into a single frame to invent bifocals. Joseph Jackson Lister (1786-1869) developed a system of lenses which were spaced to correct for chromatic aberrations and to reduce spherical aberrations. Joseph Fraunhofer (1787-1826) began experimenting with telescopes to detect radiation outside the visible spectrum.

For modern optics to emerge, it was necessary to be able to understand the mathematics of optics. Johann Karl Friederich Gauss (1777-1855) developed a theory of lenses (Gaussian optics) that provided a mathematical framework for optical imaging theory.

Modern Optical Manufacture

Improvements in glass manufacture and polishing and the positioning of lenses to reduce color aberrations contributed to the evolutionary development of lenses in the late 1700s and early 1800s. The world's largest refracting telescope was established at the Dorpat Observatory in Estonia, making it possible to systematically chart the astronomical bodies of the Northern Hemisphere. Not long after, lenses became important components in photographic devices, evolving into still cameras, moving film cameras, and video imaging devices. The technology was evolving from simple devices to enhance human vision to more sophisticated devices to record visual events.

By the mid-1800s, some of the significant optical companies known today were founded, including the Karl Zeiss Optical company.



Telescopes were one of the most prevalent early visual surveillance tools used in seafaring and land-based warfare and exploration. Left: Zachary Taylor (1784-1850) is shown in military uniform holding a telescope. Right: A European 19th century wooden mariner's telescope. [Library of Congress By Popular Demand collection, copyright expired by date; Classic Concepts photo ©1999, used with permission.]

Miniaturization

Portability is often an important aspect of surveillance technologies. Scopes, lenses, microscopes, and other viewing devices that could be built in small packages, without sacrificing clarity or precision, are favored for travel, scientific fieldwork, onsite forensics, and covert observation.

By the mid-1800s, designers were getting better at putting good optics in small casings. The Nachet pocket microscope was a portable brass instrument with good quality optics and interchangeable lenses. The platform was designed to reverse so the scope could be packed up and transported. The Nachet microscope was available for purchase up to about 1872.

A pair of scleral contact lenses from around 1948, from the collection of Thomas A. Farrell, M.D., show that contact lens technology had continued to develop as well.

The development of synthetic lenses has had an important impact on the optics industry. Plastic is now used to create impact-resistant lenses for a variety of uses. Plastic contact lenses were developed after World War II, but did not achieve widespread use until the 1970s.

Visual Recording Technologies

In China, the phenomena forming the basis of the pinhole camera had been recorded by 500 B.C., but the capability to accurately record an event and easily review a visual transcript at a later time is less than 200 years old.

By the Middle Ages, pinhole images were known in Europe and the idea of controlling the image size and quality by manipulating the size and distance of the aperture had been recorded. By the mid-1500s, Daniello Bararo had experimented in channeling the light going through the pinhole by using a lens.

At this point, inventors sought ways of 'registering' the image to create a more permanent record. Semi-permanent recordings, such as 'sun prints' were developed by 1800 and over the next three decades, experiments evolved into heliographs and daguerreotypes. It was now possible to create a picture that could be viewed over and over again over time. In fact, daguerreotypes are so robust, many of the earliest ones still exist.

The first photographs on metal created by Joseph Nicéphore Niepce were called *heliographs*. Louis Jacques Mandé Daguerre (1789-1851), another pioneer of photography, went into partnership with Niepce in 1829. He began experimenting with silver salts on copper plates and found that light could darken the salts. Daguerreotypes exhibited good permanency but were relatively awkward and expensive to create compared to later paper prints. The copper base was heavy (though tin was used later) and the images were somewhat faint and ethereal depending on how the plate was held in the light for viewing.

Left: An early daguerreotype photograph taken around 1840 to 1860. The subject of the portrait, Mary Manuel Lisa, is wearing a pair of glasses and holding a second pair in her hand. One wonders if the possession of two pairs of glasses was a sign of status or pride at the time, since they are so prominently displayed and recorded. Right: Another early daguerreotype, taken around 1856 to 1860. The subject, John Hanson, a Senator from Bassa County, is wearing spectacles in the style of the time. [Library of Congress America's First Look into the Camera collection photos, copyrights expired by date.]

In 1833, William Henry Fox Talbot made significant strides toward industrializing photography when he found a way to fix silver onto coated paper. He created early examples of contact prints, a development that evolved into prints on paper, which then became a primary means of recording photographs.

By 1847, Calude Felix Abel Niepce had found a way to create an emulsion on glass to create a negative which could then be duplicated many times as a positive. Eventually a way was found to put this on plastic rather than glass. Thus, Daguerre, Talbot, and Niepce created a new industry that was to have far-reaching effects on human social structures and technological evolution, particularly in the fields of communications, entertainment, and surveillance.

Capturing a Moment in Time

Once the technology became available, photographers started recording everything, people, plants, animals, instruments, vehicles, oceans, deserts, and constellations. It was discovered that film was more sensitive to the light from celestial bodies than a human eye peering through a telescope. Thus, the development of telescope optics aided in the creation of cameras, and the creation of cameras aided in surveillance of the heavens with telescopes. More stars could be observed by recording them on film, movement could be recorded by taking successive frames, and changes over time could be compared through photos taken at longer intervals. In other words, photography didn't just record what humans could see, sometimes it could record what humans couldn't see. The same principle pertains to surveillance in general, the recording of information allows it to be shared, compared, and analyzed in ways that are not possible through unrecorded observation.

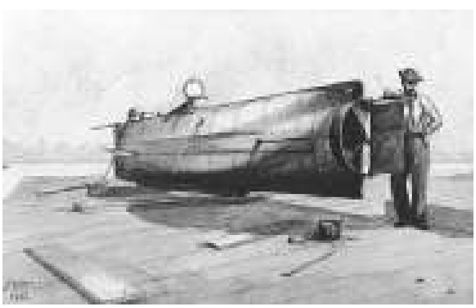
Left: Lieutenant Colonel Huntington and Sergeant Goode using a spyglass to spot Spaniards at Camp M'Calla in June 1898. Right: A photographic record of a painting taken around 1900 to 1920. The painting depicts a woman using a telescope to search the distance. [Library of Congress Touring Turn-of-the-Century America photo by Edward Hart; Detroit Publishing Co. photo of painting possibly by Charles Reinhart, copyrights expired by date.]

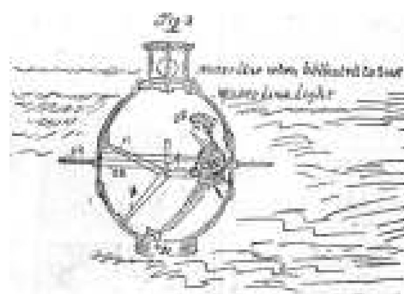
A scientist using a microscope and other devices in a workshop around the 1910s. [Library of Congress, Fred Hulstrand History in Pictures collection, NDIRS-NDSU, Fargo, copyrights expired by date.]

Surveillance Craft and Gear

A large part of visual surveillance involves the use of vehicles and specialized gear to carry a human observer into locations where he or she would otherwise be vulnerable to the environment or to detection. Thus, diving suits, space suits, diving bells, submarines, aircraft, and a great variety of other technologies have been created over the last couple of hundred years to allow a human to observe and record more safely in unfriendly environments. Sonar is one of the primary surveillance technologies used with submarines but the earliest submarines were in use almost half a century before the development of sonar and the primary means of surveillance on early subs and diving bells was through direct observation or enhanced observation with telescopes and periscopes.

Submarines in the 1800s were manually powered, with almost all the crew members charged with turning a hand crank while another steered and observed the surrounding waters. Submarines were put into service as patrol vessels and torpedo-launchers during the American Civil War. From there they evolved dramatically. By World War II, not only did subs incorporate sonar devices, but the Germans had created an experimental synthetic rubber skin designed specifically to counter sonar probes.





The Confederate submarine H. L. Hunley was one of the early stealth vessels patroling the oceans and, during the Civil War, the first to sink a battleship. It was simple technology, one crew member observed and steered while eight others powered it with a hand-turned crank. [U.S. Naval Historical Center archive photos of painting by R. G. Skerrett, 1902 and drawing by W. A. Alexander, ca. 1863, copyrights expired by date.]

Left: Documentary photographers having lunch in the Bull Run area before the second battle in 1862. Right: Photographic evidence of the destruction of a stone bridge at Bull Run, Virginia, in March 1862. [National Archives and Records Administration Photos by George Barnard and James Gibson, copyrights expired by date.]

As soon as photographic equipment and processes became portable and practical, photographers set out to document the events of their times and to offer their services to businesses and government agencies who wanted a record of operations or covert images to aid in reconnaissance operations. A number of photographers became noted for their portraits of Civil War dignitaries and for reconnaissance photos that assisted military generals during the War. They also created historical records of their travels and the plight of the less fortunate who perished in the War.


Left: This haunting and moving documentary photograph by Capt. Andrew J. Russell shows the dead Confederate soldiers behind the stone wall of Marye's Heights in Fredericksburg, Virgina. The soldiers were killed during the Battle of Chancellorsville, May 1863. Right: A grim, chilling, but perhaps necessary reminder of the realities of war in which Timothy H. O'Sullivan photographically captured both Union and Confederate dead at the battlefield of Gettysburg, Pennsylvania. [National Archives and Records Administration Photos by Andrew Russell, copyrights expired by date.]


Left: George N. Barnard's photographic equipment set up southeast of Atlanta, Georgia, in 1864. A row of tripods is in the background. Right: A documentary photograph by Barnard of the fortifications near the Potter House in Atlanta, Georgia in 1864. [National Archives and Records Administration Photos by George Barnard, copyrights expired by date.]

Surveillance from New Heights

There were strong commercial and military motivations for developing craft that would allow people to see the world from new heights. Entrepreneurs were eager to offer tourists sightseeing flights and hunting expeditions; scientists could study new lands, and topological, geological, and archaeological structures not visible from the ground; military agents could scout new lands and latitudes anywhere a plane could fly, sometimes while dodging the bullets of unfriendly nations.

Many important milestones in aviation surveillance occurred early in the 20th century. Since national defense was a priority, and ships were relatively slow-moving vessels, many of the technological advancements of particular interest occurred in the U.S. Navy. The challenge of deploying fast-moving aircraft from short runways on heaving sea vessels was a significant one and naturally led to the development of some of the more sophisticated visual/ aerial surveillance technologies.

After seeing public demonstrations by the Wright brothers in 1908, naval agents evaluated the potential of aircraft as fleet scouts. In December 1908, an aviation report by Lt. George C. Sweet was presented to the Secretary of the Navy, specifying an aircraft capable of performing scouting and observation missions from naval vessels, essentially the first proposal for an aircraft carrier fleet. Apparently the technology was not considered sufficiently advanced or proven, for in August 1909, the Acting Secretary rejected a request for two 'heavier than air flying machines.' Dirigibles and balloons were then receiving a lot of attention and were probably given higher priority.

As often occurs, international and commercial competition provided part of the motivation for the Navy to change its mind. In 1909, F. L. Chapin, the U.S. Naval Attaché in Paris reported on the Rheims Aviation Meet in Europe, promoting the usefulness of aircraft in naval operations. The viability of marine 'airstrips' was further demonstrated when a civilian pilot took off from an anchored ship, in November 1910, using a wooden platform on the bow.

Meanwhile, in the United States, Captain W. I. Chambers continued to advocate the potential of aircraft. By 1911, both a successful shipboard landing and a hydroaeroplane-landing on water had been demonstrated, so naval pilot training commenced, along with the purchase of the first naval aircraft. This same year the Navy began to experiment with another essential surveillance technology, wireless communications. Radio sets could allow pilots to more effectively coordinate their scouting missions and convey their observations to remote command stations. From this point on, the evolution of naval aircraft, and the means of launching and catching the planes on moving ships, were continuously studied and refined.

By December of 1912, naval reconnaissance planes were ready for peacetime patrols and testing of specific tasks, including submarine spotting, mine and target detection and location, and aerial photography. Within a year experimental craft, including an amphibious flying boat called the OWL, for Over Water Land (an A-2 redesignated as E-1), was being tested. In early 1914, a wind tunnel for aviation experiments was constructed at the Washington Navy Yard.

Thus, with the outbreak of the Mexican conflict, and later World War I, the basic technologies related to visual surveillance from the air had been established and the Armed Forces looked for ways to put them into service. By spring 1914, the U.S. Navy was using AH-3 hydroaeroplanes for reconnaissance over Mexico, in spite of the fact that naval aviation was not yet formally recognized. The Navy subsequently commissioned swept-wing Burgess-Dunne hydroaeroplanes for the AH line, and by July 1914, naval aviation was finally acknowledged through establishment of the U.S. Office of Naval Aeronautics.

During this period of development in aviation, cameras were also improving in portability and utility and the Navy had an interest in improving recording capabilities from the air. In May 1916, the Naval Observatory sent a Hess-Ives color camera to the Naval Aeronautic Station at Pensacola for testing in aeronautics. Outfitting of ships to serve as aviation hosts was also underway and in July, the North Carolina (ACR 12) became the first U.S. Navy ship equipped to carry and operate aircraft. By December, it was reported that an Eastman Aero camera had been tested in aircraft at altitudes of 600 to 5,100 feet and produced very satisfactory photographs for naval purposes. The following month 20 Aeros were requisitioned. Visual surveillance from the air had evolved in just a decade to aerial surveillance, and over the coming years other types of photography and imaging were developed.

During World War I, around 1918, the naval forces began painting many of their reconnaissance vessels to reduce their visibility (a foreshadowing of the development of low-sonar and low-radar-signature vessels two decades later). In the spring, flying boats were used for long-range reconnaissance off the German coast and the H-16 aircraft was engaged in submarine-spotting from U.S. and European stations. Kite balloons with weather-sensing instruments were launched as well.

Visual surveillance sometimes has its comic side. In one case it was reported that a kidnapper was arrested after the New York Police Department (NYPD) tailed his carrier pigeon. In 1929, the NYPD began its first Aviation Unit and was conducting regular air patrols by 1930.

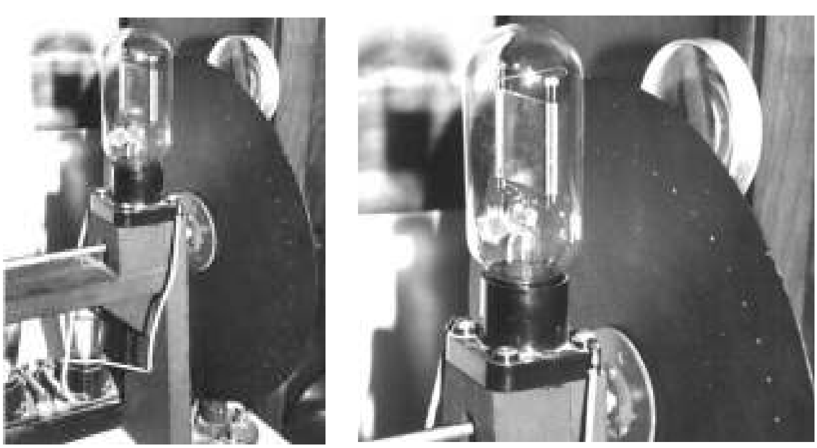
In Germany, at this time, aircraft and Graf Zeppelin dirigibles were being used in reconnaissance and bombing raids against the allied forces, and Britain was employing a variety of airplanes and airships. Visual surveillance from the air was now firmly established. After the war, these technologies continued to evolve and were becoming widespread in commercial aviation by about 1937 and were again put into the service of warfare when World War II broke out.

In 1947, the NYPD acquired the first helicopter in its Aviation Unit and helicopters eventually superseded the fixed-wing planes in the Unit. It now conducts patrol and surveillance activities, and responds to emergencies and medical evacuation needs.

Following World War II, the invention of the transistor, in 1947, greatly enhanced the ability of engineers to install small, fast surveillance technologies on fast-moving aircraft and their inventions are described further in various sections in this book. (See the chapters on Aerial Surveillance and Radar Surveillance which include not only information on various imaging systems but also further information on the history of balloons and dirigibles as support vehicles for visual surveillance.)

The Development of Image Transmission

Consumer video cameras and recording devices evolved hand-in-hand with broadcast television technology.



The Nipkow disc, pioneered by Paul Nipkow, directed light though a rotating disc perforated with a spiral pattern of holes. Photosensitive selenium behind the disc registered dark and light areas as the image was sequentially scanned. The device is from the collection of the Bellingham Antique Radio Museum. [Classic Concepts ©1998, used with permission.]

One of the most significant events in television history was the discovery of the light-sensitive properties of selenium. In France, in 1878, M. Senlacq suggested that selenium could register dark and light shapes and hence might be used for recording documents. By 1881, Shelford Bidwell in Britain had succeeded in transmitting silhouettes, but the effect was primitive and for a while no big advances were made.

The idea of transmitting images over distance caught the imagination of many inventors around this time, and there was a lot of unspoken competition to develop the first practical system. Paul Gottlieb Nipkow was one of the first inventors to receive a patent for a historic television, in 1884, and patents by other inventors soon followed. Most of these early devices were low resolution, somewhat unstable systems but they represented *proof of concept.* There were a number of basic aspects that needed to improve to create practical systems:

Signal Amplification. The early television pioneers needed a means of amplifying weak signals before they could develop the technology into practical devices, but vacuum tubes had not yet been invented. In 1904, John Ambrose Fleming (1849-1945) developed the Fleming valve, the first vacuum tube which could function as a simple rectifier. In 1906, Lee de Forest, an ambitious experimenter, added a crucial third element to a Fleming valve, a grid which was able to control the flow of electrons from the cathode to the anode, providing a means of amplification. While de Forest himself didn't understand how the tube worked, his invention, called the *Audion*, represents a significant milestone in the history of electronics.

Power. These early inventions were developed in the days when houses were lit by candlelight and heated by wood, coal, or sod fires. The production and transmission of power were important aspects of the development of image transmission technologies. Charles Proteus Steinmetz (1865-1923) was one of the pioneers to investigate the alternating current AC phenomena. This important groundwork led to the development of better motors, generators, and power distribution systems, all of which are crucial to broadcast technologies. Nikola Tesla (1856-1943) was an eccentric genius who had regular communications (not all of which were friendly) with Thomas Edison. At one point the Nobel Prize was offered jointly to the two men, but Tesla eschewed the offer and it went instead to a Swedish scientist. Tesla championed alternating current (AC) at a time when other renowned scientists were promoting direct current (DC), and made some important discoveries that have since been incorporated into commercial systems, including some implemented by George Westinghouse (1846-1914).

