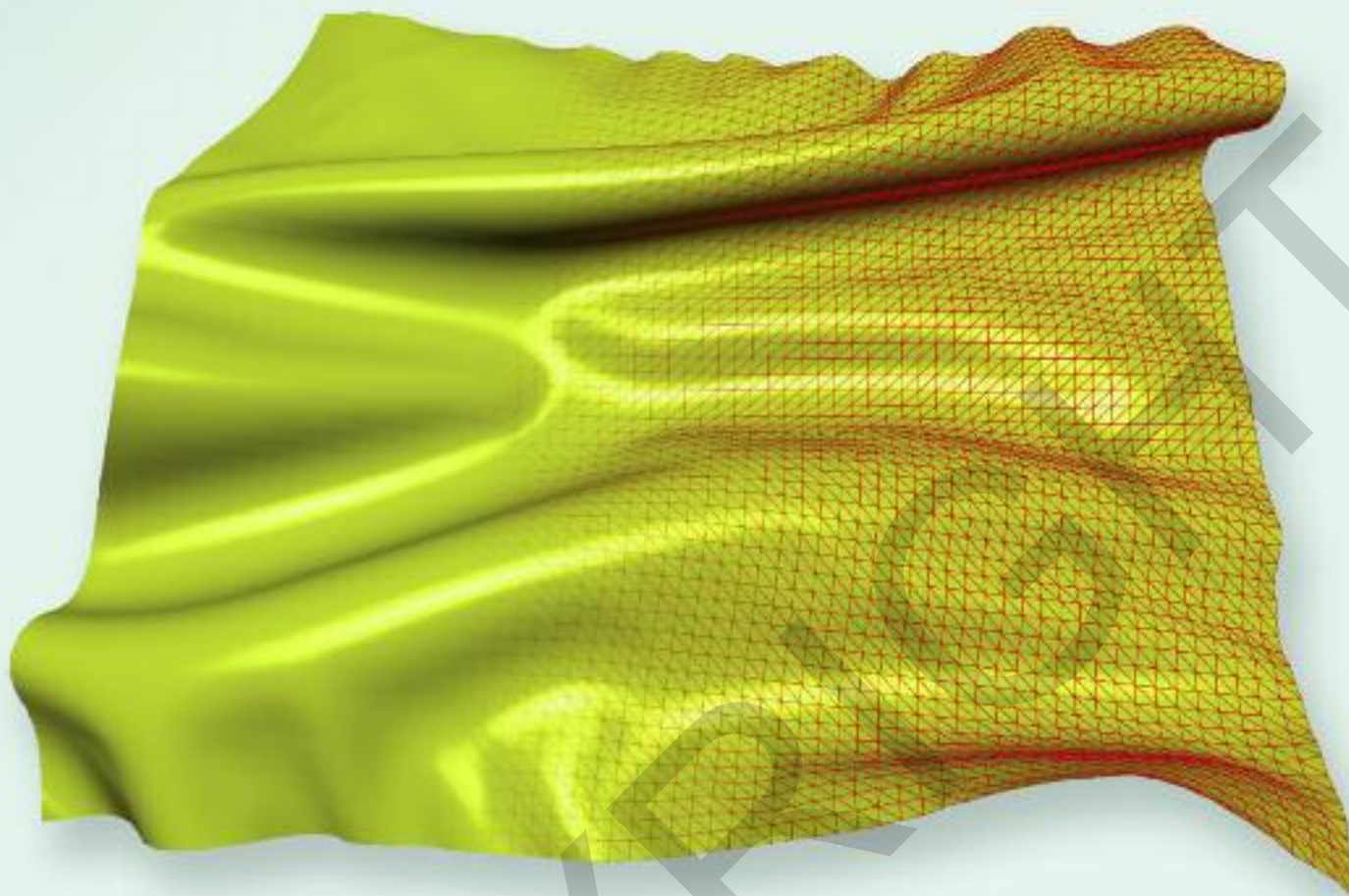




Next generation of virtual shoe design

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At the 16th UITIC Conference at Elche in 2008, I reported on the status of a research project concerning virtual shoe design being carried out by the Test and Research Institute Pirmasens (PFI) in conjunction with the Technical University at Chemnitz, Germany. This virtual reality system was being developed for footwear designers in order to provide them with the artistic licence to work as intuitively and creatively as always.

