WHEN OFF-THE-RACK BECOMES OFF-THE-NET

Virtual-reality technology, the Internet and computer-aided manufacturing may soon combine to bring custom clothing to your closet. **By Stephen Gray**

MARIA SITS AT HER OFFICE DESK, her mind wandering to powdery Caribbean beaches and azure waters. Her boyfriend, Chris, has asked her to join him in Barbados for his company's Christmas party, but her busy schedule leaves no time to shop for just the right outfit.

Suddenly, she remembers the "smart" card she got at Harrow's, the department store, a few months earlier. The card contains an ultra-accurate three-dimensional digital image of her body, produced on the store's body scanner. The saleswoman said the scan would help them select the best-fitting garments off-the-rack.

At home that evening, Maria logs on to the e-mail address on the card. The Web site's screen shows the pleasing interior of a virtual-reality (VR) store. A voice asks Maria if she wants to select clothes and tells her she can see her scanned body shape if she swipes her smart card through the reader on her personal computer. Maria does and instantly sees a dynamic mannequin of her accurately proportioned virtual body (yes, her behind really is that size), ready to try on virtual clothes.

Maria says she is looking for "a really sexy, sophisticated cocktail dress," and the voice-recognition program allows her mannequin—which moves with lifelike fluidity—to try on dozens of dresses. None of them is exactly right. Frustrated, she turns off the machine and climbs into bed.

The next day Maria logs on and immediately hears from her "personal agent" program, which searches the Internet for her when she is off-line. The personal agent has found Paolo Poniari, a designer near Rome with an amazing collection of dresses, and connects her to his Web site. Clicking on a beautiful dress, Maria is told that this dress was custom-commissioned and is not for sale. Her personal agent interrupts: "Paolo offers a designer service for individual customers," it says. "Shall I connect you?"

After a moment, Paolo himself appears in a video window on-screen. He asks Maria what kind of dress she has in mind, and as she speaks he sketches on a computer screen. She falls in love with the design. Best of all, Paolo guarantees it will be ready in time for the Christmas party and asks Maria to swipe her smart card so he can download her full-body scan.

Five days later Paolo e-mails Maria that he can't get the silk fabric he wants from Thailand in time to cut and ship it to her before her departure. He can, however, have the silk flown directly to Barbados. "I've found a small design studio there," he says. "I'll send the patterns I've made from your body scan, and they'll make it up and deliver it to your hotel room."

"Perfect," Maria says. Seconds later the Internet is alive with traffic: pattern templates and illustrations are sent from Rome to Barbados, cloth orders and delivery instructions go to Thailand, and Maria e-mails Chris to check flight times.

THE VARIOUS TECHNOLOGIES that will enable Maria and Paolo to make this custom fashion transaction are closer than you might think. In fact, some key ones are already in place. Other critical aspects are on the verge of being perfected, and still others are in a preliminary stage of development.

Currently, based on work associated with the Virtuosi program at Nottingham Trent University in England, it is possible to create in-store digital scanning systems that quickly and inexpensively generate accurate 3-D color representations of customers' bodies. Associated hardware and software transform those scans into dynamic, 3-D VR mannequins that can "try on" VR clothes for shoppers and then move around to model them.

Virtuosi, which ran from 1993 through 1996, was created by the university's Computer Clothing Research (CCR) center, of which

MARC PHARES *Epic Studios*

A virtual runway will be a part of a future custom-clothing system. Before ordering a garment, buyers will be able to see how it looks on a virtual mannequin whose proportions are identical to their own. The system will permit views from many different angles and under diverse lighting, and it will accurately depict the "drape" of the garment as the mannequin moves.

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Years from now, the first step in ordering a custom garment could be an electronic scan by sensors that precisely measure the contours of the body. The data would then be stored on a smart card, enabling the holder to quickly order made-to-measure clothing anytime off the Internet.

I am director. Intended for use by professional designers, it would enable Paolo to perform most of his job today. It displays a virtual-design studio—complete with interactive in- and out-boxes, filing cabinets and a wall screen for selecting swatches of fabric. Using computer keys or voice commands, designers can choose styles and construct the 3-D garment on static mannequins. This garment can be accurately "unwrapped" into a traditional two-dimensional block pattern that is used to cut cloth. The 2-D pattern can also be translated back into a 3-D garment after changes have been made on it, in order to view their impact on the finished design.

Still impossible, however, is a crucial part of the process: realistically modeling the garment on a moving mannequin to see how the cloth falls and flows while in motion.

TRANSLATING FROM 3-D TO 2-D

The Virtuosi program differs significantly from other attempts at computerized clothing design and display. These earlier efforts, by Cyberware in Monterey, Calif., and Hamamatsu Photonics in Japan, involved capture systems that scan 3-D clothing designs and unwrap them into 2-D pattern templates. Another company, Textile Clothing Technology in Cary, N.C., is developing this technology for made-to-measure goods.

These approaches use static mannequins and depend on point-by-point laser scanning to capture their 3-D clothing templates and the body shape of models or customers. But laser scanning is not commercially viable because it is slow and expensive, requiring prohibitive amounts of computer processing. In addition, the static models in these systems do not allow the clothes to be dynamically evaluated by designers or shown off to shoppers.

Virtuosi uses a less computationally intensive, faster and cheaper digital scanner to capture full-color, 3-D body images, from which the individual's measurements and shape can be extracted. Such a system can also capture images of people with unusual shapes, such as disabled individuals. And it can capture people in different positions, along with the garments they are wearing, to allow animation of the images. The resulting 3-D template is then input into the VR system, where it becomes a mannequin that can be dressed and moved about a virtual showroom by a customer like Maria.