Image Display. Breaking up an image and amplifying an image are not enough to produce a television set. There needs to be a way to display this image at a reasonable brightness and size. A specialized electron tube developed by Vladimir Kosma Zworykin (1889-1982) provided this means. Zworykin patented the cathode-ray tube (CRT) in 1928 and further developed the *iconoscope* based on his CRT invention. The cathode-ray tube has since become an indispensable aspect of many surveillance technologies, from televisions to radar screens and computer monitors, cathode-ray tubes, in spite of being awkwardly large and bulky, have been a primary display technology for almost 70 years. Zworykin went on to become the director of research for the Radio Corporation of America (RCA).

The first primitive, vacuum-tube-based television systems began to appear around the globe in the mid-1920s. Scottish-born John Logie Baird (1888-1946), Japanese inventor Kenjito Takayanagi, and American Philo T. Farnsworth, independently demonstrated working television systems within the span of about a year. Most early televisions were based on mechanical disc technology but Zworykin soon patented an electronic scanning system, in 1928.

Baird is less known for inventing another type of visual technology. In 1928, he introduced a *video album*, a means to store video frames on a 78-rpm recording disc that could be replayed at 12.5 frames per second. Video tape recording media emerged in the late 1940s but initially suffered from a number of limitations that were worked out over the next few years. Video tape recorders as we know them began to become practical in the early 1950s.

Video tape recorders were about to dramatically change television broadcasting which, up to now, had been based entirely on live performances. They would also provide a practical medium on which to store surveillance footage so that a human operator didn't have to be staffing a monitor 24 hours a day.

In 1956, the first television program that was recorded to tape was broadcast by replaying the tape. Prerecorded programming and reruns quickly became a staple of television programming. The price of the first blank commercial black and white reel-to-reel video recording tapes was astronomical compared to today's $3 consumer tapes. The first professional tapes sold for about $300 each, about two month's wages for the average person at the time. But the television network could replay a tape many times and use a prerecorded tape to increase their programming options and expand their time slots, so the price of a tape was for them a very worthwhile investment. For the average consumer, however, the technology didn't become available until the mid-1960s and wasn't affordable until the mid-1970s when JVC introduced the VHS format.

Image Broadcasting

As soon as practical television systems appeared, broadcast stations sprang up all around the country. The industry had learned that radio broadcasts could be profitable and many entrepreneurs were convinced that television broadcasts would be even more profitable. The first broadcast stations were established in the late 1920s, and by the mid-1930s, the public broadcasting industry emerged. Still, it took another 20 years before commercial television sets were mass-produced. These black and white sets were eagerly bought by consumers in the late 1940s and early 1950s and were characterized by fuzzy pictures, test patterns, and lots of fiddling with the horizontal and vertical hold knobs to stabilize the images.

Closed-circuit television systems were developed along with public broadcast systems, but since there were no subsidies or advertising revenues for closed-circuit systems, they remained expensive until the late 1960s, when black and white closed-circuit systems became practical and affordable for security surveillance in the business world. The biggest disadvantage of these early systems was that they required a person to watch the system at all times. Video recording systems were cumbersome and expensive until the introduction of the VHS and Beta video tape recording formats.

There were a number of historic developments between 1962 and 1972 that set the stage for future video surveillance systems technology:

- In 1962, satellite broadcasting began with the Telstar 2.
- Up until this time, the only news about warfare that had been available to the public was through newspaper and radio broadcasts. In 1968, television news broadcasts from Vietnam were shown to the public.
- In July 1969, American astronauts touched down on the Moon and sent back live images of their historic first steps while millions watched on televisions from around the world.

- Digital television began to be used in commercial broadcasting in 1971, when the British Broadcasting Service (BBC) combined the audio signal with the video signal in their transmissions.
- Commercial television broadcasting was first available through the geostationary ANIK 1 satellite which was pioneered by the Canadian Broadcasting Corporation (CBC) in 1972.
- In 1968, Intelsat was establishing a global satellite communications system that was launched in 1972.

Thus, the essential building blocks for television broadcasting and the capability of global transmissions were in place by the early 1970s. Institutions that could afford closed-circuit television started almost immediately to use the new technologies for surveillance but, for the average user, television was still too limited and expensive to use for security purposes. In 1976, Ampex began creating video recording technologies that would greatly improve the viability of television broadcasting as a surveillance medium, making it possible to record video images in slow-motion. Extended recording formats and time-lapse systems from a number of developers would follow over the next several years.

Video Viewing Technologies

As solid-state technology evolved, smaller and smaller components were designed and manufactured. Most people watched television in their living rooms, but there were some who wanted to be able to take the sets with them. The first 'portable' televisions were luggables that needed the same AC power source as stationary sets. Then basketball-sized transportable sets were developed and, eventually, clock-sized sets that could run on batteries were manufactured. At the same time that TV sets were becoming smaller, the technology for image resolution was improving. The increasing popularity of computers in the 1980s improved viewing technologies in general. Because readable text on a computer screen required better display technologies than the average television program, there was a demand for improved monitors which, in turn, had some spillovers into television technologies.

Video technology-based surveillance systems began spreading in the 1980s and closed-circuit television for consumer applications became a practical reality in the early 1990s.

Visual Surveillance in Homes and Offices

Standardized video cameras that could be wired into a central switching console and displayed on television sets or computer monitors were becoming prevalent by the early 1990s. Homes and small offices could now afford to wire their premises for video and retail stores eagerly installed the systems to monitor shoplifting and employee theft.

Small cameras, camcorders, time-lapse recording decks, and inexpensive video/audio transmitters all contributed to the current explosion of fairly sophisticated video surveillance technologies. Broadcast quality images were in professional hands until about the late 1980s, when Hi-8 mm video formats began to catch on. By the mid-1990s, handheld Hi-8 camcorders were under $1,600 and dropped to less than $700 each by 1999. Hi-8 recording devices were small enough to fit in a purse or a briefcase. Coupled with a tiny pinhole camera hidden in a pair of sunglasses or a tie clip, it was now possible to wear a 'video wire," a video version of the covert cassette recorder that had been a surveillance staple for the last couple of decades.

In the 1970s and 1980s, some parents installed intercom-like 'Baby Monitors' in their infants' and children's rooms. By the late 1980s and early 1990s, small video monitors were being designed especially for this purpose, becoming affordable by the mid-1990s. About this time, television news teams revealed that some of the cameras had picked up gross examples of abuse by child caregivers while parents were away. The shocked public began to buy more cameras, especially pinhole cameras, to ensure that their children were getting the best care. This demand fueled development of a new class of products called *nannycams.* Nannycams were small, discrete cameras and transmitters or recorders that could broadcast video and audio signals for a short distance, usually up to about 300 feet. By the year 2000, nannycams were becoming more sophisticated, with FCC-approved distances, from reputable vendors, up to one or even three miles. With an appropriate antenna, this range could be extended even further. This made it practical to monitor the caregiver from the workplace or a friend's place across town. It also made it possible for other people within range of the transmissions to pick up the broadcast and look in on the home that was being monitored.

Surveillance and the Legal System

By the mid-1960s people were beginning to introduce video surveillance tape as courtroom evidence and the courts were working out the issues of the admissibility and interpretation of this kind of evidence.

In the early and mid-1990s, various court cases related to nonconsentual video taping in various workplaces and public areas were beginning to be brought to court. In general, monitoring and recording in public places were not judged to be violations of a person's rights, whereas monitoring in dressing rooms and washrooms was, in some cases, found to be a violation of a person's privacy. These cases are still being debated and no firm pattern has yet been established.

By the late 1990s, it was estimated that there were at least a million video cameras installed in the United States for the purpose of promoting public safety and security, not counting those covertly installed for the purpose of spying.

By 1999, security advocates and privacy advocates were meeting at various conferences and summits to debate the pros and cons of video surveillance monitoring and recording of public areas for safety and security purposes. Security vendors wanted to be able to freely promote their commercial products to prospective buyers, and privacy advocates wanted to carefully evaluate the ramifications of the use of these products and possibly curtail the indiscriminate commercialism of technologies that could have negative consequences if used in unethical ways. It was pointed out that a clandestine or covert video tape was, in many ways, more intrusive than an audio wiretap.

Digital Technologies

In the early 1980s, television technologies began to be interfaced with personal computers or with microcomputer electronics. Chyron, a leader in video titling equipment, introduced a character generating system in 1982 that could be controlled by a personal computer. Two years later, a small group of visionary computer designers created the Amiga computer, which debuted late in the summer of 1985. Unlike other systems, the Amiga, with a few hardware additions, could be readily interfaced with video equipment to provide control, titling, and animation capabilities that previously had only been available on professional video systems costing tens of thousands of dollars. The Amiga precipitated a desktop video revolution that dramatically reduced the price of computerized video technologies. It also presented new ways of generating and manipulating video images that could be used for courtroom simulations and forensic re-creations of relevant events.

As digital video technology evolved, so did digital still technology. Digital still cameras were available to consumers in the 1980s, but the prices were initially high, sometimes as much as $25,000 for a single-lens reflex camera that could only shoot medium-resolution images. By the late 1990s there were cameras with faster shutter speeds, higher storage capacities, and similar imaging capabilities for about $1,100. Digital cameras thrived commercially partly because of the ease of uploading the images to Web sites. Internet auction and store sales were often improved by images, providing a strong motivation for online vendors to purchase digital cameras.

Encrypted digital video also has future possible ramifications for law enforcement, since digital video is easily altered and thus may not meet all criteria for use as courtroom evidence. If various encryption or tampering mechanisms can be built into digital video, then its use might become practical as courtroom evidence.

Databanks and Visual Surveillance

In the 1980s and 1990s, the most significant developments in visual surveillance since the invention of video cameras occurred. Within two short decades, programmers developed ways to read, store, and manipulate images, and artificial intelligence researchers developed sophisticated algorithms for pattern recognition and artificial vision. Taken together and interfaced with video data, these developments made it possible to automatically detect, recognize, track, and analyze video images from security cameras and covert surveillance devices with a minimum of human intervention.

While the technical tools for handling the images were evolving, the Internet and the World Wide Web were also evolving and gradually revolutionizing global communications. Now it became possible for the image processing to be monitored and transmitted from and to any location with an Internet connection. A company with a head office in California could visually monitor the work of employees in a branch office in Sweden without making long-distance calls. A police officer in New York could check a suspect's record against national databases and discover that he or she was wanted for a violent crime in Utah three months earlier. A shopping mall could store a database of known troublemakers in a central security facility and configure the system to ring an alert when any person found in the database walked in the door, even if he or she wore a hat or glasses. Anonymity in public places was quickly disappearing and personal privacy was slowly disappearing.

International Compliance

There are many industries that must conform to strict industrial and emissions guidelines. There are also many international treaties governing weapons production and the detonation of nuclear armaments. Starting around the 1990s, video technologies were gradually being integrated into compliance and safety regimes.

For example, in the fall of 1995, the International Atomic Energy Agency announced that it was planning to install Gemini, a fully authenticated digital video surveillance system at global nuclear sites to enforce the Non-Proliferation Treaty, a multilateral agreement intended to prevent the proliferation of nuclear weapons. The Gemini system is housed in a tamper-proof enclosure with two independent surveillance units, each with a camera to capture and authenticate images. The system is further designed with Ethernet linking capability to allow it to interface with computer workstations optimized for high-bandwidth video data display.

Thus, by the year 2000, video cameras could be seen in almost any type of environment within developed nations, and sales projections indicated that this was only the beginning. The numbers were expected to triple over the next couple of years.

5. Description and Functions

Visual surveillance is probably the most important surveillance technology because humans are highly visual and devices that aid in visualization are plentiful and often inexpensive and readily available. Whereas radar and infrared surveillance typically involve expensive technologies and lots of training, most people can readily use a magnifying glass, pocket scope, or portable camcorder. Thus, the number and variety of consumer vision-enhancing and recording devices are large and expected to continue to increase.

5.a. Basic Equipment

Magnifying Glasses

Magnifiers are used to make nearby objects appear larger. Since a handheld magnifying glass is relatively portable, it may be carried in a pocket or briefcase, and magnifying eyeglasses are worn like prescription eyeglasses. Magnifying glasses are often used in laboratories and classrooms and at crime scenes. Good lighting is important and some magnifiers are equipped with supplemental lighting.

Handheld magnifying glasses (top left) are widely used in laboratories and at crime scenes. Bar magnifiers (top right) aid in reading small print, revealing the presence of code in small markings (e.g., microdots), and evaluating security features such as watermarks, impregnated substances, and special fibers. Tweezer magnifiers (bottom left) help in handling very fine evidence such as hairs and fibers. Pocket magnifiers (bottom right) are handy for many jobs in the field and the cover helps keep debris off the surface of the lens. Sometimes pocket knives have built-in magnifiers. Magnifiers are widely used in many fields. They aid in studying fiber evidence, stains, bruises, fingerprints, documents, security markings on negotiable items, and many other items of interest to police agents, scientists, and detectives. [Classic Concepts photos ©1999, used with permission.]

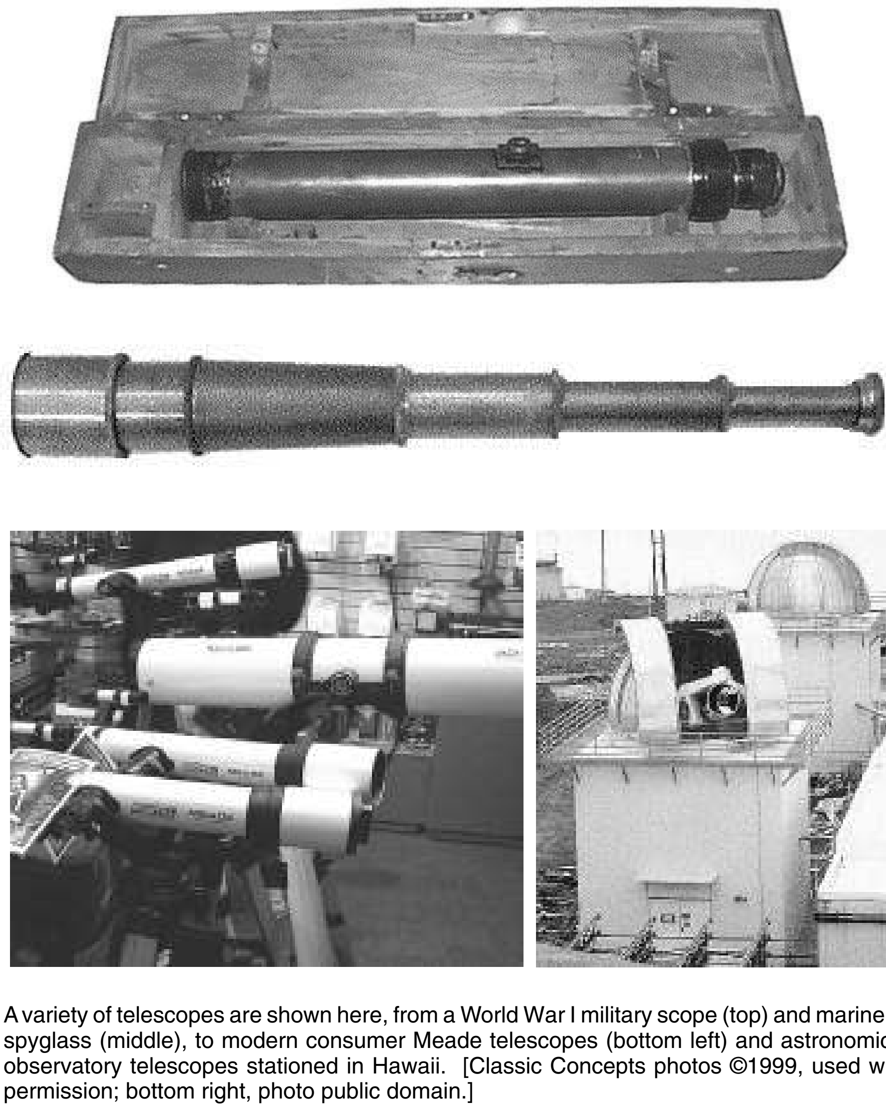
Scopes

Scopes are used for making distant objects larger and easier to view. Scopes come in a wide variety of sizes and magnifications, from small handheld hiking and night-vision scopes to observatory-sized astronomical telescopes. Spyglasses are simple scopes like those pictured in paintings of historic mariners, especially pirates and explorers. Binoculars are two scopes attached to one another to provide magnification for both eyes. Periscopes are viewing scopes used in submarines. Microscopes, which magnify tiny objects, are important laboratory tools, especially in the forensic sciences.

Scopes range in cost as much as they range in size, with higher magnifications generally associated with higher prices.

Just the act of using a scope may alert the target to the fact that s/he is being surveilled. Since most scopes use glass lenses which are reflective at certain angles, the glint off of the scope may attract attention. For this reason, there are scopes made from different materials, some with baffles, coatings, or other reflection-reducing devices and chemicals.

A tripod might be necessary for steadying the scope since high levels of magnification will cause the image to shiver from even the slightest movement of the scope.

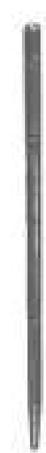


A variety of telescopes are shown here, from a World War I military scope (top) and mariner's spyglass (middle), to modern consumer Meade telescopes (bottom left) and astronomical observatory telescopes stationed in Hawaii. [Classic Concepts photos ©1999, used with permission; bottom right, photo public domain.]







Top Row: Historic scopes from the late 1800s and early 1900s are essentially ‘spyglasses.’ Second row: A variety of military binoculars and scopes. Bottom left: A high-power microscope suitable for medical, laboratory, and forensic applications. Bottom right: A true ‘spy’ scope, a telescope disguised as a walking stick. [Top Photos: Library of Congress, copyrights, expired by date; Second Row and Bottom Left: U.S. DoD news photos, released; Bottom Right: Classic Concepts ©1999, used with permission.]


Left: An M-137A1 Panoramic Telescope is used in a tactical employment demonstration by members of a peacekeeping mission in Bosnia and Herzegovina. Sgt. Thomas McEwen, U.S. Army, explains the use of the telescope to members of the Russian Separate Airborne Brigade. Right: Night-vision goggles are used for ground and air surveillance (and sometimes for night-time parachute jumps). This hands-free set is used on helicopter flight helmets by the U.S. Army. [U.S. DoD 1999 news photo by James V. Downen, Jr., released; 1997 news photo by G. A. Bryant, released.]

