

Scanning for a better fit

Monika Richter, PFI, Germany

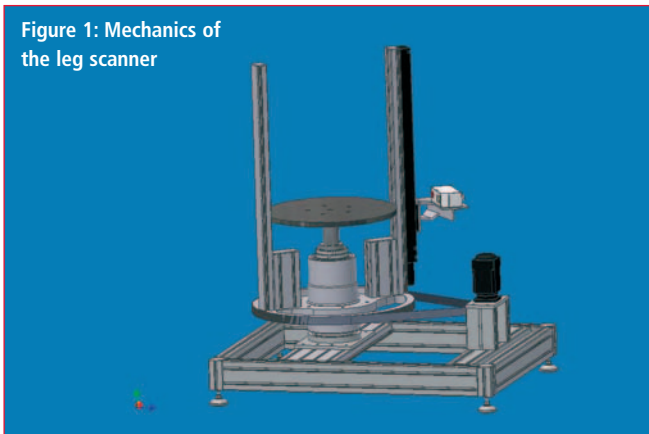
Today's footwear market is making it increasingly difficult for manufacturers in developed countries to survive. Imports of shoes from countries such as China and Vietnam have grown rapidly and this is forcing them to look for new sales and production strategies. One approach is to concentrate on niche products that are not of interest to the lower priced mass-production factories of Asia.

Small volume individual production runs, customer oriented service and an emphasis on comfortable and functional products, look to be the way to overcome the drawback of high manufacturing costs and to persuade potential customers to spend money at a traditional shoe shop rather than at a lower-price supermarket outlet.

However, the customer will only be willing to pay more money for a product if it offers better value compared with a cheaper one from a competitor. In the case of footwear, material, fashion and workmanship are extremely important. So also is comfort and, importantly, fit. The latter is based on a set of demands regarding lasts, materials, production processes, knowledge and experience. An important requirement, therefore, is access to up-to-date information and measurements of potential customers' feet.

The last relevant survey in Germany regarding the measurement of foot dimensions took place in the 1960s. The German ministry of economics and labour therefore provided a grant for a research project with the aim of delivering important fit information for the production of shoes and boots. A key part of the project has been the measurement of men's and women's feet and legs to determine mathematical correlations and variations of measurement on different heel heights.

Figure 1: Mechanics of the leg scanner

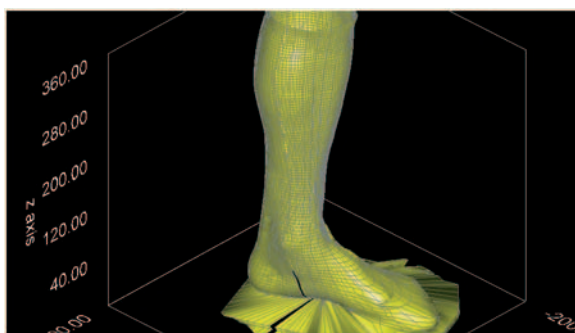


PFI leg scanner

To do this it was necessary to scan the geometry of legs from the sole of the foot up to the knee. The test and research institute PFI developed and built a prototype leg scanner that is capable of scanning the 3D geometry of a leg. With the help of this device the feet and legs of 300 people have now been measured in the course of the project.

The leg scanner essentially consists of a circular base plate on which test subjects place themselves and a moveable triangulation laser scanner that scans and measures the surface of the legs and feet three-dimensionally. The base plate is adjustable for different body heights and one leg is scanned at a time (*Figure 1*).

