ABSTRACT

Footwear is designed and promoted to meet the demands of the variety of movements and improve the ambulatory functions of the human feet. The design of footwear is a complex, multidisciplinary task spanning the fields of mathematics, thermodynamics, mechanical engineering, physics, chemistry, fashion among others. The important variables to be accounted for in a good footwear design include the ground reaction forces on shoe impact for force attenuation and shock absorption; muscle activation patterns based on foot landing strategies; stress-strain profiles; pressure distribution; force vectors and coefficient of friction; environmental ambience around the foot; torsional properties and their effect on shoe flexibility and energy expenditure. While the aforementioned variables are vital for shoe design, the “comfort” of a shoe and proper foot health is ensured by a proper “last” (3D representation of a foot). To arrive at the “last” parameters it is imperative that a foot measurement survey be carried out and anthropometric investigations of the feet be undertaken. Statistical techniques play a major role in this study as it is impossible to measure each and every person.

In the footwear industry it is essential to have statistical data of the proportions of the foot of the local population. This is essential for last development as lasts designed and manufactured in other countries cannot serve their purpose in India, owing to differences in population, climate,
wearing conditions, urbanization etc. It is therefore imperative to conduct a nationwide survey for reliable data on foot proportion. This thesis aimed to characterize the foot dimensions of the Indian population based on a specially designed foot measurement survey.

The sample sizes for measurement were determined and the places of measurement selected based on geographical, ethnic, social and biological variables. The measurement methodology consisted of a high precision, fully automated video based computerized equipment where the subjects feet were captured as images in the form of orthogonal projections. These images were stored and later processed by finding their boundaries, determining linear measurements and typical angles according to a predefined network. The pixel graphic picture files were converted into a vectorized data stream for later retrieval of foot data. The basis of the statistical data analysis was the unified database retrieved from numerical data collection and from calculations based on graphics images.

The ultimate objective was to identify the length, width ranges required to cover the need of the local population for footwear, to define proportions and rules of constructing shoe lasts required for providing well fitting and healthy footwear. For computations, the database files were transferred into a set of spread sheets. The statistical averages, empiric standard deviations, ranges of each measured and derived data were computed
for each geographic region within each basic size group as well as for the sample population of that particular size group. The ‘student’s $t$-test’ was applied to test whether a geographic region differs significantly from the foot sizes representing the entire country. The ‘$F$-test’ was also applied to compute the reliability. To investigate all possible combinations of the data fields and various types of relationships, the ideal correlation and regression analyses were carried out. Analysis of the various statistical descriptions helped formulate the parameters for the geometric modeling of the “last”.