The system enabled a virtual shoe design to be created using a real last which doubled as a contact point for the

pen and for the virtual last to be moved. In order to do this, it was necessary to fasten the marker to the last, pen and designer's special glasses in order to determine their relative position (or tracking technology). Previously, styling lines had been drawn with a pen directly onto a solid last. Now, although the designer could still take the pen and draw lines on the last, there would only be a virtual image and no actual lines on the solid last itself. The styling lines were only visible on the virtual last.

To achieve this, it was necessary to know the position and movement of the last and pen in order to simulate

them in the computer program and so produce the virtual images (motion capture). This was achieved through the use of cameras. The tracking technology determining the relative positions of the pen and the last required this information for the system's computer software program. Furthermore, this program also needed to know the relative position of the designer's eyes in order to calculate a correct perspective of the virtual last and pen, which is why the designer needed to wear special glasses equipped with markers.

The software that was used offered

various methods to sketch lines and an interface allowed the transfer of line coordinates to 2D CAD systems. The program included all functions of a 2D system too. It was also possible to add a great deal of fine detail including individual upper sections, different material looks and textures, placing trims and accessories on the upper, 3D presentation of seams, lacing and different types of edge treatment.

This initial virtual design system could not however be used for all types of shoes, only sandals, low shoes and courts. This was because all lines had to be drawn on the surface of the last; it was not possible to draw anything outside that. The system could therefore not, for example, be used for boots and this caused a problem. A conventional CAD process uses only 2D construction for designing boots and this has some disadvantages. For instance, the designer cannot gain the true overall look of the design because the boot leg is flat. If he wants a real impression of the design for smaller or bigger leg girths, the boots have to be physically produced. That needs more time and the costs are higher.

At that time, there was also a lack of up-to-date information on foot and leg dimensions. German shoe producers had only very old and incomplete data at their disposal. Now things are much better and 3D data of more than 5000 adult feet and legs has been measured in a special research project.

ESSENTIAL DATA

To do this it was necessary to scan the geometry of legs from the sole of the foot up to the knee. PFI developed and built a prototype leg scanner that was both simple to use and at the same time capable of scanning the 3D geometry of both leg and foot. The scanned leg is displayed three-dimensionally and the measurement values exported for analysis in either spread sheet or CAD format.

During the measurement process, the computer permanently collects position data of the axes and the laser sensor. It then filters out position data that does not belong to the surface of the leg/foot and compensates effects based on surface colour variations and shadowing. This positioning data regarding the leg's surface is then

transformed into a Cartesian XYZ representation of the scanned leg. Depending on the density chosen, the program can register anywhere between 50,000 and one million points per leg.

Visualising the leg and foot using reference points is not however the best way to calculate measurements such as circumference, ball girth, etc., so these values are converted into surface representation formats showing measuring points, lines and circumferences for easier analysis.

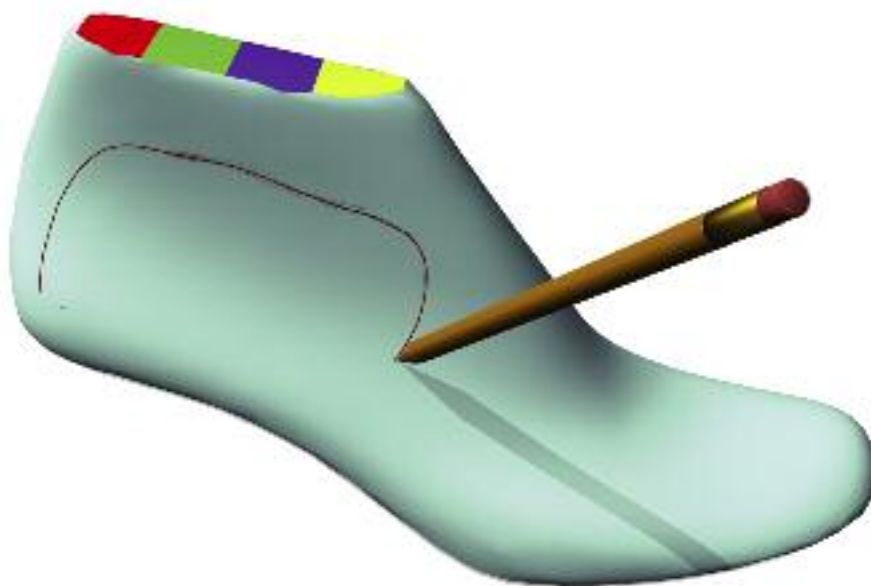
The data obtained helps the calculation of average values for important foot and leg measurements including calf, instep, circumference versus leg height, lower leg shapes, calf and shinbone position and orientation, all of which are useful for footwear production. The influence of heel height on foot and leg measurements has also been determined as a result of the project. In addition, guidelines for the design of lasts and shoes have been established and verified in practical fit and wear tests.

