International Journal For Recent Developments in Science & Technology
2581-4575
Crossref
A Peer Reviewed Research Journal

IMPROVEMENT OF AN ASSIMILATED CAD/CAM COORDINATION FOR SHOE LAST

[1]S.RAM MOHAN REDDY, [2]E.VENKAT REDDY, [3]E. RAJESH, [4]M. SRINIVASULU REDDY

[1,2,3&4]Asst.Professor, Department of Mechancial Engineering, Malla Reddy Engineering College (Autonomous), Maisammaguda(H), Gundlapochampally Village, Secunderabad, Telangana State – 500100

ABSTRACT

Shoe last is the solid form around which a shoe is molded. The application of CAD/CAM technology is the vital solution to improve shoe last industry. This paper presents an integrated CAD/CAM system development approach for shoe last. The system is implemented in Unigraphics software and Visual C++ programming. The shoe last CAD model is represented by a regular surface point data set. The design process is realized by manipulating the data set. The data set can then be used to construct surface model of shoe last. With the help of the CAM functions provided by UG/Manufacturing, the NC program can be obtained from the surface model and then controls a specialized shoe last NC machine to finish the machining process. The use of this integrated system greatly results in the production of high quality shoe lasts in a shorter time. This system development method is suitable for other CAD/CAM systems development of products with complex shapes.

INTRODUCTION

Footwear is the need of every human being. Recent studies show that unfit shoes are the principal cause of forefoot disorder. Shoe design has three aspects: ergonomic, functional and aesthetic, and all three are important though the degree of importance may vary from person to person. In general, footwear is categorized by its length and the width. However, keeping the length and the width the same, different consumers may have different foot shapes and have different requirements. In order to find a pair of shoes that perfectly fit the customer's choice, custom-tailored footwear is necessary. Recent development in technologies such as CAD/CAM and RP has made it possible to design and fabricate shoes as per the need of each customer. Such footwear will be especially useful for patients with podiatric disorder.

The demand for such footwear is on the rise, especially in European and American markets. Indian footwear industry has tremendous potential in the domestic market as well as for export. One needs to develop methodologies and user-friendly tools to create job opportunities.

Various Aspects of Footwear Design

To manufacture a shoe, one has to take into account three major constituents: (i) shoe upper (ii) shoe last and (iii) sole. The fit of a shoe depends greatly on the shoe last. Several styles of shoes can be made with one pair of shoe lasts. The design of good lasts is a masterpiece of engineering and a work of art on which depends the fitness, quality and

2581-4575
International Journal For Recent Developments in Science & Technology
Crossref
A Peer Reviewed Research Journal

appearance of the finished shoe. A shoe last can be categorized by the material, style, production method and usage occasion. In general, several important measures are available for a shoe last. Change of last sizes determines whether these measures will be increased or decreased. These major measurements include:

1. foot length,
2. joint, waist, and instep girth,
3. heel pitch,
4. toe spring, and
5. bottom width.

The orthopaedic shoe industry routinely makes bespoke shoes for individuals who are unable to wear normal shoes because of a medical condition. Under the Health Service provision in the United Kingdom, the orthotists or shoe fitters of orthopaedic footwear companies are contracted to visit clinics at hospitals, special schools and residential homes where a consultant doctor can prescribe such footwear for appropriate cases. The footwear is then provided by the orthopaedic company under the supervision of the consultant. An estimated 70000 pairs of bespoke shoes were made in 1990 in England, extrapolated from an informal survey of several major companies. Although detailed costings are not kept by the Department of Health, the annual cost of provision, repair and adaptation of footwear is estimated at 215.6 million in 1988.

Manufacture at present is largely a craft process in the United Kingdom. For each patient an individual pair of shoe lasts are developed either from a set of measures of the feet or, for more serious deformities, from plaster casts. These shoe lasts are the basic form over which the shoe will be fabricated. Typically the next stage in the process of shoe manufacture requires the development of pattern pieces for the proposed shoe style. A pattern is generated by presenting paper up to the last, and the pattern is then transferred to leather. The leather uppers and liners are cut and 'closed' (stitched together) and the entire upper is pulled over the last and attached to the sole unit with appropriate stiffeners and insoles.

These practices may vary both in the United Kingdom and abroad. In the United Kingdom the orthotists take the measures and casts, which are then usually relayed back to the central manufacturing facility where last and patterns are generated and the shoes fabricated. In the Netherlands, for example, it is common for the shoemaker to measure up and make his own last, but to contract the pattern cutting to a specialist. Other models might have the individual shoemaker completing the entire process. In recent years, some dissatisfaction has been expressed with the provision of orthopaedic footwear in the United Kingdom. Surveys of patients revealed a need for improved cosmesis and styling. Our own survey of prescribing consultants and a more recent patient questionnaire assessment indicate that the delay in provision, usually taking at least eight weeks from first visit to delivery and often more, is an additional factor. The level of satisfaction varied around the country, with satisfaction with the speed of service ranging from 25 to 67 per cent of responding consultants in the worst and

International Journal For Recent Developments in Science & Technology
2581-4575
Crossref
A Peer Reviewed Research Journal

best health service regions. With the craft technology, control of these factors is difficult because of the heavy dependence on skills and manpower in quite small companies. Computer aided technology has been introduced in other manufacturing areas for its advantages in speed and consistency, and graphical systems are now common for aesthetic design. Employment of computer-based technology is then an obvious consideration for solution of some of the perceived needs in orthopaedic footwear provision.