Goggles

Better night vision can be provided by magnifying low light-level images or by using infrared-sensing technologies. Those which use light intensifiers have safety ‘shutoff’ mechanisms to prevent a sudden blinding light from injuring the user. Those which work with infrared frequencies sometimes require a separate source of infrared illumination.

5.b. Image Recording Devices and Accessories

Film

Since most reconnaissance activities involve field work in less-than-ideal working environments, there are some concerns particular to the use of film in surveillance.

Film Roll Lengths

Most of the film used in surveillance activities tends to come in longer rolls, usually 36 exposures for traditional still photography, and rolls of 100 or 250 feet or more for aerial photography. Longer rolls reduce the likelihood of having to stop to replace film (which might attract attention) and there is less chance of missing a shot. Aerial photography often requires that a lot of territory be scanned and imaged in a short period of time, necessitating long rolls of film. As with most technologies, there are tradeoffs. Longer rolls are heavier and associated with more inertia, making it difficult to advance the film quickly and smoothly. Special mechanisms are needed to facilitate film advancement. Long rolls are also larger and heavier, requiring stronger reel mechanisms, larger cannisters, and sturdier mounting systems. Estar films are favored for many aerial film needs because the stronger base allows the film to be thinner and hence lighter. A 100-foot roll may weigh about six pounds.

Curl

Most photographers are familiar with the fact that film tends to curl. This is usually because the film is composed of more than one layer sandwiched tightly together, and the layers may have different compositions. To minimize curl, many specialized aerial films have a gelatin coating on both sides of the base layer. An antihalation coating may also be included (this is discussed in more detail in the Infrared chapter) to help prevent film fogging.

Environmental Extremes

While conventional film is fairly robust in various extremes of temperature and humidity, specialized films, like coated aerial films, infrared films, etc., may be sensitive to heat and humidity. Extreme cold will make film brittle, while extreme heat or humidity will blister or fog the film (especially infrared-sensitive film).

Image and Data Processing

Computer processing adds an entirely new dimension to the handling of visual information. Some of the more sophisticated digital imaging systems can recognize a human and track the person's movements through a complex, even identifying the person from matches in a computer database. Computer networks can allow the data to be viewed from anywhere in the world with a dialup or direct Internet connection.

When surveillance video cameras are combined with intelligent computer visual recognition software they create powerful surveillance systems. It is possible to process the images to detect movement, home in on an approaching face, switch to another camera as the person moves through the complex, consult a database to identify the individual person, and play spoken messages to that person, if desired. This example is simulated, but computerized systems that perform these functions are already in use. They have been interfaced with databanks of identified criminals and installed in locations such as public malls. [Classic Concepts ©2000, used with permission.]

Computer processing makes it possible to manipulate and transmit data in many ways.

Here are some of the most common ways that are relevant to surveillance:

- The tedious job of retrieving and analyzing visual surveillance data can be partly automated. Computer software can preview the hours of footage and seek out areas of video where movement or anomalies may have occurred and flag them.
- Computers can be programmed to recognize certain people or events which can then serve as a trigger for automatically starting up recording machines, checking databases, or sounding alerts to a human operator.
- Image processing can be used to take data from a number of successive frames and incorporate them into a clearer picture so that a specific person or the make and model of a car and sometimes even the license plate can be recognized. However, this is expensive, difficult work that may only be partly successful and should only be done when necessary. (Note: It is usually much less expensive to buy better resolution equipment than it is to try to clean up poor video footage.)
- Data compression can be used to store large amounts of information in smaller amounts of space.
- Data encryption can be used to protect the data.
- Computer networks can be used to access or transmit the information around the office or around the globe.

5.c. Management and Storage of Recording Materials

When sales representatives promote visual surveillance systems to various organizations, they don't always spell out the costs of maintaining and repairing the systems and archiving and retrieving the recorded data. These are administrative aspects that are important to consider before purchasing multiple-camera surveillance systems.

The costs of monitoring will depend on the system. Some systems are monitored by live operators and the events are not recorded, while some are monitored by live operators and also recorded. Some systems are automated and live operators are only summoned if an alert is triggered. Other systems record continuously and the recordings are only reviewed if an unusual event happens (e.g., a convenience store robbery). Whichever method is used, there are labor and maintenance costs associated with monitoring, taping, or reviewing events.

If a location that is being surveilled is *not* being recorded, then an employee has to be available at all times to watch the monitors. If surveillance is 24 hours a day, as in a subway or busy hotel, then three 8-hour shifts are typically set up. The employees must either watch the monitor constantly, or watch it when motion is detected and triggers an alarm, in order to assess whether any action is necessary. In cases of dangerous environments (e.g., industrial settings) or environments where several cameras are used in various locations, or in applications where it is important to create a record, live monitoring may be supplemented with recordings (e.g., video replays of an industrial accident or refereed sports event).

It is impossible to know in advance if a video recording is going to be significant. The famous broadcasts of Princess Diana and Dodie al Fayed exiting the hotel before their deaths in an automobile accident in 1997 demonstrate how a seemingly unimportant piece of video footage can later become crucial to an investigation. After the Princess and her companions lost their lives, the tapes were aired to the public and scrutinized in great detail to see whether the driver might be impaired, whether the party may have been followed, or whether any other clues might be gleaned from their activities. Administrators seeking to install visual surveillance systems need to establish a process for organizing and maintaining recording archives that can be efficiently retrieved and viewed after the fact. They must also decide how long tapes should be retained, since few organizations have the resources to keep tapes indefinitely. In some cases, regulations require that recordings be destroyed after a certain length of time or if certain events occur (e.g., an employee leaving a company).

Example Costs of Archiving

As a basic example, imagine that a community is surveilling a park or a hospitality business or a small casino is surveilling its public areas. Assume there are 20 cameras in operation 24 hours a day saving to realtime or near-realtime recording machines (VHS, S-VHS, 8 mm, Hi-8 mm, and computer digital formats are most commonly used). For this example, let's say the video format is S-VHS (a high-resolution format which is used in many law enforcement activities). While time-lapse systems are often used to increase the recording duration of a tape, keep in mind that it can take as little as 7 seconds to enter and exit a room to steal money, jewelry, or a purse. Thus, time-lapse systems with a frame-rate of less than 10 frames per minute are not suitable for monitoring all types of human activities. For this example, assume that non-time-lapse recording systems optimized for 12 hours of continuous recording are used (there are machines that record for much longer, but there is usually a large trade-off in image quality or cost). Finally, assume that the tapes in this example are kept for three weeks each.

Given this basic scenario, at least two full-time employees are needed to swap tapes and to carefully label, box, and archive 40 tapes a day, at a cost of about $300 per day for materials, floor space, and labor (not including the cost of cameras, monitors, VCRs, repairs, or the cost of later viewing the tapes).

You can't just hire someone to come in twice a day to replace tapes. The tape replacement has to be staggered so that the machines are timed to end at different times. Otherwise there will be 'blank spots,' security *dead zones* in which nothing is recording because 19 machines are idle while waiting for new tapes while the first one is being replaced. Thus, machines should be staggered to end about 20 minutes apart, giving the operator time to prepare tapes for each machine and to swap them as needed. With 20 recorders, this process alone takes over six hours and must be performed twice a day.

After a period of three weeks, the archive will hold 840 tapes, requiring about 15 cubic feet of shelf space. Tapes can be reused about 3 to 5 times before the quality starts to significantly degrade and then it's best to replace them. Thus, the total cost per month of managing the machines and tapes can easily reach $12,000 ($144,000/yr). To this must be added the cost of maintaining and repairing the cameras, monitors, and tape decks.

Computerized recording systems with sufficient storage space (e.g., large hard drives) can sometimes be used to provide longer recording times, so tapes don't have to be constantly swapped, but the logistics of simultaneously recording 2 or 30 camera feeds is beyond the scope of most personal computers and off-the-shelf software (at least at the present time). Computer workstations with custom software and hardware adaptations are available at corporate prices, however, which means that consumer versions may be available in three to five years.

In both tape and computer systems, some optimization of storage can be achieved with motion detectors placed in low traffic areas that trigger the recording devices and record for a preset amount of time after motion is no longer detected.

Assuming a computer security system has 20 video inputs and can store data from all 20 at the same time (or perhaps there are five computers, each storing input from four cameras), there seem to be some advantages, but is it really cheaper? Most video tape decks store images in higher resolution than most computerized systems digitizing input through multiple videocams. Computer data need to be backed up. All computer data are vulnerable to corruption, accidental deletion, and loss due to hard-drive failures. That is not to say that computer hardware is inherently less reliable than tape recording machines, but rather that operator error and programming bugs are more likely to impact the integrity of data in a computer system than in a traditional VCR. Therefore, computer backups to high-capacity tapes or cartridges need to be made from the original computer data. In other words, you end up with the same storage, labeling, and archiving concerns for computer backup tapes or cartridges as you would with traditional video tapes. It's important to assess the advantages and disadvantages of each system before investing in visual recording systems.

6. Applications

Since this volume describes surveillance technologies as they are used, rather than how they should be used, this section includes descriptions of both legal and illegal uses of visual surveillance. Consult Section 8 (Restrictions and Regulations) for more information on lawful uses and restrictions on the use of visual surveillance devices. Note that some uses and technologies may be legal within home or educational contexts, but not in other applications.

There are thousands of different applications of visual surveillance technologies, so it's not possible to list them all, but there are enough examples here to give an overview of the some of the most common uses.

6.a. Community Safety and Security

Art Theft

Investors and cultural historians have long considered fine art to be one of our greatest legacies. Unfortunately, the value of artworks makes them vulnerable to theft and sometimes to vandalism. Many museums are installing or have installed visual surveillance systems to protect works of art and to monitor patron safety and compliance with preservation guidelines (e.g., no flash pictures).

Surveillance systems can be difficult to install on the limited budgets of organizations that safeguard public works. Even centers with surveillance measures in place occasionally experience thefts. In January 1998, a Greek stele with 4th century B.C. inscriptions was stolen from the Louvre, in spite of photo surveillance. In May 1998, a Jean-Baptiste Camille Corot painting in the Louvre was stolen from its frame from a room that lacked camera surveillance. The police searched for fingerprints on the frame and glass but had to investigate the theft without any identifying visual information.

The same month, Italy's only two van Gogh paintings, and a work by Paul Cézanne, were stolen from the Rome Museum. This tragic theft occurred in spite of the existence of a camera surveillance system. The armed and masked thieves bound and gagged the guards, stole the works, and removed a surveillance tape from the closed-circuit recording system.

In fact, many thieves now look for surveillance tapes to try to remove the evidence. The recording devices should be locked and hidden. Some institutions have two recording systems, one that is a decoy and one that is hidden as a backup.

Bullet Forensics

Magnifying technologies are used in almost every aspect of forensics. Visual technologies including microscopes and magnifying classes are used to investigate bullets that have been recovered from crimes. Bullets can be visually examined to determine whether they have been fired, and what type of gun fired them. The microscopic patterns engraved into a bullet when it spirals down a gun barrel are unique to that barrel and can be matched to a specific gun. National databases and gun and ammunition collections further aid in visual identification and categorization.

Building Inspection

Visual surveillance techniques are used in many aspects of building inspection and industrial fault detection. Infrared and ultraviolet cameras and photographic records are common in this field of application, as well.

Crime Scene and Accident Records

Photographs to indicate the state of a scene at the time of a crime, accident, or discovery of unusual activities are often extremely important for solving a crime, linking an event with other similar situations, or justifying damages for insurance or job-retention purposes.

You cannot always know in advance what aspects of a crime scene might be important. It is vital not to disturb or trample things in the process of photographing them. Footprints and tire tracks should always be photographed before people walk around the crime scene, with plaster casts taken, if possible. Anything which appears to have been disturbed should be photographed because it isn't usually known in advance what might be relevant to the crime later.

In auto accidents that might involve insurance claims and liability suits, it is important not only to photograph the vehicles and people involved, but also the conditions at the scene at the time of the accident (as these may change dramatically by the time the claim is adjudicated or the suit heard in court), along with blind spots, signs, tire tracks, and sometimes even witnesses to the accident. It may also be important to photograph injuries, including bruises, broken limbs, etc. The photos should each be carefully labeled with the event and the time and date of the accident. Any unusual circumstances that can't be photographed should be noted (oil spills, a hail storm, construction, a deer crossing the road, etc.). No matter how clear these details may seem at the time of the event, the clarity of the memory will fade in time. If the cause of an accident is a belligerent or drunk driver, the other person may not be cooperative and the photographic evidence may be the only way to assert the truth.

Explosives Detection and Disposal

The detection and handling of explosives is one of the most difficult areas of police and military work. Unexploded 'bomblets' and mines and deliberately set terrorist bombs must always be handled with care even by seasoned experts. Surveillance technologies can help to locate, neutralize, and otherwise dispose of dangerous explosives. Any surveillance technology that allows explosives to be found before people stumble across them or which allows experts to neutralize the explosives or intentionally detonate them from a safe distance are welcomed by those concerned with public safety. Traditionally, bomb experts have used heavy Kevlar bomb suits to protect them from a possible explosion but new options are becoming available through remote-controlled cameras and robots.

Vision-equipped robots can be used to get in close to hazardous materials to locate and disable explosives that might pose a danger to humans. This Remotec Andros 5A, developed at the Sandia Labs, is equipped with three cameras, a gripper, and a bomb disabling gun. The underlying software is designed so that various capabilities can be 'mixed and matched' to create a variety of types of robots specialized for specific operations such as waste cleanup or accident remediation. [Sandia National Laboratories 2000 news photo by Randy Montoya, released.]

Many types of surveillance devices are now available to locate explosives and are described in several of the other chapters. In terms of visual surveillance, some of the more interesting technologies that are coming into use include vision-equipped robots that not only detect bombs and other explosives, but may have the capability to safely dispose of them as well.

As an example, Sandia National Laboratories has developed a robot vehicle with three cameras designed to aid in bomb disposal. The Remotec Andros 5A has a gripper and a bomb-disabling gun in addition to the three vision systems. The robot is now being integrated into the Albuquerque Police Department's bomb disposal unit.

To operate its various robots, Sandia has developed a Sandia Modular Architecture for Robotics and Teleoperation (SMART) which is a 'stackable,' software base consisting of interchangeable modules for each robotic function. Using this system, the desired robot capabilities could be mixed and matched 'off-the-shelf' and incorporated into custom systems. Thus, the robotics system needn't be constrained to just disabling explosives, it could also be configured for cleaning up wastes, hazardous materials spills, or responding to accidents. Since this type of flexible technology can be applied to many law enforcement situations, the FBI is providing advisement to Sandia on the project.

Public Areas Monitoring

During the 1980s, security cameras were increasingly being installed in subway systems, parking lots, trains, and corridors, but they were not yet prevalent in town squares or public sidewalks.

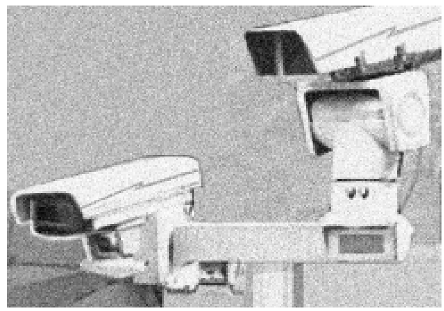
As of 1998, the number of cameras being installed in public areas dramatically increased to the point where some cities have so many, it's difficult to walk down any public sidewalk without seeing cameras every block or two. They monitor ATM stations, banks, intersections, retail outlets, gas stations, convenience stores, campuses, and gated or secured neighborhoods. Some say they prevent crime. Others say they displace crime to other areas or other types of crime. These assertions are difficult to study empirically. It appears fairly certain that video monitoring aids in identifying subjects and in convicting suspects, but it is not certain beyond a doubt that crime overall is reduced by video cameras. Given the cost of installing, maintaining, and monitoring video surveillance cameras and recordings and the significant impact on personal privacy, it is important to be aware of all the issues related to video surveillance of public areas.

Here are just a few examples of ways in which video cameras are being used in security monitoring:

- In the Bronx, cameras are used to monitor schoolyards.
- The Housing Authority is installing bulletproof cameras in corridors of city housing projects. In Harlem grant houses, almost half a million dollars were invested in surveillance camera systems, with a reported drop in crime.
- Valhalla and Dutchess Counties are adding cameras to guard helmets, visiting rooms, and some prison cells.
- Los Angeles, Oakland, Tacoma, Seattle, New York, Baltimore, and Charleston are just a few of the cities that have taken steps to recommend or install video surveillance systems in public areas, most often parks, streets, parking lots, and bridges. In some cases the recommendations were defeated before the cameras were installed. In some, the cameras were put in place without public hearings and later removed as a result of public concerns. In some, the cameras were supported and implemented and later removed. And in a few cases, the cameras were supported, implemented, and continue to be used.
- In Gulfport cameras have been proposed to help police monitor high crime areas and to act as a deterrent. These are intended to be mounted on telephone and light poles.
- Throughout the U.S., Canada, and the European Union, video surveillance cameras are being promoted as a way to reduce crime and promote public safety. There is as yet no hard evidence that this is so, partly because the technology is new, and partly because it is hard to tell when reduction in crime is strictly due to one change or a number of changes, or is related to displacement, that is, the movement of criminals from a surveilled area to an unsurveilled area.
- A small community in interior British Columbia was experiencing repeated thefts and vandalism and the residents were frightened that the activities might escalate. The community banded together to set up human surveillance shifts around the clock and used handheld cameras and clipboards to record the comings and goings of everyone into and out of the community. The concerted effort resulted in a halt to the series of thefts that had plagued the community.
- In Newham, East London, a video system in a shopping center has been installed which can create a facial code from digital video and compare it to a database of local criminals. A match sounds an alarm in a control room and the security person on shift assesses the computer match and alerts local authorities. Similar systems are being evaluated for airports and border crossings.

Traffic Monitoring

Speeding, running red lights, and showing lack of care and attention when approaching pedestrian areas result in thousands of deaths each year from irresponsible motorists. Some cities have instituted a number of speeding violation surveillance systems and intersection cameras to detect those who run the lights. Some of the more sophisticated systems being developed can sense the sounds of a crash and store the previous several minutes of video in order to evaluate what happened to cause the accident.