UPDATING THE SYSTEM

The large amount of data now available has enabled it to be collected into specific leg groups. This, in turn, has now made it possible to achieve a

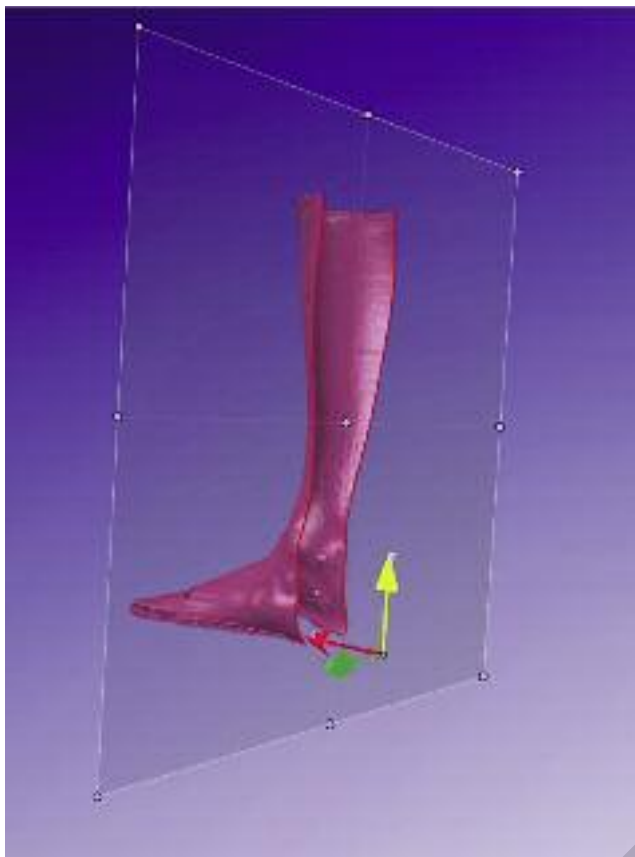
high level of accuracy as regards the final fit of boots. The point clouds enable the exact description of legs of women and men to be transcribed for virtual reality designing. Needless to say, there were some problems. The first was the asymmetry of human legs, the shape of which greatly differs from the ideal look needed in a boot and was therefore not accepted by designers. The second difficulty concerned last shape. The last to be used could not be altered even though it differed from the lower limb shape. In addition, we also had to take into account the importance of the heel girth.

The solution was to join the last and an idealised lower limb to produce an extended last. The area around the malleolus (bony protrusion at each side of the ankle) has been used as the equation area. The normal orientation of the last with its heel height is adjustable by parameters. The amounts allowed for the girth of lower limbs are the same as from the leg and only the shape has been changed. This method enables an easy exchange between different lower limb types. During the course of the project, the flattening of the 3D data has also been developed and tests have shown that boots constructed to this flat 2D pattern fit perfectly.



A designer is able to draw directly onto a virtual last exactly as if it was a real one except that the lines drawn will also be virtual.

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Cartesian computer image of a leg scan.