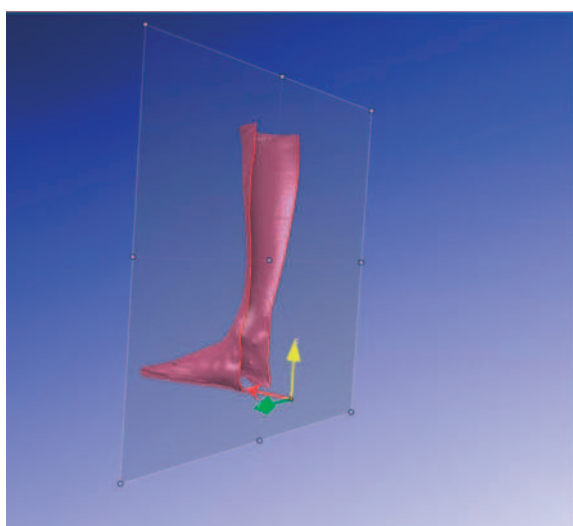
Two stepper motors move the sensor rotationally and vertically during measurement and scan the foot/leg during this

Figure 2: Presentation of data on the PC screen


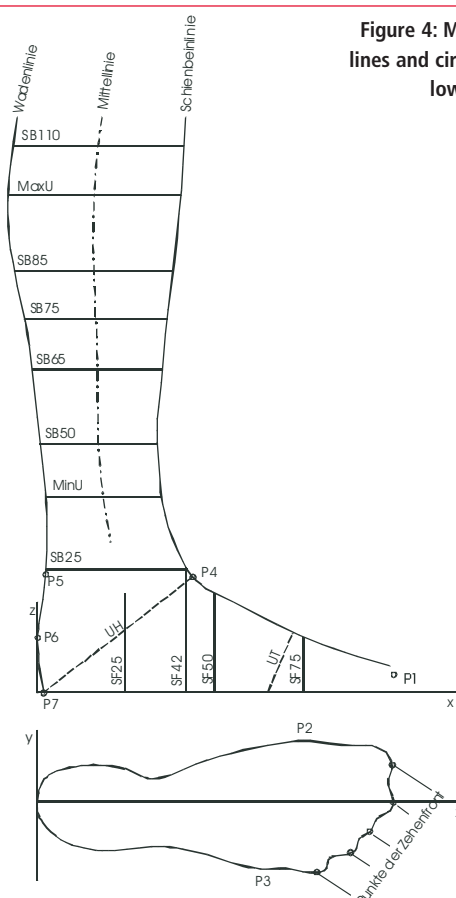
spiral movement. The maximum measurement height is 50cm. The actual scanning of a leg from sole to knee takes about 20 seconds. The scanner is controlled by a PC, which also carries out all calculations, conversions and handling of the data obtained using software developed by PFI.

Use of the device is simple. Once the subject is in the measuring position, with one leg in the scanner and the other outside (*See main image*), the operator starts the measurement process via the PC mouse. It is important that the subject's leg and foot is positioned on the base plate correctly and kept still while measurement takes place. Once this is complete, the scanned leg is displayed three-dimensionally on the computer screen (*Figure 2*) so that the operator can quickly detect if the process was satisfactory. Measurement values can be exported and analysed 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 (*Figure 3*). Depending on the density chosen, the program registers between 50,000 and 1,000,000 points per leg.

Figure 3: Computer image of a leg scan


Visualising the leg and foot using reference points is not the best way to calculate measurements such as circumference, ball girth, etc., so these values have to be transformed into surface representation formats more suitable for this analysis. Due to the algorithms and handling procedures used, the software is able to present calculated results from the scan after only a few seconds.

Figure 4: Measured points, lines and circumferences on lower leg and foot


To minimise the influence of different sock thicknesses, colour and surface structure, all subjects must wear nylon stockings. Their legs are scanned with the feet standing flat and at a heel height of 30mm. Women's legs are additionally scanned at 50mm. The heel is simulated by means of a metal support with exchangeable height elements and a flexible stand plate that self-adjusts its angle to the heel height.

Based on the calculated and recorded data from the feet and legs scanned so far, extensive analyses have been performed and correlations to existing last and shoe construction guidelines examined. The points, lines and circumferences used for evaluation and analysis are shown in *Figure 4*.

The data obtained will help to calculate average values of 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. 