Powerful, zoom-enabled, swivel-mounted CCTV-based surveillance camera systems have been installed on many public sidewalks and intersections in the U.S. and the U.K. These are intended to monitor accidents and to reduce street crime. Traffic advisory cameras have also been installed on interstate highways. [Classic Concepts ©2000, used with permission.

Border Patrol

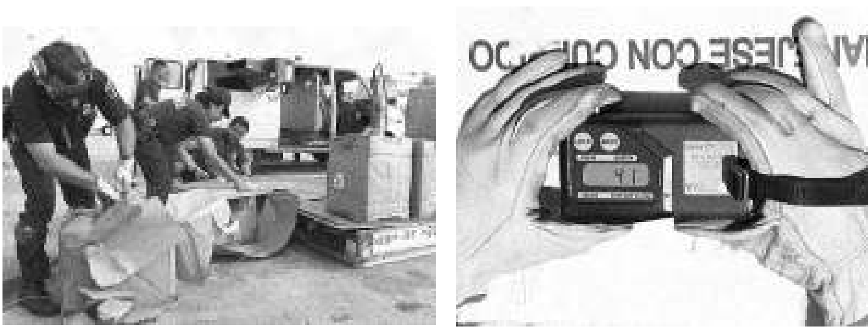
The U.S. Customs and Immigration services were some of the first agencies to make regular use of visual surveillance technologies to patrol borders and inspect cargo and luggage to make sure they complied with import restrictions and safety guidelines. Over the years, they have also equipped aircraft and marine vessels with a number of visual, infrared, and ultraviolet sensors to aid in patrolling coastal areas in various types of weather and conditions of light or dark.

Many border checkpoints are equipped with cameras that monitor vehicles as they pass through Customs and Immigration. Inside the booths, computers are used by officials to collect and verify border traffic statistics. [Classic Concepts ©1999, used with permission.]

Customs has installed a number of visual surveillance systems which can read the license plates of vehicles passing through a checkpoint and automatically relay law enforcement information that may be relevant to the computer terminals of inspectors in nearby booths or buildings.

Customs officials sometimes use a high-tech ‘optical viewing instrument called a *fiber-optic scope*. This is similar to instruments used in medical diagnostics to probe tiny areas that are difficult to reach any other way.

Optical fibers are tiny filaments that can readily transmit light and bend around corners. They are well suited to making instruments that can slide into tiny openings and otherwise inaccessible pockets or compartments. In customs work, they are used to probe inside vehicle walls, gas tanks, and compartments. In other aspects of surveillance, optical fibers are also used to transmit computer data or broadcast programming (e.g., digital cable).



Left: Visual inspection is frequently used by customs agents to check cargo or may be used to confirm the detection of anomalies with high-tech devices. Right: The inspection technologies used by customs agencies are so varied, some of them are difficult to categorize. This image shows an instrument used by U.S. Customs to measure density variations. Since many smugglers create false walls or floors in their vehicles, a density monitor with a visual readout can help detect abnormal variations that might indicate hidden articles. [U.S. Customs news photos by James R. Tourtellotte, released.]

6.b. Home and Family Safety

Domestic Help Monitoring

With costs dropping, small cameras are now being purchased by home consumers, usually to watch their infants and children and sometimes to watch aging parents who need extra care. They have also been used on occasion to monitor contractors and house cleaners.

Cameras installed in private homes have uncovered the disturbing fact that some contractors and housekeepers steal from their clients. Money from drawers, piggy-banks, jars, and closets, and small-but-valuable items such as jewelry are most often taken. Even when confronted with their actions, most of the thieves completely deny the thefts. They don’t usually admit their actions until they are shown the tapes or the money is found in their possession.

Pinhole nannycams have disclosed that a small percentage of caregivers are appallingly abusive. Video recorders have shown that there are nannies who regularly hit children, neglect them, or drag them without considering their safety and well-being. While the incidence of this type of abuse is low, it shouldn’t happen at all and parents have been motivated to record the conduct of these workers to make sure their children are safe. Surprisingly, many of the abusive caregivers caught on tape had been informed in advance that they might be recorded and still engaged in this astonishing behavior.

Some of the common household objects in which people hide pinhole cameras (not all of which are pictured here) include potted plants, books, stuffed animals, smoke detectors, thermostats, cabinets, keyholes, stereo systems, lamps, picture frames, speakers, pencil sharpeners, and clock radios. [Classic Concepts photos ©2000, used with permission.]

Entry monitoring

Doorways and entries to amusement park rides and sports stadiums are often monitored to see who is entering and exiting and to make sure there are no unexpected obstructions to fire exits or entry to hazardous areas without correct attire or authorization. Entry monitoring is also an important part of surveillance on transportation systems, cruises, air flights, and train trips (see the X-Ray and Magnetic Surveillance chapters).

Employee Monitoring

Surveillance cameras are being installed in the workplace in increasing numbers. Some of these installations are to monitor hazardous areas where there might be heavy machinery, chemicals, or the possibility of radioactive contamination. However, some employers are also monitoring office areas, staff rooms, dressing rooms, and washrooms. These activities are questionable, particularly when the management isn't being similarly scrutinized. Any employee monitoring should be explicitly notified and the method and schedule for archiving made known to people who are being taped. Tight security should be maintained on archive tapes, so they don't get copied or put into the wrong hands. There should be restrictions as to how long an employer may keep the tapes as well as regulations that prevent an employer from selling the tapes to outside parties such as insurance companies or marketing agents. There should also be guidelines on how long recordings can be kept after an employee has left the company.

Hazardous Area Monitoring

People seem compelled to break rules. If a popular hiking area is closed due to avalanche danger, a dozen people a day will hop the fence anyway. When dangerous cables or electrical systems or bridges are posted with No Trespassing signs, children and teenagers will still play in and under them. Unfortunately, search and rescue operations are often financed by tax dollars, pranksters may be injured or killed, and people breaking the rules will sometimes surprise everyone by suing for their injuries even though they clearly broke the rules. For these reasons, surveillance cameras are often aimed at hazards in efforts to avert possible tragedies.

Unfortunately, surveillance cameras are only as good as the people who maintain them. In a 1999 accident on a popular tourist bridge near Vancouver, B.C., it was reported that two surveillance cameras were monitoring the bridge when a mother unexpectedly dropped her infant daughter almost 200 feet into the edge of the riverbed below. The baby's life was saved only because the fall was broken by trees and foliage below the bridge. Law enforcement officials were having difficulty determining if the mother's actions were deliberate or accidental. It was discovered that the surveillance cameras were apparently not functioning at the time and the only relevant footage was shot by a tourist moments before the accident. In this case, surveillance photos might have helped authorities determine the facts of the case.

Munchausen Syndrome by Proxy

Munchausen Syndrome by Proxy is an illness in which a parent or caregiver abuses a sick or healthy child by endangering his or her health. The person may even be trying to murder the child (most often through poisoning or smothering) but may deny the fact to others and sometimes even to him- or herself. The parent with the syndrome typically claims to be concerned about the child's welfare and may appear to be caring for the child. The parent may exhibit other types of mental illness and may engage in frequent fabrications. The child may be in a home, a social agency, or a health care facility. Since the person with the syndrome is often adept at hiding the abuse, it is sometimes difficult to establish whether indeed Munchausen Syndrome is a factor.

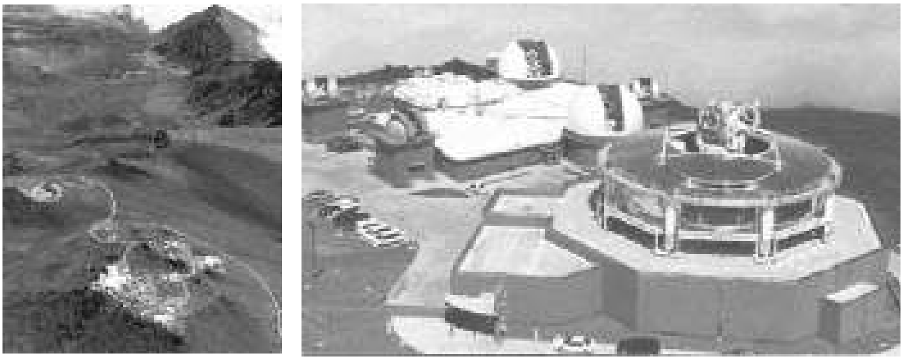
In most of the news coverage and studies on Munchausen Syndrome, the focus has been on mothers; however, it has been reported that fathers also carry out the abuse [Meadow, 1998].

In the past, the primary means of confirming the syndrome has been to remove the child from the care of the parent and see if the child improves. Obviously, there are many situations where this may not be sufficient evidence to establish the syndrome and it may be difficult to find the initial justification to remove the child from the parent. Since proving the syndrome can be difficult, social agencies and health care facilities are now installing video surveillance systems to determine whether the parent is a danger to the child. Sometimes two cameras with different vantage points are necessary, since the parent may have a back turned to the camera.

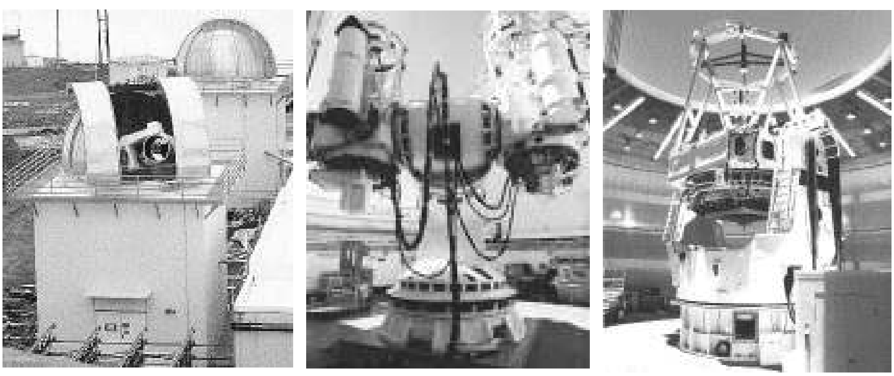
6.c. Space Surveillance

Amateur, commercial, and military surveillance of outer space has yielded an astonishing amount of information about our origins and the billions of galaxies and solar systems that were once beyond the reach of our technology and almost beyond the reach of our imaginations. The continued evolution of telescopes and the launching of the early space vehicles prompted the development of both ground and space-based space surveillance strategies and complexes.

The 18th Space Surveillance Squadron operates the *Maui Space Surveillance Complex* on top of a dormant volcano on the island of Maui. The contracted staff members detect, track, and identify space objects with an electro-optical deep space surveillance system (GEODSS) and the Maui Space Surveillance System (MSSS). The Space Object Identification data are supplied to several agencies including the Space Control Center, the 1st Command and Control Squadron Control Center, and the Combined Intelligence Center in Colorado.



Left: An aerial view of 'Science City' which includes the Maui Space Surveillance Complex atop a dormant volcano on Maui in Hawaii. Space telescopes are generally located away from cities in locations where there is less interference from light and air pollution. Right: The Maui Space Surveillance Complex, Detachment 3. Note the numerous telescopes of different sizes. [U.S. Air Force news photos, released.]



Closeup views of telescopes within the Maui Space Surveillance Complex. On the left is a 1.0-meter telescope. Specialized optics and highly polished precision mirrors are used in many aspects of telescope design. [U.S. Air Force news photos, released.]

6.d. Media Applications

Journalism

Gossip journalists track many people who don't want to be photographed using long lenses and covert surveillance technologies. There has been a lot of controversy over this, particularly when the journalists shoot compromising private photos of people and their families in and around their homes or vacation getaways.

Investigative journalists often prepare news reports on people who don't want to be photographed. In some cases the unwilling subjects don't want their privacy and safety compromised. In other instances, journalists have been known to uncover evidence of criminal activities and have made law enforcement agents aware of the situation. Thus, journalists make use of visual technologies not only for regular community features and articles, but also for covert investigations of criminal suspects.

6.e. Scientific Research

Atmospheric Studies

Atmospheric physicists use specialized cameras to study phenomena called *sprites,* fleeting light phenomena which tend to appear in the mesosphere during lightning storms, with night-vision (image-intensified) cameras that can shoot from 1,000 to 6,000 frames per second, compared to a conventional 16 fps camera [Baker, 2000]. By using the cameras in conjunction with signals from Global Positioning System (GPS) satellites, the phenomena being observed can be located. Clearly these specialized high-speed, low-light cameras would be suitable for many different types of surveillance activities.

Marine Studies

Underwater cameras are widely used in diving and marine studies of creatures and plants and their habitat. Since water and delicate instruments rarely mix well, special waterproof cameras or waterproof camera housings are typically used. Earlier in the chapter, a number of camera-equipped diving vessels and suits were illustrated.

While not every part of the Earth's terrain has been viewed on foot, scientists have certainly endeavored to inspect every aspect of the Earth's terrain with cameras installed in airplanes, helicopters, and satellites.

Terrain Studies

Environmentalists, geographers, paleontologists, cartographers, agronomists, mineral and oil prospectors, miners, researchers, and military strategists are interested not only in Earth's terrain, but in the terrain of other planets as well.

Purdue University professor Jon Harbor and two students (Luke Copland is shown here) traveled to Switzerland to gather video images from beneath a glacier. The special, waterproof video camera provided a view of a detailed network channels, streams, and changing ice structures. A high-pressure hot-water drilling system was used to drill vertical boreholes through the Arolla Glacier near the Matterhorn. The holes ranged in depth from 100 feet to over 450 feet. [Purdue 1996 news photo, released.]

6.f. National Security and International Peace-Keeping

Remote Administration

Videoconferencing technologies are now used in many aspects of military communication. They provide a visual/auditory link for meetings, tactical discussions, personal calls for service members deployed abroad, and long-distance enlistment.

This video camera and monitor form part of a videoconferencing system aboard a U.S. aircraft carrier. Here it is being used for an administrative ceremony, in which P.O. 2nd Class David Lee, Jr. is re-enlisted while onboard the carrier in the Persian Gulf. The ceremony itself was conducted remotely at the Navy Command Center in the Pentagon. [U.S. DoD 1997 news photo by Brian Fleske, released.]

Operations Monitoring

Cameras are used extensively by the U.S. military to document operations and exercises. Here, a U.S. Navy Photographer's Mate uses a Hi-8 mm video camera with an extended lens to record activities on an aircraft carrier deployed in the Persian Gulf. [U.S. DoD 1997 news photo by James Watson, released.]

Visual surveillance technologies are being routinely used now for recording military operations, equipment, and personnel. This facilitates the review and revision of exercises and operations, provides accountability, and a historical record of events.

Surveillance photos can be used to assess the effectiveness of commercial or military activities after some action has been taken. They can record mine explosions designed to release more ore, controlled burnings intended to prepare land for crops, or reconnaissance imaging to assess the effect of bombing missions. These U.S. Department of Defense 1998 aerial photos are reported by the DoD as being bomb assessment images. They include the Tikrit Radio Jamming Station (left) and the Al Basrah Military Cable Repeater Station, both in Iraq. Buildings reported by the DoD as being destroyed in Dakovica, Kosovo are shown here before and after the bombing mission. [U.S. DoD 1998 news photos, released.]

Aerial Surveillance

See the chapter on aerial surveillance for a more extensive treatment of this application. (A large part of aerial surveillance is carried out with infrared technology; see the Infrared Surveillance chapter for additional information).

Aerial surveillance and surveillance of aircraft are accomplished with a variety of devices, from basic scopes to sophisticated digital computer imaging systems. Left: Cpl. O. Villarreal of the *2nd Low Altitude Air Defense Squadron* uses binoculars to spot aircraft in a multinational tactical air defense exercise at the NASA White Sands Test Site. Right: On board an aircraft carrier Intelligence Center, Intelligence Specialist Rasch (IS2) performs imagery interpretation, photometrics, and analysis of Tactical Air Reconnaissance Pod System (TARPS) film. [U.S. DoD 1996 news photos by Benjamin Andera and Daisy E. Ferry, released.]

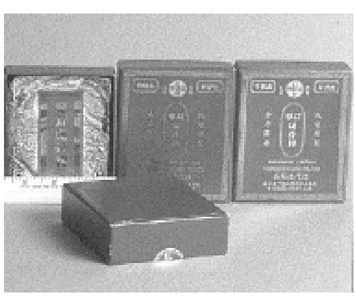
Aircraft tactical reconnaissance pods are designed to house a variety of surveillance equipment, visual systems are often supplemented with infrared sensors to provide imagery in darkness or bad weather conditions in low altitude assignments. Typically these pods are bullet-shaped units of about 1200 pounds that are centerline-mounted under the belly of tactical aircraft. They typically include several types of cameras, recording devices (e.g., tape recorders) and, in some of the more recent systems, realtime or near-realtime radio-frequency downlink technologies.

Hostile Territory or Political Climate

Left: A U.S. Army private of the 4th Chemical Company dons chemical gloves during a nuclear, chemical, and biological skills challenge held in the Republic of Korea. Right: The gas mask and goggles are to help protect against dangerous nerve agents (pills are sometimes also given to help protect against nerve agents). Environmental suits allow people to enter and observe in hazardous areas. [U.S. DoD 1998 news photo by Steve Faulisi, released.]

Virtually all visual surveillance technologies and associated gear, environmental suits, and strategies are used for monitoring hostile territories or nations at one time or another. Many of these technologies, particularly environmental suits, are not so much surveillance devices in themselves as they are a means for human beings, with their excellent visual acuity and problem-solving skills, to enter unusual or unfriendly environments.

Compliance Monitoring and Enforcement



Left: Documentary photos of animals that have been injured or killed by industrial accidents have aided in tightening regulations. This unrecognizable animal is a sea otter that died as a result of oil from the Exxon Valdez spill. Since that time ship hull designs have been improved and additional safety procedures implemented. Middle and Right: Photos can help document illegal products created from endangered species that are killed by poachers. This chilling photographic evidence of glue made from the bones of endangered tigers illustrates the lengths to which resellers will go to make a profit from precious and fast-disappearing resources. There are less than 5,000 remaining wild tigers on the entire planet. In human terms, that's barely enough to populate one small village. [U.S. Fish and Wildlife Service news photos, released.]

There are many ways in which surveillance is used to safeguard public safety and enforce laws. Wildlife management requires constant monitoring to ensure compliance with licensing, limits, and endangered species laws. Sensitive areas need to be protected from construction, mining, and trampling by hikers or tourists. Treaty agreements are monitored and coastal offsets are patroled on a regular basis. Large industries with the potential to pollute are regulated and monitored by law enforcement officials and environmental organizations. Visual surveillance strategies and technologies form an integral part of these processes. Gear for harsh environments or hazardous areas sometimes are used with the cameras to inspect places that might otherwise be inaccessible.