In addition to allowing the design and manufacture of more expensive custom clothing, the Virtuosi system can also bring off-the-rack shopping closer to custom quality. At CCR we are now using its database—which contains 2,500 templates of 3-D body shapes created with the 3-D scanner—to synthesize a range of virtual mannequins that reflect the average bodies of today's women. (We believe this database of 3-D bodies is the largest by far in the world.) The data for the mannequins could be used to manufacture more accurate new dummies for garment makers.

If Maria did not want a custom-made dress, a 3-D scan of her body could be matched against the proportions of these virtual average mannequins, which would allow her to select the best-fitting garment from the rack and view it on her mannequin. Using the

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3-D scan of her body, one of Paolo's fitters could also identify the closest fit from his stock of 2-D pattern templates and adjust it to the subtleties of Maria's body.

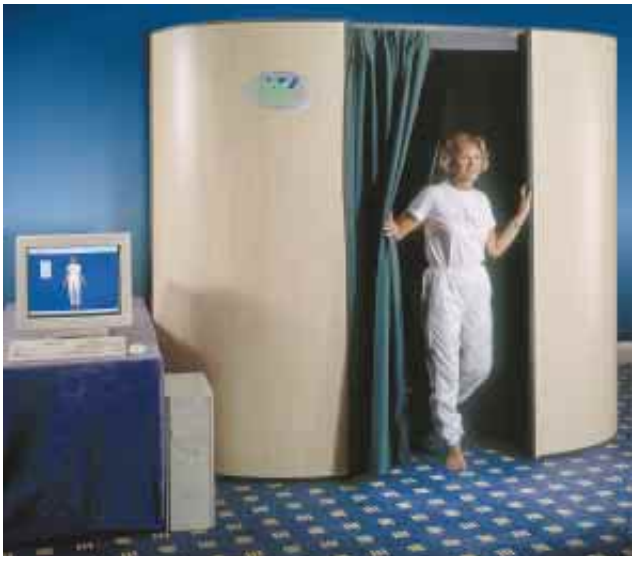
The program's final output is the digital version of the 2-D block patterns used for cutting the cloth. These patterns are intended to be used as input for CAD/CAM (computer-aided design/computer-aided manufacture) systems that actually make the clothes.

CALCULATING DYNAMIC DRAPE

There is, however, more to a fine garment than a good design and the right material, pattern and fit. The garment must move properly when we move, hang well and flow over our body surfaces in a flattering way in order to capture the eye of a discerning shopper like Maria.

This fabric movement is called "dynamic drape" and is the most daunting challenge in computerized fashion design. Whereas fabric characteristics such as yarn structure, fiber content, elasticity and rigidity have been measured and digitized, no commercial modeling system yet exists that can manipulate more than a few of these attributes. Current systems such as Clothreyes, made by Infografica in Madrid, can be used with only very simple, static fabric products such as curtains and tablecloths, which follow very basic shapes.

No one has yet been able to combine fabric properties into a single mathematical model that can yield natural-looking 3-D graphic images. Sueo Kawabata of Shiga University in Japan is doing advanced research on precisely this kind of problem, but his work is still some distance from practical application.



COURTESY OF STEPHEN GRAY

The scanning booth at Nottingham Trent University's Computer Clothing Research center makes templates of three-dimensional body shapes. The booth uses a digital camera to capture the body's frontal outline and side profile, which a computer translates into a digital file in minutes. This template then becomes a three-dimensional virtual mannequin, on which garments can be viewed before they are created.

The reason is that supercomputerlike processing power is needed to model even one piece of cloth draped over a static object. The complexity is significantly multiplied when the cloth is in motion, because the graphic must reflect the effect of every encounter the cloth has with the moving mannequin and with itself. Beyond this, the program must also calculate and represent the effects of the garment's fasteners, linings, seams, padding, facings and stiffeners. Currently such calculations cannot be performed in real time, which makes it impossible to present an animated VR "fashion show."

Our goal at CCR is to find a solution to this problem that will generate cloth with accurate dynamic drape without having to scan and model every mechanical detail of the actual garment. We are now experimenting with the 3-D scanner, using it to capture bodies in different positions while wearing garments, so that the movement of the body and cloth together can be animated to show at least some of the dynamic drape and fit.

Maria and Paolo may be able to make their transaction in about five years, at a reasonable cost. Now that the Virtuosi program has solved the first real challenge—selecting correct fit—there are no major technological hurdles to clear beyond the problem of dynamic drape. A program called MetaStream, from MetaCreation in Carpinteria, Calif., now offers the ability to see all around 3-D objects using a desktop PC, the first step toward 3-D apparel catalogues.

In the end, economics will be the driver. Until the mathematics of dynamic drape are perfected and linked to the 2-D pattern-engineering process, VR custom clothing will be too expensive for the marketplace. Ultimately, VR clothing's timesaving benefits will be the key factor: it can cost $500 to create one sample garment for a product that will retail at $40 and take about 30 days for the various stages in the approval process, such as changing the type of buttons, the shape of a neckline or the design of the fabric. If VR design can speed this up and lower costs, the garment could move into the market more quickly.

When VR custom-wear finally arrives, it should cost just 25 to 33 percent more than off-the-rack apparel. In all likelihood, those kinds of prices will cause a shift in the garment industry, opening the custom clothing market to moderately affluent, time-starved professionals like Maria—a considerably larger clientele than the small coterie of mostly wealthy fashion plates who buy it today. In the notoriously fickle and fleeting world of fashion, this development, unlike most others, will endure. And when it becomes part of our lives, we will all truly look better.

ABOUT THE AUTHOR

STEPHEN GRAY is director of the Computer Clothing Research center and a senior research fellow at Nottingham Trent University in England. Before turning to computer applications in textiles and the arts, he was a command-and-control specialist, writing the graphics software used in the British navy's Opcon system.