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ADDING DETAIL

The styling of boots frequently calls for some special design elements such as folds and zippers. A fold can be achieved by simple drag and drop a line with the upper 'stretched' in the neighbouring areas to compensate for the material the fold has taken up so as to maintain overall shape. This method allows the simulation of both defined overlapped and random folds.

The definition of different material parameters is also possible. The virtual surface consists of triangles which behave like a spring system. The thickness of the material, its contact with the last and the surface appearance of individual upper sections have all been included in the program. The representation of random folds is also possible using material simulations taken from the textile industry. The title image at the beginning of this article shows an example of a sheet of material simulated using the mathematical (mass-spring) model which is also used as the basis for generating creases on the upper material of the final virtual shoe.

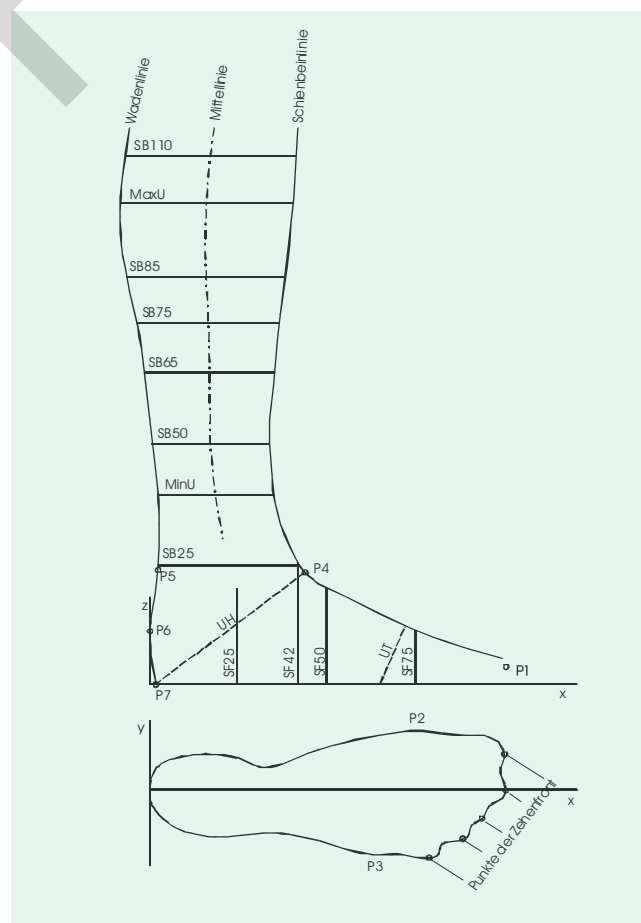
Zippers are often used as an element of the overall design as well as functional fasteners. In virtual styling, they have to follow the upper surface to ensure a realistic 3D effect. For that reason, zippers have to be built up from single elements and this also means that it is possible to reproduce different types of zipper. The generation of simple sole types is also important in order to have a realistic rendition of both shoes and boots. A parameter-controlled model has been specifically developed for this application and allows a variety of outsole designs to be created.

HAPTIC TECHNOLOGY

The new generation of virtual shoe design uses a haptic* device. This is necessary because the extended last does not exist as a real object. The device, in this case a haptic pen, allows the simulation of the extended last surface by a tactile feedback. The pen can be used for sketching, 'feeling' the material surface and selecting the menu functions. A 3D working environment has been developed around it that includes working space, focus distance and stereoscopic properties. To achieve the latter, shutter technology has been used for the monitor.

This new generation of virtual shoe design offers new prospects for a design process close to the current working methods of designers as artists. It now provides a design process for all types of shoes without using a real last. A realistic presentation of the design is achieved with a broad range of design elements and better fitting boots can be produced using the new data pool of lower limbs.

**The word haptic is taken from the Greek word haptesthai meaning to touch. Haptic technology is defined as being a tactile feedback technology which takes advantage of the sense of touch by using mechanical stimulation to assist in the creation of virtual objects in a computer simulation and to then both control and enhance them. It effectively does for the sense of touch what computer graphics does for vision. Designers can therefore 'feel' as well as 'see' the virtual product they are creating. *



Measured points, lines and circumferences.

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