6.g. Emergency Services

There are two main trends in the emergency services industry. The first is for the use of a 'visual-911' systems, that is, emergency call boxes equipped with video surveillance cameras. The other is for the use of CCTV systems to record the activities of emergency deployment teams. Emergency teams are sometimes recorded by third-party news agencies or production companies, with the footage sometimes being aired on television or the Internet.

Visual surveillance technologies are an intrinsic tool for search and rescue operations. Scopes, night-vision goggles, illuminators, aircraft, and imaging devices are all important in assessing terrain, movement, the presence or absence of people, damage, chemical leakages, and structural integrity. These tools are often used in conjunction with other surveillance technologies including infrared, X-ray, radar, and tracking dogs.

Search and rescue operations take place in many types of marine, forest, mountain, and urban environments. In cases where a missing or injured person is suspected of being a victim of foul play, law enforcement and intelligence agents may work in cooperation with search and rescue personnel. This is important, since the very act of seeking and retrieving individuals may disturb a crime scene in ways that may interfere with investigation of the causes. This is particularly true in homicides, kidnappings, and bombings.

Left: FBI agents, fire fighters, and FEMA Urban Rescue Task Force members work together in 1995 to carry out a visual search to find survivors and clues in the Oklahoma City bombing. Right: Protective gear, including hardhats and dustmasks, protect workers looking through a collapsed structure in Puerto Rico. Disaster situations must be carefully administrated so rescue workers who help victims don't inadvertently damage evidence that might reveal clues about the cause of the disaster. [Federal Emergency Management Agency news photo, released.]

Interagency cooperation often happens in cases of searches for missing persons (who may be ill or injured) and runaways (who may cross state or national borders). Border patrol agents have been known to supply equipment, air surveillance, and tracking expertise in locating missing persons.

6.h. Commercial Products

Pinhole Stationary Video Cameras

Video surveillance technologies are currently considered to be a growth industry. The sale of security cameras is expected to reach almost $6 billion by 2002.

Cameras the size of a quarter can be hidden in many common consumer products. They can be attached to a cable that interfaces with a VCR or other recording device, or they can be attached to a wireless transmitter (usually broadcast FM, 900 MHz, or 2.4 GHz frequencies) which sends the signal to a remote recording device. Most consumer wireless pinhole cameras have a range from about 100 to 300 feet with a few that will transmit to about 1,000 feet. It should be remembered that anyone in the vicinity, like next-door neighbors, with a receiver tuned to the same frequency can also intercept wireless broadcasts.

Pinhole cameras can be purchased in three basic configurations:

board level - This is a circuit board integrated with the camera that comes without a housing. It can be self-installed by individuals with sufficient technical knowledge. Often the boards have not been FCC approved for resale or use outside of hobby or educational settings.

encased - This is a camera installed inside an indoor or outdoor casing. The long narrow casings are known as *bullet* housings. These consumer products are usually, although not always, FCC approved.

hidden - This is a 'consumer-ready' camera that is already built into a consumer electronics device, home furnishing, or other host. Common examples include VCRs, clock radios, clocks, teddy bears, paintings, pencil sharpeners, speakers, pagers, smoke detectors, telephones and other common items that are typically in a position to survey a room without attracting attention. If you don't know where the device is, it can be very difficult to detect by sight alone. Some of the hidden cameras are in dummy devices (ones which don't work) in which the covering is just a shell for the camera. Others are hidden in working devices (clock radios, clocks, etc.).

Pinhole Portable Video Cameras

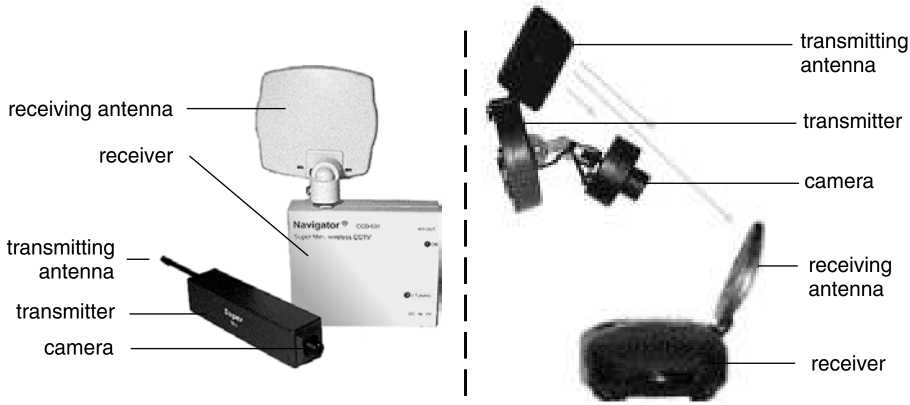
Portable video cameras have the same basic capabilities as pinhole stationary video cameras. Their resolution and features are similar. The main difference is that they are battery-operated to allow them to be carried around. They are usually built into wearable items such as tie tacks, watches, pens and belts and carryable items such as pens, pagers, cell phones, etc.

Most portable pinhole cameras are used with Hi-8 mm recording decks since the decks are compact enough to fit in a briefcase or purse. Some of the tiniest recording decks can be body-worn, but are more expensive.

Pinhole cameras have also been specially installed in sunglasses so they can be unobtrusively worn while recording. They typically link to portable recording units that are worn elsewhere on the body or connect with body-worn transmitters worn on the hip or in a pocket. The ones with transmitters can send the video signal to a monitor in another room or a recording system offsite in a van or another building nearby. These range in price from $700 to $3,700.

Body-worn cameras can be detected easily by metal detectors or pat-down searches and thus are vulnerable to discovery. The battery life is limited and the ones with transmitters can be picked up by anyone with an appropriate video scanner. Nevertheless, there are situations in which they are effective surveillance devices.

Two Varieties of Wireless Miniature Cameras



There are a variety of types of designs for wireless pinhole cameras. On the left is a 2.4 GHz wireless NTSC 0.5 lux color camera that weighs less than 50 grams and includes a wireless transmitter inside the dark casing that is about the size of a screwdriver handle. It can transmit with a range of about 100 feet to the 100 gram Navigator® receiver. The suggested retail price is $400. On the right is a different design approach. The XCam2™ NTSC color 'bullet' camera with audio has a directional 2.4 GHz wireless 100-foot range transmitter attached to the base of the camera. It is rated for outdoor use with a suggest retail value of about $300. [Classic Concepts photos and illustration ©2000, released.]

Miniature still cameras, often called *spy cameras,* are frequently associated with secret agent movies and, indeed, they have been used for decades for clandestine photography. The smallest of the spy cameras are the *subminiatures* which are remarkably small, about 3" *x* 1", not much bigger than a matchcase.

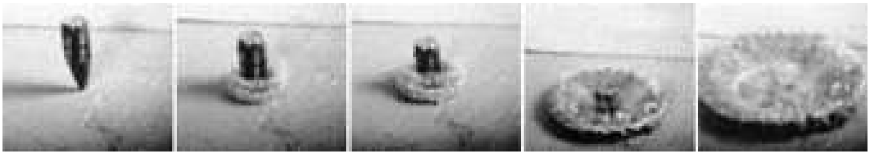
Public Security Cameras

Optech Integrated Systems has installed more than 100 of their Passenger Help Point Systems in rail link centers in London and selected London Underground stations since 1987. These are, in essence, visual 911 centers. Passengers needing information or emergency assistance can activate an alarm button on the console that switches on a video camera that is aimed at the caller. The emergency or dispatch staff at a central control center can then see the caller and communicate with him or her while viewing a map of the area on a computer terminal. Depending on the nature of the call, they can send out whatever assistance might be appropriate. The communication is automatically recorded in much the same way that 911 phone calls are currently recorded to tape.

Specialized Cameras

Many aspects of surveillance require special types of cameras. Surveillance often occurs in low light or may require special filters for sensing infrared or ultraviolet. Sometimes high speed photography is used to capture fast events or events which need to be viewed in slow motion.

The U.S. Department of Energy and Sandia National Laboratories *Albuquerque Full-Scale Experimental Complex* (AFSEC) provides a number of specialized photographic technologies including high-speed and ultra-high-speed photography, image-motion photography, still, time-lapse, and Schlieren photography. These are especially useful for scientific research, reconnaissance, and forensic investigations.



AFSEC Photometrics products include high-speed and ultra-high speed cameras that can produce between 40,000 and 26 million frames per second. This selection from a series of images of a bullet impacting an armor plate was captured as the bullet travelled 2,750 feet per second. [U.S. DoE and Sandia National Laboratories news photos, released.]

Very fast frame rates can be used to photograph explosions, projectiles, fast-moving aircraft, and natural phenomena for later analysis. Schlieren photography can be used to record shockwaves associated with supersonic events.

Video Intercoms

Video Intercoms are essentially the same concept as the more familiar audio intercoms. A small intercom camera unit can be located by a door, using power from the existing doorbell outlet and will transmit images to a receiver elsewhere in the house either by a wired connection, or a wireless connection. The video image area is quite small. They sell for around $400.

Vehicle Environment Camera/Recorder Systems

Trucks and cars can now be equipped with cameras that allow drivers to view their blind spots, especially behind the vehicle or the back right-hand side. Others are designed to monitor and record events happening all around the vehicle so that if some important event or accident occurs, there will be a record of the event. Docudrive has such a system for $5,000. The system records the immediate environment of the vehicle and stamps the video images with the date, time, and other information.

6.i. Display Devices and Accessories

Monitors, Monitor/Receivers

Most video surveillance signals are either displayed in realtime or recorded and displayed in continuous mode or time-lapse mode. Display monitors are somewhat generic, so it is often possible to display a video signal on a variety of devices ranging from consumer TVs to video monitors, to computer monitors. Monitors with built-in receivers operate in a variety of frequencies, including UHF and 900 MHz.

Multiplexing or Splitting Units

In surveillance, it is common for more than one video source to be monitored at the same time and it is convenient to display a large number of camera inputs on a smaller number of display monitors, especially if the viewing room is small. A multiplexer allows multiple inputs to be displayed on a single monitor. A splitter allows a particular input to be sent to more than one monitor. Multiplexers are commonly used for surveillance. Unless you have large, high-resolution monitors that can display up to about 6 or 8 scenes, it is usually advisable to limit a multiplexed display to four views. In other words, four camera sources can be multiplexed onto one screen and, with a good multiplexing system, individual inputs can be displayed full-screen as well, if desired, at the touch of a switch or as set by a timer.

Time-Stamp Generators

A time-stamp is often an important aspect of surveillance videos, especially those used for forensics. Most camcorders allow the time and date to be preset and then ‘stamped’ on the image as it is being filmed. Live camera images that are sent through a cable or a video transmitter to a VCR can sometimes be time-stamped on the VCR (depending on the system), or can be passed through a specialized time-stamp generator, a component that resembles a switcher. Some time-stamp generators are also equipped to superimpose the camera position onto the video image since there are now cameras that can swivel and pan to capture video from many directions. Since time-stamp-generating components and VCRs are usually specialized for surveillance purposes, they may also have autostart and timed-recording mechanisms.

Time-stamp, autostart VCRs range in price from $200 to $1600 and peripheral time-stamp components range from about $50 to $120.

6.j. Recording Systems and Devices

Event Timers, Time-Lapse VCRs

Recording for long periods of time is important for many types of surveillance activities. Retail stores don’t want to have to change tapes in dozens of machines every six hours, as is typical for consumer VCRs on extended play modes. Time-lapse VCRs commonly can record from 24 to 960 hours for about $500 to $1800, depending on the length of the recording, the frequency of the frames and the quality of the image. Black and white time-lapse VCRs typically feature higher resolutions and lower prices than color systems.

Portable/Covert VCRs

Body-worn spy cameras that are incorporated into sunglasses and tie-tacks require either a wire or a tiny transmitter to send the image from the source to a recording or display device. Thus, video recorders that are intended to be used with a wired body-worn cameras are designed to be small enough to fit in a large purse or small briefcase. Hi-8 mm is a very high resolution video format in a small package, and thus is very convenient for use with portable recorders. Some of these VCRs have time-lapse capabilities, though most are continuous-recording devices. They range in price from about $1,100 to $2,000 and weigh about three pounds with the tape and battery.

A normal three- or four-pound camcorder can sometimes be used with wearable cameras. By leaving the lens cap on the camcorder (primarily so the lens won’t get scratched) and running RCA cables from the camera to the camcorder and then setting the camera, if necessary, so that it accepts input from the line rather than from the lens, it can be used as a recording device with a pinhole camera.

The biggest problem with using consumer camcorders for surveillance is that many of them have a *power-saver* mechanism that shuts off the system to conserve power if the camcorder is not used for a few minutes. In some cases, this feature can be disabled, but that is not always the case. Since it is hard, in surveillance activities, to anticipate what needs to be recorded and when it needs to be recorded, it may be impractical to check the camcorder to see if it has powered down automatically or is ready to record. However, there may be situations where some kind of recording is better than none with a camcorder filling the gap.

Intranet and Internet Remote Video Surveillance

Organizations that have a number of branch offices or a number of people who work off-site sometimes use remote video surveillance to monitor their employees and contractors. A head office in Chicago, for example, could monitor branch offices in Texas, Germany, Florida, and Washington in near-realtime over the Internet. Systems designed with these capabilities typically require certain basic components, including

- a digital or analog video camera at each station,
- an interface box that handles the input from several cameras or a personal computer or interface box associated with each camera,
- a fast Internet link which can be accessed at prearranged times or which is live all the time,
- interpretation software at the receiving end, and
- some type of storage and display system (usually a computer).

Many of these network video systems work on a time-lapse basis, transmitting an image every few seconds rather than continuously. This saves computer processing power and transmission time.

Fast connections work best for these applications. The connections can be through a variety of services, including ISDN, DSL, satellite, or cable modem. Slower, but still useful connections, can be achieved through 33K or 56K fast modems through normal phone lines. Some systems operate with dedicated software, others use Web browsers to display the camera images which may or may not be enhanced with Sun Microsystem's Java programming routines.

Some Internet video connections use software or hardware motion detectors to trigger alerts if an event happens at one of the remote camera stations. Currently, hardware motion sensors work better. Computer software motion sensors that process the data from the video cameras tend to have false alarms from changes in light or other events that aren't relevant.

7. Problems and Limitations

Visual surveillance is such a large and diverse field that it's difficult to make generalizations about limitations of the various types of systems. Price used to be a limitation of visual surveillance devices; digital cameras and high quality video cameras and recording devices cost thousands of dollars each a few years ago, but this is no longer true. There are now many good quality options for under $1,000. However, it is still true to some extent that the more expensive systems provide better quality images, longer recording times, and better processing capabilities.

Resolution and Image Clarity

Many older surveillance systems suffered from low image quality, but newer systems are remarkably good and eventually the older systems will be replaced by crisper, smaller, more efficient systems. Hi-8 mm video formats are preferred over VHS for most surveillance applications, though many retail outlets still use VHS. Super-VHS offers superior image quality but requires larger cameras and decks than Hi-8. Compact VHS (VHS-C) offers an option for smaller, portable camcorders, but doesn't provide the high image quality or long recording times of Hi-8.

Digital Versus Analog Technologies

The new digital video and still cameras are convenient in many ways. They are small, relatively easy to use, and the memory cards can be swapped in and out more easily than film can be changed. They work in reasonably low light conditions. The still cameras usually store more images than traditional film cameras (50 to 200 images versus 20 or 36 on film).

The most convenient aspect of digital cameras is that there's no film to take to the processing center and no wait to see the images. It takes less time to link a digital camera to download images to a computer than it does to process and scan photos or film negatives.

However, digital technologies also have some disadvantages. Except for the most expensive cameras, the resolution of digital images is not as high as film images. Most digital cameras do not offer the options of interchangeable lenses that are currently available for film cameras (this will probably change as prices drop and digital camera options improve). For forensics, one of the biggest problems with digital images is that they are not 'tamper-proof.' Courtrooms are reluctant to accept evidence that can be changed without any sign of tampering, as is possible with digital photography. There are companies that have designed video encryption systems for international monitoring and it is possible that this technology will eventually be built into digital cameras for forensics work so that digital images can be effectively used as evidence in courtroom trials.

Recording Times

Probably the biggest limitation of video surveillance is the limiting recording times for tapes or memory for digital images. In general, consumer tapes hold about two hours of realtime video in regular play modes and up to about six hours of video in extended play modes. For 24-hour, seven-day-a-week recording applications, this is obviously inadequate as someone would have to be on hand to constantly change the tapes. If 20 cameras are in operation, this would mean changing tapes 80 or more times per day. Time-lapse recording systems are designed to greatly extend recording times, to as much as 20 hours per tape and sometimes even up to 960 hours on high-end systems. There is a trade-off in terms of image quality and there may be small events that go unnoticed because they happen between the moments when the system is recording but, generally, time-lapse video is a good compromise in terms of price and convenience. Newer digital video systems may use gigabyte and terabyte hard drives and image compression schemes to record a large amount of video, more than can be saved on some time-lapse systems. As the price of computer hard drive storage continues to drop, huge hard drives will probably be favored over tape systems. At the present time, many systems still rely on tape, for reasons that have been discussed in earlier sections.

8. Restrictions and Regulations

When a new product or technology is introduced, it will often be distributed for a while without legal restrictions. If responsible use of the product shows that it poses no danger to health or safety, then unrestricted distribution may continue. However, sometimes new products are used by individuals in ways that impact the lives of others and people will want to establish restrictions or penalties for their improper use. Drivers' licenses weren't established until inexperienced drivers had been involved in many accidents. Motorcycle helmets and seatbelts weren't required until accident statistics showed that they reduced fatalities. Automotive radar detectors weren't illegal when they were first introduced. For each new technology or product, there is a period during which the public and the lawmakers gradually become aware of the product and its impact on their lives. During this 'ramp-up' period, citizens have a choice as to whether they will use the technologies in responsible or irresponsible ways. If they are used in irresponsible ways, innocent victims who may be affected by their conduct will often lobby Congress to regulate the technologies.

When film and video cameras were first introduced, people used them to photograph special events and friends and families. Employers used them to monitor construction yards and hazardous environments. Abuse was not prevalent and the use of the cameras went unregulated for several decades. However, now that tiny video cameras are inexpensive and recording devices widely available, people are starting to use video cameras in questionable and sometimes highly irresponsible ways. Some blatant abuses of privacy and decency have occurred over the last three or four years. Employers have been putting hidden cameras in washrooms, without informing their employees, and Internet entrepreneurs have taken covert nude shots and uploaded them to the Internet, charging money for them without the subjects' knowledge or consent. These types of actions have provoked concern among citizens and privacy advocates, who are now asking lawmakers to step in and provide protections.

One of the first laws to handle an intrusion into a person's privacy was put in place in 1903. It became known as personality rights, the right to control the use of one's name and image for commercial purposes. Essentially it established property rights to one's persona. There have been many debates over this protection, particularly since the news media want the power to report on individuals and their activities. At the present time, the use of images of public personalities in documentary news reporting is permissible.

In the 1960s, searches and seizures were more stringently regulated to protect a person from arbitrary and unwarranted intrusions. Prisoners were considered to be exempt from these regulations, however.

With the increase in travel, communication, and computer networks in the early 1980s, the international community began discussing privacy regulations. The *Protection of Privacy and Transborder Flows of Personal Data of 1980* is a set of international guidelines governing the flow of personal data between countries.

Now that interactive TV is becoming a reality, it is technologically possible for broadcasters to monitor their subscribers and they may eventually want to supply small TV-top video cameras with their cable subscriptions that allow them to personally communicate with and visually monitor television viewers. However, some people are concerned about the consequences of using the technology in this way. They are particularly concerned with the safety of their children and the security of their homes. As a result, the *Cable Communications Policy Act of 1984* was put forward to prevent interactive cable operators or third parties from monitoring the cable consumers' viewing or buying habits. It also prohibits the collection of personally identifiable information without the consumer's proper consent, except as may be needed to render a service to the consumer as provided by the operator. The cable operator is required to provide notice, in the form of a separate, written statement to such subscriber, which clearly and conspicuously informs the subscriber of the use of any information that may have been collected.

Current Regulations

Peeping Tom laws are intended to protect us from prying eyes, so most people assume they protect us from prying video devices. However, many states don't have Peeping Tom laws. If someone watches you undressing in the shower through a bathroom peephole, they might be charged in a region that has Peeping Tom laws. However, if the same person videotaped you undressing in a public dressing room, it may not be possible to lay charges against them due to the wording of the law, or as we call it the *letter of the law*. Private citizens often assume laws are based on logic, when in fact, much of the interpretation of law is based on definitions and precedents. Here is an example:

> *In the 1970s, a male prostitute was apprehended on charges of prostitution with ample evidence to make a conviction. The legal definition of a prostitute in that jurisdiction stated explicitly that a* prostitute *was a* woman. *Since he was a man, he could not be considered a prostitute according to the law and he was freed.*

There are many laws like this that are written to reflect a specific social attitude or technology at a particular point in time. When new situations come up that reveal the limitations of these types of laws, they may be revised, but it can sometimes take years to change a law. Many current laws intended to safeguard privacy don't protect us from new and evolving technologies like video surveillance cameras. Often, when a conviction *is* made, it is because other aspects of law are brought into the case. Here is an example of a situation in which the primary offense could not be prosecuted, but a secondary aspect was used instead:

> *A landlord installed a two-way mirror in the bedroom of an adjoining suite and rented the room to two female college students. He videotaped them in compromising situations. The tape was discovered and the man was charged. The prosecuting attorneys are unable to get a conviction based on the video tape evidence. They were, however, able to prosecute the landlord under laws related to wire tapping, based on the fact that he recorded sound on the audio portion of the tape.*

This specificity of laws creates a difficult situation for citizens, law enforcement agents, attorneys, and judges concerned with protecting community welfare in a society where technology is evolving and changing rapidly. It is complicated further when the Peeping Tom is aware of the 'letter of the law' and blocks the microphone, thus eliminating the audio portion of the tape in order to avoid prosecution.

It may surprise to reader to discover that in the workplace, the rules are even more lenient. Employers have very broad powers to protect their investments. Thus, it may be completely lawful in some regions to videotape employees anywhere, even in dressing rooms or bathrooms. Given that most employers currently have no legal obligation to let employees know they are being surveyed (this is gradually changing) and given that employees have no equivalent opportunity to visually surveil managers and upper-level executives, it is not only privacy that is at stake, the potential for double standards or discriminatory practices are great as well.

In general, employers currently may put cameras and other monitoring devices almost anywhere. In *Vega-Rodriguez v. Puerto Rico Telephone Company*, 1997, the company could monitor employees in open work spaces. However, there have been some cases in which videotaping of employees was found to infringe on the employees' rights, as in *Anderson v. Monongahela Power Co.*, January 1995, in which employees were videotaped in locker rooms by covert security cameras.

Advanced Swivel-and-Zoom Capabilities and Voyeuristic Temptation

Hidden or remotely controlled cameras are becoming highly sophisticated. It is now possible to swivel and aim them from remote-control command center booths. Some camera systems are now powerful enough to zoom in on newspaper text held in the hand of a person across the street. If you doubt this, keep in mind that orbiting commercial satellites way above the Earth can resolve an object on the ground the size of a doghouse. (Military surveillance systems are even more powerful.) Compared to that, reading a headline a few meters away no longer seems surprising.

Recent research has found that operators controlling swivel-and-zoom cameras designed to protect public streets and transportation systems have been taking liberties with the technology. Cameras installed on traffic lights, for example, are intended for monitoring the intersections for traffic violations, but they are sometimes aimed down the blouses of pedestrians who are crossing the street.

Retailers, too, have made intrusions on privacy by installing cameras and two-way mirrors in dressing rooms, explaining that this is where most shoplifting occurs. That may be true, but it has also been shown that men are monitoring women's dressing rooms whether or not there is just cause to suspect the shopper might be shoplifting.

Privacy violations are not limited to men. Anyone staffing a security system has the opportunity to step outside the bounds of decency and professionality and observe people in inappropriate ways. However, statistically, there are more men than women monitoring security systems, and there are more women than men being watched through the systems with voyeuristic intentions. The one exception is with cameras monitoring high crime areas. In these instances, men are targeted more often than women, on the assumption that men are more likely to commit crimes than women. The higher percentage of men arrested or incarcerated in prisons is sometimes used as a justification, but it is not a good one, as it becomes a self-fulfilling prophecy. Discrimination at the basic level of observation for which the cameras are intended should be discouraged.

Due to these various problems, there have been calls for laws analogous to the Electronic Communications Privacy Act to protect citizens from video surveillance.

With the exception of certain FCC emissions requirements, the designing, constructing, and selling of video surveillance devices such as pinhole cameras and tiny recording decks are loosely regulated. The onus is on the user to use this equipment lawfully. There are many legitimate personal, commercial, and educational uses of cameras and restricting them completely is not practical or desirable in a free society. Just as it is incumbent on the public not to use a hammer to bludgeon a next-door neighbor, it is incumbent on the public not to use a video camera to invade another person's privacy.

Examples of Privacy-Related Bills

In 1890, a Warren and Brandeis article in the Harvard Law Review referred to Cooley's definition of privacy as the "right to be left alone" and argued that this was "the most comprehensive of rights, and the right most valued by a free people." This established in a social and legal context a boundary between the desire to observe and the right to not be observed. (Discussion of the debate over privacy rights can be cross-referenced in the *Introduction Chapter* and the *Audio Surveillance Chapter*.)

The following sampling of privacy-related bills from the state of Maryland helps illustrate the types of concerns lawmakers have about intrusion into privacy from visual surveillance devices and also gives some insights as to how slow and reactive (rather than proactive) the judicial process can be compared to changes in technology.

House Bill 273 "Crimes - Visual Surveillance," Criminal Law - Substantive Crimes. Delegate Dembrow.

Broadening the application of provisions prohibiting the visual surveillance of a person in certain places; allowing certain damages to be awarded; and making it a felony to break and enter, enter under false pretenses, or trespass on any premises with the intent to place, adjust, or remove visual surveillance equipment without a court order.

Status: Mar. 1996 passed in the House; Mar. 1996 at hearing stage in the Senate. See House Bill 780.

House Bill 779 "Crimes - Visual Surveillance - Private Residences," Criminal Law - Substantive Crimes. Delegate Dembrow.

Prohibiting a person from placing or otherwise bringing, or procuring another to place or otherwise bring, a camera onto real property for purposes of conducting visual surveillance of persons inside a private residence on the property; providing that ownership is not a defense if the owner is not an adult resident or the resident's legal guardian; providing a defense for good faith reliance on a court order; providing penalties and exceptions; providing for a civil cause of action; defining terms; etc.

Status: Mar. 1997 passed in the House; see House Bill 170 for continuance.

House Bill 780 "Crimes - Visual Surveillance," Criminal Law - Substantive Crimes. Delegate Dembrow.

Prohibiting persons with prurient intent from conducting or procuring another to conduct visual surveillance within specified private places; providing penalties; providing for a civil cause of action; defining terms; providing specified exceptions; providing that the Act does not abrogate or limit specified other remedies; etc.

Status: Mar. 1997 passed in the House; Mar. 1997 Senate hearing. See House Bill 170.

House Bill 170 "Crimes - Use of Cameras and Visual Surveillance," Criminal Law - Substantive Crimes. Delegate Dembrow.

Prohibiting a person from placing or procuring another to place a camera on real property to conduct deliberate surreptitious observation of persons inside a private residence; prohibiting the conducting of visual surveillance with prurient intent in dressing rooms, bedrooms, and rest rooms in specified places; providing that ownership is not a defense; providing a defense; providing penalties; providing for a civil cause of action; etc.

Status: Feb. 1998 passed in the House; Apr. 1998 Senate hearing. See House Bill 95.

House Bill 95 "Crimes - Use of Cameras and Visual Surveillance," Criminal Law - Substantive Crimes. Delegate Dembrow.

Prohibiting a person from placing or procuring another to place a camera on real property to conduct deliberate surreptitious observation of persons inside a private residence; prohibiting the conducting of visual surveillance with prurient intent in specified private places; providing that ownership of the private residence is not a defense; providing that a good faith reliance on a court order is a complete defense; providing penalties; providing for a civil cause of action; etc.

Status: Feb. 1999 passed in the House; Apr. 1999, passed in the Senate. May 1999, vetoed by the Governor as duplicative (see Senate Bill 689).

Senate Bill 689 "Crimes - Use of Cameras and Visual Surveillance," Criminal Law - Substantive Crimes. Senator Forehand.

Prohibiting a person from placing or procuring another to place a camera on real property to conduct deliberate surreptitious observation of persons inside a private residence; prohibiting the conducting of visual surveillance with prurient intent in dressing rooms, bedrooms, and rest rooms in specified places; providing that ownership is not a defense; providing a defense; providing penalties; providing for a civil cause of action; etc.

Status: April 1999 passed in the Senate; May 1999 signed by the Governor.

(See the Audio Surveillance and Aerial Surveillance chapters for other privacy and surveillance regulations. The introductory chapter also has general information on privacy regulations.)

9. Implications of Use

9.a. Social Implications

As mentioned in the introduction to this chapter, the prospect of a world based on Big Brother surveillance was depicted George Orwell's famous novel "1984," released in the aftermath of World War II. Orwell's classic is still required reading in many educational programs. However, it lost part of its clairvoyant mystique when 1984 came and went without the dystopian scenario coming to pass; people who valued personal freedoms and feared excessive government monitoring sighed with relief. Many concluded that Orwell was overly pessimistic.

Given the proliferation of technology since 1984, it is time to reassess. Orwell's primary theme was audio/visual surveillance of people's personal and business activities through systems that were installed with tax dollars by an overly controlling government. Surveillance technologies didn't become highly prevalent until 1994, but now they are increasing rapidly, not just in government applications, but in businesses and homes. We now spy on children, nannies, housekeepers, and employees on a regular basis. Satellite and aircraft surveillance of the entire planet is routine; government and community monitoring of criminals has increased.

Surveillance is no longer limited to audio/visual technologies. Vehicle traffic is monitored with radar; military personnel and criminals are subject to mandatory DNA testing. Violent offender lists are circulated through communities when convicts are released. Video cameras automatically match faces to individuals listed in databases in shopping malls. It could be argued that in some ways we are already surveilling people more closely than even Orwell anticipated.

So why did the Orwellian scenario frighten and enrage citizens twenty years ago, while only a small percentage of protesters now oppose these activities? What happened to the justified concern about the reduction of our privacy and liberty? There are several reasons why surveillance is becoming prevalent:

1. *When people are frightened, they more willingly give up their liberties.* Most people would oppose surveillance cameras in public washrooms, for obvious reasons, but if a series of assaults or child kidnappings were to occur in washrooms in airports or shopping malls, and cameras were installed to safeguard the safety of citizens, most people would grudgingly or even willingly accept the technology rather than risk disfigurement, murder, or potential harm to their children.
2. *When private citizens have access to the same technologies as governments and corporations, they appear to be less threatened by the technologies.* People have a tendency to accept the familiar, even if it is potentially harmful. Because video cameras are in the hands of many private citizens, they may not immediately recognize the long-term consequences of surveillance. Surveillance by Little Brothers may be a bigger threat than surveillance by Big Brother but may not be perceived as readily as being a threat.

The benevolence of 'equality of technology' is assumed rather than proven. In other words, private citizens may have access to GPS receivers and thus not feel threatened when governments are using them, too, but they may overlook the fact that larger social organizations sometimes have wider legislative leeway than private citizens (e.g., higher resolution transmissions). As an example, citizens may have infrared cameras for ground-level photography, but the government usually has cameras with greater capabilities, such as aerial-mounted infrared cameras or regular video cameras on every street corner. This initial impetus for having street cameras might be to report traffic congestion or icy road conditions, information-gathering intended to benefit all, but the records might later be analyzed for other purposes, such as determining whether a car-jacking took place at the corner or whether a particular person passes by the corner at the same time every day.

With better technologies and higher-resolution cameras, there might come a time when a competent lip-reader could look at the images and interpret a private business conversation. If a lip reader can do that, then a computer program could potentially be designed to do the same thing. Currently there are few legal impediments to commandeering information gathered for one purpose to serve another. This is not to say that governments are the primary abusers of power and technology. The incidents of entrepreneurial voyeur sites that publish intimate images of people without their consent indicate that immoral and unscrupulous individuals who are regulated less than law enforcement officials are potential abusers of technology. The incidence of employee surveillance in corporations, without a balancing ability on the employees to surveil their bosses, is another area in which there is considerable potential for abuse.

3. *When change occurs gradually, a threat is not always recognized.* High school teachers often tell the parable about dropping a frog on a hot frying pan. When it hits the pan, the frog will jump out and try to get away, whereas if you put it in a pot of cool water and raise the temperature very gradually, it will overlook the danger and eventually boil to death. There are certainly precedents in human history that support the hypothesis that changes that occur slowly are less likely to provoke public protest. Visual surveillance, like the slowly rising temperature of the water, has insinuated itself into our society gradually. First there were hidden cameras in banks and department stores where shoplifting was prevalent. Now there are cameras in banks, many retail stores, homes, businesses, industrial complexes, private clubs, ATM machines, schools, and amusement parks. Many people have videocams in their homes and offices that broadcast directly to the Internet. There are even people who have cameras in every room in the house.

9.b. Balancing Privacy, News Coverage, and Safety

To give an idea of how far some employers will go in visually monitoring their employees, some employers have sent detectives to videotape employees taking sick leave to see if they are actually sick. Many have put video cameras in private areas in their businesses where employees go on their breaks. It has been argued that employees have a right to privacy during break times and also that the employees' work can suffer if they are constantly being monitored and don't feel that they are trusted. Currently, it is legal in all but a few states for employers to place hidden cameras in locker rooms and even bathrooms.

There are some aspects of law enforcement in which video cameras do provide benefits. It has been found that response times to crimes increase in regions where patrol rates are low and where video cameras supplement patrols. It has been found that the rate of confessions increases when suspects see that their actions have been caught on tape. It has also been found that convictions and prosecutions that are supported with video evidence generally go more quickly and smoothly. However, not every type of law enforcement video surveillance system has such clearcut benefits. Some systems have been opposed and others have been removed after it was found that they were not as effective as was initially hoped or were too expensive to maintain. Here are some examples that help illustrate the complexity of the issues:

- After twenty-two months of monitoring surveillance cameras in Times Square, it was found that the systems resulted in only 10 arrests. The cameras were later removed.
- A CCTV-based surveillance system was proposed by a Police Department in 1996. This was a high-resolution, swivel-mounted, zoom system that could capture movement and details at a distance of up to about a mile. After some debate about privacy issues and efficacy in reducing crime, the Police withdrew the recommendation for the camera systems to be installed.
- The city of Seattle established a privacy policy because of law enforcement surveillance in the 1960s and 1970s. This ordinance prohibits targeted surveillance of individuals or groups solely because of their political views. Those shooting footage of protesters were asked to destroy their tapes and those investigating the incidents were appalled that the videographers had not identified themselves while shooting the footage.
- A New York Civil Liberties Union volunteer canvas of surveillance cameras focused on public areas in December 1998 located 2,380 apparent cameras in the New York area, and it is expected that there are many more hidden cameras. Most of the systems are privately operated, secured to rooftops, building entrances, and lamp posts. Some are swiveling globe-covered cameras. Recommendations derived from this informal tally include the registration of cameras that are aimed at public places and limiting the duration of taping that may be stored. The NYCLU has published a map on the Web that shows the location of the identified surveillance cameras.
- In spring 1999, southern California officials were seeking to install street-based surveillance cameras aimed primarily at sidewalks and parking lots. It was intended that signs be posted to let people know they are being monitored. Cameras would be monitored by law enforcement agencies. After a trial period, if the program was successful, the goal was to expand the installation of the cameras. This was after a similar plan was rejected two years earlier.
- On Sullivan's Island in Charleston, an infrared camera points offshore to monitor boats that may be lingering for too long near the wreck of the Confederate submarine Hunley. Suspect boats are visited by the Coast Guard.

James Ditton, of the Scottish Centre for Criminology, who monitored cameras in Glasgow for four years, has cast doubts on the benefits of video surveillance. He reported that crime had indeed fallen in the surveilled area, but that the data had to be considered in conjunction with data from the non-surveilled areas, where crime fell even more. This raises not only questions about the cost-effectiveness of the video surveillance programs but also about how the effectiveness of new camera systems is assessed. If surrounding areas that don't have the cameras are not included in the research statistics, there is reason to doubt the validity of any reports of increase or decrease in crime.

In some cases, judges have been offering the opinion that public spaces such as parks afford no expectation of privacy, yet people have often used publicly accessible spaces for precisely that, as places to have private business or personal conversations, for lovers to spend personal time together, and for grieving people to find time to be alone.

News Surveillance

Over the last several decades, news photographers have become very aggressive in shooting video footage of private moments. The news media have a great deal of leeway in reporting the news and in exercising its rights of freedom of speech. However, some news photographers have stepped over the line by climbing over private fences and aiming lenses in the bathroom windows and backyards of celebrities and sometimes photographing their children and friends. Some of them live in their cars, following celebrities 24 hours a day, waiting outside doorways, hotels, and recreational establishments to catch images of the people they are 'staking out.'

> "The American rule is that photographers may shoot whatever they can see while standing in a place to which they have the right of access. Nonetheless, courts have put limits on photographers who, at least in the courts' eyes, behaved badly in pursuit of individuals. This has happened with or without a finding that the behavior of the news people could have been enough to break a specific law, and even when the photographer stood in a public place."
>
> [Alice Neff Lucan, "Existing Limitations on News Photographers in Pursuit of Individuals," 1998.]

Recently, news crews have come under criticism from the public for accompanying police departments on their patrols. These news crews will sometimes wear police caps and vests making it appear to the public that they are directly associated with the police and have the same authority. This causes a great deal of confusion for individuals dealing with the police. The rules for interacting with the police are not the same as those for news crews. If a police officer stops you while driving and tells you to roll down your window and step out of a car, you are legally obliged to comply. If a news agent tries to stop you while driving or order you out of your vehicle, you have no obligation whatsoever to comply. Similarly, if a news agent steps into a house with a video camera and begins taping while police officers are issuing a search warrant, the average citizen has no idea whatsoever what his or her rights are with video technicians and, in such a stressful situation, can't distinguish between a news crew member or a police officer if they are all wearing clothing labelled 'Police.'

This is not a hypothetical problem. This situation has already occurred in several regions in which news crews have been accompanying police on their patrols and searches. Given that the person is considered innocent before being found guilty, there are also questions as to whether the news crews have the right to air privileged footage that is only available through the execution of the police search warrant without actual proof of guilt. It could be argued that this contributes to defamation of character. The police have generally supported these news tapings to help the police educate the community about their activities and there are possible positive benefits from increased public awareness of police activities, but three things need to change. News crews should be clearly distinguishable from the police. Video footage should not be shown until after a person has been found guilty or innocent of an offense and if the person is innocent, it shouldn't be shown at all without informed consent, as it could contribute to defamation of character and other negative consequences.

In other instances, the presence of news crews in hostile conflicts overseas or domestic violence or hostage situations, armed forces personnel and police have expressed concerns that live news coverage cannot only endanger the lives of agents trying to handle volatile situations, but may actually affect the outcome of a situation. Unstable individuals can be provoked by the presence of cameras or, in some cases, may grandstand for the camera, carrying out acts of violence for publicity purposes that they may not otherwise have attempted. These factors need to be taken into consideration by news media personnel when covering sensitive stories and events.

In some cities, the news media have entered into voluntary agreements with police departments to restrict live coverage of terrorist and hostage situations and incidences in which unbalanced or distraught individuals are threatening violence or suicide.

9.c. Prejudice and Monitoring

We like to think that surveillance systems provide objective records of human behavior, but it has been found that the placement and use of surveillance cameras sometimes magnify the prejudices of those installing or operating the systems, or those selecting or evaluating the records. Several research studies have shown that people of color, young people, and males were disproportionately targeted as suspects of shoplifting or other criminal behaviors, and that a high proportion of white male camera operators have been surveilling females for voyeuristic rather than security reasons. Homeless people were also disproportionately targeted, as were people who challenged the right of the camera operators to monitor them.

The aim of one study by Norris and Armstrong was to evaluate who was being watched by public CCTV surveillance systems. The researchers studied operators of 148 cameras in three major areas. They reported in their results that 40% of people were targeted for no obvious reason related to criminal behavior and were apparently selected for belonging to a subculture (black, male, or homeless). Those wearing uniforms appeared to be exempt from targeting. In the conclusion, the authors reported that

> "The gaze of the cameras does not fall equally on all users of the street but on those who are stereotypical [sic] defined as potentially deviant ... singled out by operators as unrespectable. In this way youth, particularly those already socially and economically marginal, may be subject to even greater levels of authoritative intervention and official stigmatisation, and rather than contributing to social justice through the reduction of victimisation, CCTV will merely become a tool of injustice through the amplification of differential and discriminatory policing."

9.d. Privacy and Identity Protection

Commercial businesses have always been interested in identifying shoplifters, but now they are also collecting data on regular customers, previous clients who haven't paid their bills, and other commercially significant individuals. We are already seeing examples of this type of *identity profiling* on the Internet, with companies using Web browser 'cookies' to see who is logging onto their systems and making purchases. Currently these cookies are used to streamline shopping, especially shopping with credit cards, so the customer doesn't have to fill out a form every time he or she wants to buy something online. However, it's only a matter of time before everyone using a computer has a small videocam attached to the computer that provides videoconferencing capabilities to the online database and the seller could potentially collect demographics on the unwary shopper from the camera images, including gender, approximate age, ethnic group, etc. and match them with purchase preferences and income levels. All it would take to make this a reality would be to build the videoconferencing capabilities into the Web browsing software. Some proprietary Web browsers already do this.

A great deal of unregulated targetable information would then be in the hands of retailers. Since a majority of trusting consumers have historically been vulnerable to marketing hype, propaganda, and commercial coercion this brings up questions about how they can be protected and educated about identity profiling and lifestyle surveillance on the part of retailers who may be gathering personal information without their knowledge or consent.

There are also indications that the databases from many different agencies are being linked together through the Internet to share data, for a fee. This is similar to junk mail lists. If you buy a magazine from a mail order vendor, that vendor often makes more money selling your name and address to other vendors than from selling you the magazine. Currently, there is not an effective process for having yourself removed from these mailing lists (in spite of efforts to set up exclusion lists). There isn't even an effective way to correct errors. Vendors are supposed to offer the consumer the option of privacy but they often require the consumer to take extra steps, like writing a letter or filling in a little box buried in the fine print. In most cases, without the consumer's explicit written request to be kept off mailing lists, vendors are free to sell their names to other agencies. These same principles can apply to images and information acquired off the Internet when the person makes a purchase online. If videocams are integrated into Web browsers, these detailed databases may include a picture of the face of the computer user and even the titles on the books on the shelf behind him or her.

It may seem obvious that all you have to do is turn off the videocam while visiting sites that potentially want to market your private information to others, but marketing reps have many ways to convince people to give up their freedoms. Supermarkets currently run deep discount specials on desirable shopping items to 'members only' to get people to sign up for electronic member cards that store their shopping preferences in a database. Another very effective method of acquiring information is to run high-stakes contests and sweepstakes. By offering million-dollar prize opportunities to consumers who put their names and faces in a visual database, most people can be convinced to give up their identities. Since these marketing strategies are already being used to assess shopping habits in supermarkets and to collect names and addresses of Internet users, it's likely it will eventually be used to collect visual data when the technology is put in place.

9.e. Evidence Issues

From a surveillance point of view the distinction between analog and digital data is sometimes important. Analog technologies are more difficult to 'forge;' that is, it is harder to insert or delete images on an analog video tape (or a film photo) without evidence of tampering. Thus, some analog technologies may serve as stronger evidence in court. The disadvantage to analog technologies is that it may be difficult to get good still images for closer analysis. If you have paused the tape on a VCR, you have probably noticed the degradation in signal quality and the relative coarseness of the image that occurs when viewing still frames. Surveillance tapes of convenience store robberies are an excellent example. They may show the general features of the robber, but not details like the color of the eyes, the brand of watch, small moles, or other identifying features.

Digital technologies, on the other hand, may provide better still frames, but the images are easy to alter with computer software. The potential for tampering or forgery is very high. Thus, a digital photograph may not serve as strong evidence in court and may not even be admissible in some circumstances. If the imagery is being used in law enforcement and crime investigation, it is important to consider the end-goal of the images before choosing a recording device.

Keep in mind, however, that even traditional photos can now be digitally altered. The traditional photo can be scanned with a very high-resolution digital scanner, altered with an image-processing program and printed to a high-resolution dye-sublimation-style device that creates images that resemble photos. At one time a photo was considered a 'true' record of events, and photos are widely used in the justice system, but there are now serious difficulties with authenticating any type of photographic evidence.

For genealogists and historians, the 1990s represents a significant milestone in the sense that families and events as represented by photos are now altered on a regular basis. There are commercial image processors who will charge a fee to change your business photos and family photos in any way you like. There are examples of divorced couples having all their family photos of their life together altered to remove their ex-spouses. In other words, instead of pictures of both parents with the house and children, only one parent is seen in the picture, as though the other never existed. This revisionism will make it impossible for future generations to look at past visual records and know what is 'true' and what is not. It also makes it easier for clandestine activities to be covered up and for fraudulent 'news' agencies to make up the news. The truth may be out there, but it may no longer be possible to distinguish the fact from fiction in visual images.

10. Resources

10.a. Organizations

Inclusion of the following companies does not constitute nor imply an endorsement of their products and services and, conversely, does not imply their endorsement of the contents of this text.

American Society for Industrial Security (ASIS) - The world's largest and oldest association for security professionals with more than 30,000 members worldwide. Members are mainly involved with internal commercial security and make wide use of access-control systems and security cameras. An annual conference is sponsored in the fall. http://www.asisonline.org/

Analog VLSI and Robotics Laboratory - Part of the Indiana University's Department of Computer Science, there are projects on robotics, analog VLSI, and emerging computation. The Stiquito project is an interesting effort to build a colony of tiny robots in order to study cooperative behavior of autonomous agents. http://www.cs.indiana.edu/robotics/avlsi.robotics.html

CECOM - A U.S. Department of Defense mailing-list clearinghouse which automatically distributes IRIS conference proceedings to qualified subscibers. Subject to clearance by the Security Manager for the IRIA.

Consumer Project on Privacy - Organized by Ralph Nader in 1995 to focus on telecommunications regulations and pricing, fair use issues, and the impact of technology on privacy.
http://www.cptech.org/privacy/

Laboratory for Integrated Advanced Robotics (LIRA). Located at the University of Genoa, Italy, this lab focuses on artificial vision and sensory-motor coordination from a computational neuroscience perspective. http://www.lira.dist.unige.it/Introduction/intro.html

Neuromorphic Vision and Robotics - At the Higgins Lab at the University of Arizona, this research lab focuses on neuromorphic engineering, with a focus on vision and robotic systems.
http://neuromorph.ece.arizona.edu/

Office of the Information & Privacy Commissioner for British Columbia - The Commissioner exercises duties and authorities under the Canadian Freedom of Information and Protection of Privacy Act. The Web site includes news releases and information on publications, investigations, court decisions, and legislation.

Privacy Commissioner of Canada - Information on the role of the Privacy Commission, the Privacy Act (put into effect in 1983), and various reports associated with the office. http://www.privcom.gc.ca/

Privacy Commissioner for New Zealand - This site includes information regarding the office of the Privacy Commissioner, the Privacy Act 1993, and Privacy Act Reviews with summaries and charts.
http://privacy.org.nz/top.html

Privacy International - A London-based civil rights group. Hosts an annual "Big Brother" ceremony (since fall 1998) in which awards are given to organizations judged to have contributed to the destruction of personal privacy and those who have contributed to the protection of privacy in Britain. Judging is carried out by selected academic, media, and legal professionals.
http://www.privacyinternational.org/

Robotics and Intelligent Machines Coordinating Committee (RIMCC) - Since 1993, RIMCC has been dedicated to helping accelerate the advancement of key robotics technologies and providing a link between government- and university-based research and the community of users at-large.

Robotics Manufacturing Science and Engineering Laboratory - Located at Sandia National Laboratories where there are many research projects devoted to robotics applications.
http://www.sandia.gov/

The Surveillance Camera Players - This group of actors/activists stages live plays/protests in front of surveillance cameras, accompanied by an attorney to protect their civil rights. The actions of the players have resulted in a number of arrests in spring 1999, some of which were said to be unconstitutional.

Visual Computing Lab - The University of California, San Diego, Visual Computing Lab has research projects on video surveillance and monitoring (VSAM). Projects include Multiple-Perspective Interactive Video (MPI-Video) technology-development. http://vision.ucsd.edu/Vsam/

10.b. Print

Biberman, Lucien M.; Nudelman, Sol, Ed., "Photoelectronic Imaging Devices," two volumes, New York: Plenum Press, 1971.

Brin, David, "The Transparent Society: Will Technology Force Us to Choose Between Privacy and Freedom?" New York: Addison-Wesley, 1998. This noted nonfiction and science fiction author discusses the electronic age and its impact on society.

Brugioni, Dino A., "Photo Fakery: The History and Techniques of Photographic Deception and Manipulation," London: Brassey's, Inc., 1999, 256 pages. The author is a former CIA photo interpreter and founding member of the National Photographic Interpretation Center who describes how deception is accomplished and how to spot it. Includes examples.

Cohen, S., "Visions of Social Control," Cambridge: Polity Press, 1985.

Davies, Simon, "Big Brother: Britain's Web of Surveillance and the New Technological Order," London: Pan Books, 1996.

Edwards, Charleen K., "A Survey of Glassmaking - From Ancient Egypt to the Present," Chicago: The University of Chicago Press, 1974.

Geraghty, Tony, "The Irish War: A Military History of a Domestic Conflict," London: Harper Collins, 1998, 404 pages. The Irish-born British journalist describes how surveillance technologies that were developed for monitoring the IRA in Northern Ireland are being adapted for surveillance of the general population. British subjects do not have the same constitutional protections as Americans. Geraghty is also the author of "Brixmis," an account of western intelligence missions inside the Iron Curtain. It was reported in May 1999 that Gerahty had been charged with offenses under the British Official Secrets Act.

Jensen, Niels, "Optical and Photographic Reconnaissance Systems," New York: John Wiley and Sons, Inc., 1968, 211 pages. From the Wiley Series on Photographic Science and Technology and the Graphic Arts. The author was affiliated with the Reconnaissance & Intelligence Laboratory at Litton Data Systems Division and associated with Hughes Aircraft on a project to photograph the moon. The volume covers fundamentals of reconnaissance imaging systems and atmospheric optics including some of the basic math.

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Land, Barbara, “The Telescope Makers: From Galileo to the Space Age,” New York: Thomas Y. Crowell Company, 1968.

Lyon, D., “The Electronic Eye,” Cambridge: Polity Press, 1994.

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Pritchard, Michael; St. Denny, Douglas, “Spy Camera: A Century of Detective and Subminiature Cameras,” London: Classic Collections, 1993. Documents several hundred subminiature and ‘spy’ cameras sold at Christie’s London Auction in 1991 from the collection of David Lawrence.

Ross, Douglas A., “Optoelectronic Devices and Optical Imaging Techniques,” London: Queen Mary College, 1979.

Rothfedder, Jeffrey, “Privacy For Sale: How Computerization Has Made Everyone's Private Life An Open Secret,” New York: Simon and Schuster, 1992.

Rule, J., “Private Lives, Public Surveillance,” London: Allen-Lane, 1973.

U.S. Department of Energy, “Robotics and Intelligent Machines Critical Technology Roadmap,” Washington, D.C., October 1998. Describes the future robotics technology needs of the DoE and provides a structure for meeting those needs. This came about as a result of the 1997 Congressional Exposition on Robotics and Intelligent machines, sponsored by the DoE, RIMCC, and Sandia National Laboratories.

White, William, “The Microdot: History and Application,” Williamstown, N.J.: Phillips Publications, 1992. Documents techniques of reducing text and images using photographic and electrographic techniques. Includes magnified examples of microdots and related items.

Articles

Baker, Oliver, “The Importance of Being Electric,” *Science News*, 2000, V.157(3), pp. 45-47.

Boal, Mark, “Spycam City: The Surveillance Society,” *The Village Voice* online newspaper. http://www.villagevoice.com/

Davidson, Michael W.; Abramowitz, Mortimer, “Museum of Microscopy,” sponsored on the Web by Olympus America and Florida State University, 1999.

Davies, Simon, “Privacy in the Workplace Survey Report,” *Society for Human Resources Management, 1991 SHRM*, Virginia, 1992, p. 192.

Dixon, Tim, “Invisible Eyes: Report on Video Surveillance in the Workplace,” *Committee of New South Wales paper no. 67*, August 1995.

Etienne-Cummings, Ralph, “A Visual Smooth Pursuit Tracking Chip,” *Advances in Neural Information Processing Systems,* 1996, V.8, pp. 706-712.

Etienne-Cummings, Ralph, “Intelligent Visual Sensors: Will Robotics Benefit?” *Proceedings Workshop on Biomorphic Robots,* IROS98, Victoria, B.C., 1998.

Everett, H. R. “Breaking Down the Barriers,” *Unmanned Vehicles,* V.3(1), 1998, pp. 18-20. A brief history of robotic security developments.

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Honess T.; Charman, E., "Closed Circuit Television in Public Places," *Crime Prevention Unit paper no. 35*, London HMSO, excerpt from Privacy International, CCTV FAQ.

Kelly, Sean; Blankenhorn, Dana, "Capturing the night; New technology aids war coverage," *Electronic Media,* 4 Mar. 1991, p. 14.

Kirven, Tristan H., "Beyond the Negative: A Criticism of Police Pictures: The Photograph As Evidence," *Journal of Criminal Justice and Popular Culture,* V.6(1), 1998, pages 10-14. An editorial art criticism of S.S. Phillips' historical survey of forensic photography shown July 1998 at the Grey Art Gallery at New York University.

Krupp, E.P., "Echoes of the Ancient Skies: The Astronomy of Lost Civilizations," Meadow, Roy, "Men capable of Munchausen syndrome by proxy abuse," *Archives of Disease in Childhood*, March 1998.

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Norris, Clive; Armstrong, Gary, "The Unforgiving Eye: CCTV Surveillance in Public Space," Hull: Centre for Criminology and Criminal Justice, Hull University study.

Rochelle, Carl, "Public cameras draw ire of privacy experts," *CNN Interactive U.S. News*, March 1996.

Security Industry Association and International Association of Chiefs of Police "Information Brief for Guildine On Closed Circuit Television (CCTV) for Public Safety and Community Policing," 31 October 1999. Describes intentions to integrate the best practices of public and private policing using state-of-the-art technologies. http://www.siaonline.org/cctvinfobrief.html

Waters, Nigel, "Street Surveillance and Privacy," *Privacy Issues Forum,* New Zealand, 1996, p. 3.

Whalen, John, "You're Not Paranoid: They Really Are Watching You," *Wired,* March 1995. The author crashes a security conference and discusses his impression of the business security industry and employee monitoring.

Journals

"Computer Vision and Image Understanding," Academic Press publication covering computer analysis of pictorial information.

"Imaging and Vision Computing," Elsevier publication on theory and applied research in image processing and computational vision.

"Imaging Science and Technology," a publication of the Society for Imaging Science and Technology covering a broad range of research and applications.

"The International Journal of Computer Vision."

"Journal of Electronic Imaging," a publication of the Society for Imaging Science and Technology covering design, engineering, and applications.

"Machine Graphics & Vision," a juried international journal published quarterly by the Polish Academy of Sciences.

"Privacy Times," a Washington newsletter published by Evan Hendricks.

"Security Newsbriefs," Executive briefing from a survey of over 1000 publications for corporate, industrial and professional security managers. Each day's issue includes about a dozen summaries on

topics that include shoplifting, employee theft, computer crime, industrial espionage, CCTV, alarms, and lighting. Available to ASISNET subscribers. http://www.asisonline.org/aboutnews.html

10.c. Conferences and Workshops

Many of these conferences are annual events that are held at approximately the same time each year, so even if the conference listings are outdated, they can still help you determine the frequency and sometimes the time of year of upcoming events. It is very common for international conferences to be held in a different city each year, so contact the organizers for current locations.

Many of these organizations describe the upcoming conferences on the Web and may also archive conference proceedings for purchase or free download.

The following conferences are organized according to the calendar month in which they are usually held.

"ACCV2002," 5th Asian conference on computer vision, Melbourne, Australia, Jan. 2002.

"IEEE Workshop on Visual Surveillance" A one-day workshop held in conjunction with ICCV'98 in Bombay, India, Jan. 1998.

"AVBPA'99 Audo- and Video-based Biometric Person Authentication," Second international conference, Washington, D.C., March 1999. Techniques for the representation and recognition of humans.

"ABA TechShow 2000" sponsored by the American Bar Association, Chicago, Il., 30-31 Mar. 2000. Topics included technology planning and high tech trials.

"Audio and Video Evidence: Tuning the Tapes to the Defense Frequency," National Defender Investigator Association's National Conference, New Orleans, La., 24 March 1999.

"Effect and Impact of the Courtroom of the Future," Claude W. Pettit School of Law - Law Review Symposium, Ada, Oh., 9 April 1999.

"Scientific and Demonstrative Evidence: Is Seeing Believing?" National conference on science and law, San Diego, Ca., 15-16 April 1999.

"Automatic Face & Gesture Recognition, 1998," Third International Conference, Nara, Japan, spring 1998. Conference proceedings for this and previous conferences are available through IEEE.

"PETS2000," 1st IEEE international workshop on performance evaluation of tracking and surveillance, Grenoble, France, 31 Mar. 2000.

"ISR 2000," International Symposium on Robotics, Montreal, Canada, 14-17 May 2000.

"International Robots & Vision Show," Chicago, Il., 5-7 June 2001. A biennial conference with practical solutions for improving product quality and increasing production.

"Second IEEE International Workshop on Visual Surveillance" Held in conjunction with CVPR'99, Fort Collins, Colorado, June 1999. Theoretical and practical aspects of visual surveillance, including tracking, scene interpretation, object detection, recognition, and other topics.

"ASIS International 2000" Orange County Convention Center, Orlando, Florida, 11-14 Sept. 2000 (the 2001 conference will be held in Texas). Industrial security issues and products.
http://www.asisonline.org/seminar/seminar.html

"Advanced Surveillance Technologies" An international conference sponsored by Privacy International, Electronic Privacy Information Center, Copenhagen, Denmark, Sept. 1995. An overview of the program is available at Privacy International's Web site.
http://www.privacy.org/pi/conference/copenhagen/final.txt

"Video Surveillance and Monitoring Demo II and Workshop," Carnegie Mellon University, Pittsburgh, Oct. 1998. The VSAM project is developing automated video processing technologies for use in urban and battlefield surveillance applications for situations in which human observation is too dangerous or costly. Examples include security for restricted areas, buildings, airports, and their environs. VSAM is sponsored by the Defense Advanced Research Projects Agency, Information Systems Office (DARPA ISO) as part of the *Image Understanding for Battlefield Awareness* program.

"International Conference on Information, Intelligence, and Systems (ICIIS'99)," Washington, D.C., Nov. 1999. Combined technical conference for interaction between scientists and practitioners from diverse fields dealing with complex problems in neuroscience, biology, robotics, image, speech and natural languages, and their integration.

10.d. Online Sites

The following are interesting Web sites relevant to this chapter. The author has tried to limit the listings to links that are stable and likely to remain so for a while. However, since Web sites sometimes change, keywords in the descriptions below can help you relocate them with a search engine. Sites are moved more often than deleted.

Another suggestion, if the site has disappeared, is to go to the upper level of the domain name. Sometimes the site manager has changed the name of the file of interest. For example, if you cannot locate http://www.goodsite.com/science/uv.html *try going to* http://www.goodsite.com/science/ *or* http://www.goodsite.com/ *to see if there is a new link to the page. It could be that the filename* uv.html *was changed to* ultraviolet.html*, for example.*

A Complete History of the U.S.S. Dyess. This is an anecdotal history of an American destroyer which conducted a variety of types of visual, audio, and radar surveillance. The historical journal is provided by Chief Petty Officer Ralph J. Brown, Sr. who served on the vessel from 1955 to 1960. http://www.extremezone.com/~pomeroy/dyess/history.html

American Civil Liberties Union (ACLU). A prominent civil liberties organization which provides nonpartisan, nonprofit education and advocacy on behalf of over 1/4 million members. Its primary goal is assuring that the American Bill of Rights is upheld and continued for future generations. There is quite a bit of searchable information on this site related to video surveillance and political issues associated with the use of the technology. http://www.aclu.org/

An Appraisal of the Technologies of Political Control: An Omega Foundation Summary & Options Report For the European Parliament. A summarized document (approx. 20 pages) of an Interim Report that discusses recent developments in surveillance technology, tracking systems, face recognition, vehicle recognition, data matching, and the proliferation of this technology in light of its practical applications and potential for use and abuse within our political structures.
http://edd.www.cistron.nl/stoa2.htm

AsherMeadow Organization. This site includes resources for the Munchausen Syndrome by Proxy community including case studies which describe the use of video surveillance in hospital rooms to detect child abuse related to this syndrome. http://www.bcpl.net/~agravels/truestories.htm

AVS-PV Advanced Video Surveillance - Prevention of Vandalism in the Metro. This Italian site illustrates vandalism in public transit in Europe, with a number of metro stations as trial sites. The focus of the project is on the economics and prevention of vandalism (graffiti, crassity, defacement, etc.) through digital processing of visual images and preventive actions undertaken by surveillance operators in the metro. Numerous photos and diagrams are included.
http://dibe.unige.it/department/imm/avspv3.html

Building to Reduce Crime: Guidelines for Crime Prevention Through Environmental Design. This site includes many drawings and photographs demonstrating how environmental planning impacts human behavior and how visual surveillance for safety can be achieved through the design of buildings and related structures. Mixed-use neighborhoods, open areas, lighting, street-facing porches, clear sightlines, and other strategies are described and illustrated. References and information about other crime-prevention initiatives are included. Prepared by Melanie D. Tennant for the Development Services Department, City of North Vancouver.
http://trinity.cnv.org/CrimePreventionThroughEnvironmentalDesign.htm

CCTV Archives. A site that asks the question of whether the more than one million CCTV cameras installed throughout Britain affect our daily lives. Video clips are displayed, archived, highlighted, and sold on this site. One of the selections is Police Stop! a video archive of the tapes that are collected from video cameras mounted in police vehicles. Another is Really Caught in the Act which shows crime in many retail establishments and workplaces. There are also monthly featured clips. A site that is interesting from an educational point of view, but also has a voyeuristic draw and the unsettling reality that people's activities are being disseminated worldwide.
http://www.cctvarchive.com/

History of the 225th Surveillance Airplane Company. Prepared by Major Gary L. Petesch, Unit Historical Office, site maintained by Howard Ohlson. This site describes activities for the year 1968 during which ground-sensing data, traditional photographs, side-looking radar (SLAR) images, and visual surveillance were gathered for a Vietnam combat surveillance and target acquisition capabilities assessment mission. http://ov-1.com/225th_AVN/225th-history68.html

Human Rights Watch. This New York City-based organization has an extensive selection of online reports on many rights topics, including landmine monitoring, armed conflicts, the disabled, child labor and abuse against women, including a number of reports on visual surveillance, for example, allegations of excessive and unwarranted observation and videotaping of women in various states of undress in the prison system. http://www.igc.apc.org/hrw/

In Plain and Open View: Geographic Information Systems and the Problem of Privacy. Michael R. Curry, Department of Geography, University of California, LA. This Web page describes the important issues of privacy related to the constant geographical mapping of our planet, which includes our cities and individual homes. Much of this geographic imagery is paid for by tax dollars and is available to anyone who can download it through a computer. The Web page lists a large number of surveillance/privacy-related documents. http://www.spatial.maine.edu/tempe/curry.html

Museum of Microscopy. This extensive scientific site provides excellent illustrations and descriptions of microscope design and history including photographs and rendered recreations of significant scopes. It is well-organized and managed by M. W. Davidson, M. Abramowitz, through Olympus America Inc., and the Florida State University, in collaboration with the National High Magnetic Field Laboratory. http://micro.magnet.fsu.edu/primer/

The NYC Surveillance Camera Project. This site was compiled by citizens concerned with the proliferation of surveillance cameras, most of them privately owned, which are aimed at public places. To date there is little legislation governing the use of these cameras or materials recorded. The site includes maps of camera locations, information about the project, online submission of information about cameras not currently listed, and general news about video surveillance.
http://www.mediaeater.com/cameras/index.html

Privacy International Statement on Closed Circuit Television (CCTV) Surveillance Devices. A statement which reflects the policies and concerns related to the erosion of privacy and the extraordinary growth of the electronic visual surveillance industry, with entreaties for legal safeguards.
http://www.nonline.com/procon/html/conCCTV.htm

Safe Schools Design Guidelines. This interesting site from the University of South Florida (USF) Center for Community Design and Research includes a series of pages showing Safe Schools Design Guidelines (1993) which provide rationales and planning suggestions for the physical shapes and orientations of buildings and play areas. Includes numerous diagrams and explanations of how facilities planning can enhance the ability of the staff and community to monitor the activities and safety of students to reduce vandalism, crime, and accidents. http://www.fccdr.usf.edu/projects.htm

United States Postal Inspection Service. This site describes the functions and departments of the U.S. Postal Inspection Service Crime Lab Forensic & Technical Services Division (FTS&D). The service manages a national forensic laboratory and four regional labs, plus five technical services field offices. http://www.usps.gov/postalinspectors/crimelab.htm

U.S. Navy ROBART Series. An interesting illustrated site showing a series of robots equipped with a variety of types of surveillance technologies, developed since the early 1980s. The pioneer systems could only detect potential intruders, while later systems can now detect and assess and, in some cases, respond to the intrusion with defensive or offensive actions. A variety of detection systems have been incorporated into these robots, including infrared, optics, ultrasonics, microwave, vibrational sonics, and video motion detectors. http://www.spawar.navy.mil/robots/land/robart/robart.html

Video Movement Tracking. The Gerhard-Mercator-University Duisburg in Germany has three animated GIF files that demonstrate computerized image recognition and motion tracking capabilities, e.g., a human enters a door in a hallway and his motion is tracked digitally, using a combination of Pseudo-2D Hidden Markov models and a Kalman filter, as he progresses along the hallway. References for the techniques are also included. http://www.fb9-ti.uni-duisburg.de/demos/tracking.html

Video surveillance by public bodies: a discussion. Investigation Report P98-012 submitted by David H. Flaherty, Information and Privacy Commissioner for British Columbia, March 1998. This investigative report was based on research and site visits to public bodies which engage in video surveillance. It discusses the installation and pervasiveness of various types of visual surveillance, associated costs/benefits, and assessment of adverse consequences for personal privacy. It further surveys the research on the prevalence of video surveillance and reports on the efficacy of the technology. This is a valuable document for anyone planning to install video surveillance, or researching the impact of video surveillance on the public who seeks to be aware of the various pros and cons. http://www.oipcbc.org/investigations/reports/invrpt12.html

Vision Chips, or Seeing Silicon. This site has LOTS of information on vision chips and smart sensors, along with links to conferences, research labs, etc. Visit the World of Vision Chips link to get an idea. http://www.eleceng.adelaide.edu.au/Groups/GAAS/Bugeye/visionchips/

Visual and Acoustic Surveillance and Monitoring (VSAM). A project at the Computer Vision Laboratory at the University of Maryland. This site includes several pages, some with illustrations, of the goals and progress of the project to research visual and infrared spectrum and acoustic computerized surveillance mechanisms for a variety of practical applications including military, law enforcement, traffic management, and urban security. Demonstrated systems include personal computer-based realtime tracking of people and their body parts (heads, feet, etc.).
http://www.umiacs.umd.edu/users/lsd/vsam.html

Watching Them, Watching Us - UK CCTV Surveillance Regulation Campaign. This site provides public information about political developments, funding, installation, and use of CCTV surveillance equipment. It engages in important debate about the efficacy of cameras, licensing issues, the integrity of evidence, the proliferation of Webcams, and more. http://www.spy.org.uk/

What Man Devised That He Might See. An attractively illustrated history of spectacles by Dr. Richard D. Drewry, which takes the viewer through various technological improvements over the centuries from ancient times to the present. http://www.eye.utmem.edu/history/glass.html

10.e. Media

Television Series

"Caught in the Act," TV series featuring video footage of various individuals caught in the workplace and other settings engaged in criminal, unethical, dangerous, or unsavory activities. Distributed by NTV Entertainment.

"Cheaters" television series featuring video footage of surveillance of suspected cheating couples.

"Cops" series in which videotaped patrol activities are televised. http://www.tvcops.com/

"To Serve and Protect" television series of videotaped patrol activities of the Vancouver Police Department.

Feature Films

"Sliver" Motion picture starring Sharon Stone, Paramount Pictures, 1993. Video cameras are featured in an urban apartment complex drama. Rated R.

"The Truman Show" Motion picture starring Jim Carrey, directed by Peter Weir, Paramount Pictures, June 1998. A small-town insurance salesman encounters video surveillance in a surprising way. The screenplay is by Andrew Niccol, author of the movie "Gattaca" which is listed in the DNA chapter.

Museums

"Museum of Opthalmology." A foundation of the American Academy of Ophthalmology in San Francisco. The extensive holdings of the museum include historical lenses with about 100 items on display at any one time. Located at 655 Beach Street, San Francisco.

Note: If you don't enjoy typing in long Web addresses (URLs), you can access the links on the support site set up by the author for your convenience. http://www.tvcops.com/

11. Glossary

Titles, product names, organizations, and specific military designations are capitalized; common generic and colloquial terms and phrases are not.

Cartesian surface	a reflecting or refracting surface that forms an image with 'perfect' fidelity to the original
CCD	charged-couple device, a system utilizing light-sensitive photo diode elements to register light intensities which are translated into digital signals. The resolution of a CCD device is determined in part by the type, placement, and quantity of CCD elements, which can be arranged in lines or grids. Many digital scanning and image devices are CCD-based.
CCTV	closed-circuit television
CCU	camera control unit
CEPTED	crime prevention through environmental design
CFR	computerized face recognition
displacement effect	an adjustment that occurs when surveillance of any area results in criminals moving their activities elsewhere in order not to be watched
FOV	field of view, usually described in degrees. Used to describe the angle of imaging on lenses and other imaging devices.
MTF	modulation transfer function
papparazzo	a freelance photographer who persistently watches and aggressively pursues celebrities for the purpose of capturing candid photographs for publication
photoelectric cell	a light-sensitive sensing device commonly used in security systems, automatic lighting systems, automatic doors, etc. A basic photoelectric cell can be created with a vacuum tube by coating one of the electrodes with cesium.
photovoltaic device	a type of specialized semiconductor for converting light into electrical energy. Photovoltaic slices can be combined into an array, also known as a *panel*, and used, for example, as solar collection panels. Photovoltaic panels are used for solar powering many types of solar devices, from watches, pocket lights, and security lights, to satellite transceivers.
Picturephone	one of the earliest teleconferencing systems, designed by the AT&T Bell Laboratories in the mid-twentieth century, but not introduced to the public until 1970. It was far ahead of its time. Videoconferencing didn't became a mass-market product until about 1998. Picturephone-type technologies are now used not only for remote conferencing, but for monitoring of remote video security systems.

PSTN	public switched telephone network. The national public telephone infrastructure which provides universal access as originally put forth in the 1934 Communications Act.
quartz	Silicon dioxide ($SiO2$), a mineral that ranges from transparent to white and may include colored impurities. It is common, a principle component in sand and sandstone, also found in granite. Quartz is used in many types of lenses and as lens coatings.
scopophilia	the love of looking/viewing/observing. Voyeurism is a subset of scopophilism in which the observer preferentially watches scandalous or sexual activities.
VHS	Video Home Systems. This is a widely distributed sound/image recording and playback format originally developed by JVC. S-VHS (Super-VHS) is a higher-resolution version of this format which is downwardly compatible. VHS is gradually being superseded by Hi-8mm tape and DVD digital formats.
video tape	An analog video (and sound) recording medium developed in the late 1920s and introduced commercially in the 1950s. Video tape revolutionized not only home movies, but the entire television broadcast industry. No records remain of many of the earliest television broadcasts because the shows were aired live and never taped. However, reruns of popular shows from about the mid-1950s on still garner strong fan and sponsor support through reruns. Live broadcasting is now rare, mostly saved for special events, awards ceremonies, and surveillance activities in which no records are required. However, the majority of surveillance activities are taped in order to provide evidence or a record of events that can be analyzed at a later time.
vidicon	a television with a photoconducting pickup sensor
voyeur	One who watches sordid, scandalous, or sexual activities, often for sexual gratification. Voyeurs frequently carry out their observations surreptitiously.