In isolation, the upper design system might have limited value, but benefits of CAD begin to accrue when more of the production process is linked together. Indeed, a complete system which begins with a digital shape scan of the feet and produces a pair of bespoke lasts with the matching uppers would be most attractive. The consideration of any component part of the system should therefore take into account the potential for integration. An integrated foot measurement, last and pattern design system is probably best implemented on a three-dimensional system.

LITERATURE REVIEW

Leng and Du have presented a CAD framework for designing customized lasts consisting of a global deformation approach that can automatically form a customized shoe last based on scanned foot data and an existing shoe last data, and an interactive local deformation method. Cheng and Perng have analyzed the foot length and joint girth by using a bi-variate normal distribution to obtain a more efficient foot size grading system and established a foot size information system (FSIS) providing shoe last related information; such as the percentage of population that a last can fit in. Braha and Maimon have developed an approach for creating a virtual shoe last by constraining a series of 22 3-D Bezier curves to satisfy a set of measurements given by designer. Hwang et al. have derived the geometric models of template shoe-lasts by grouping various existing shoe-lasts into manageable number of groups and quantified the similarity between shoe-lasts for grouping similar shoe-lasts into respective groups. Lee et al. fabricated several strangely shaped foot models and reconstructed CAD models using stereovision technique for a low-cost foot scanner. Chen et al. have presented an integrated CAD/CAM system development approach for shoe last. The shoe last model has been presented by a regular surface point data set. Manipulating the data set has allowed the design process to be realized. The data set is used to construct surface model of shoe last.

Alcántara et al. have developed a graphical tool called semantic profile to interpret and analyze the results of product semantics on either a single product (individual semantic profile) or for comparing two products (compared semantic profile) and applied it to shoe design. Jimeno et al. have developed a tool-path generation algorithm that takes advantage of traditional copier systems that do not fulfill the CNC standards. A virtually digitized model of the last surface allows the tool path to be computed and is followed by a series of optimizations. The proposed algorithm was successfully implemented in a commercial CAD/CAM system specialized for shoe-last making. Paris and Handley have addressed the process of design and development of shoes using CAD/CAM and knowledge based systems. The process of collecting knowledge, formulating this into rules and using to select best fit shoes has been outlined. Tools to convert best fit shoes into custom fit shoes are also described. Kim et al. have proposed a grouping method, which helps in fabricating custom-tailored products quickly. A prototype system based on the proposed methodology has been implemented and used to group the shoe-lasts for custom-tailored shoes. Lai and Wang have developed an effective image-processing method to automatically extract the boundary of a shoe pattern. In the study, they first used a histogram thresholding technique to segment out a shoe pattern from the scanned input image. Wang has developed an algorithm to identify the most suitable last for a foot among the available ones using fuzzy theory and an analytical hierarchy process.

In the present work, a complete and simplified methodology which has not been reported in the literature yet, has been developed to customize the shoe last using CAD and an optical scanner. The implementation of the methodology has been accomplished in a surface modeling environment, Surfacer V10.0. For this, the foot and the nearest matching existing shoe last have been scanned using ATOS 3D Digitizer. The scanned data gave the point cloud. Then the two point clouds have been compared and the difference between the clouds has been marked. There after, a surface fitting has been done on the point cloud data of the last with the help of Surfacer. Then the surface has been modified using the control points on the surface to match the foot. Since the rear part of the last matches the foot when the approximately fitting last is selected, the modification has been done on the front part only. Once the modified last is ready, it has been rapid prototyped on a FDM machine. This model is ready to make the shoe which fits the foot better.

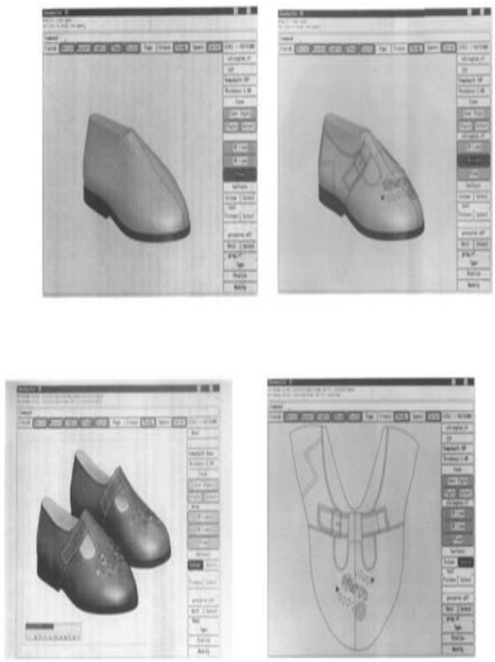
Description of the cad design system

A limited clinical trial has been conducted on a threedimensional design system, Shoemaster from Clarks Shoes, to allow both of these technical aspects and service-related factors to be investigated. At the heart of this system is a model of the shoe last. The last shape is initially input into the computer by a method of hand digitization. The last is marked up with a structured grid (Fig. la); one of the lines runs along the featheredge which delimits the upper from the sole. The intersection points of the grid are then fed into the computer (Fig.). From this set of surface coordinates, two parametric surface functions are generated for the upper and sole respectively. The limited set of coefficients for this parametric function completely define the surface at all points. Parametric techniques are well documented, for example see Newman and Sproul.

At this stage the designer hands over to the pattern engineer, who works with the two-dimensional view to add lasting allowances and optimize pattern layout with the special facilities of the

2581-4575
International Journal For Recent Developments in Science & Technology
Crossref
A Peer Reviewed Research Journal

software package, and then the pattern is output to a choice of numerically controlled cutters. In Fig. 3, the pattern pieces have been cut and closed, and the finished shoe is shown fitted to the foot.



METHODOLOGY

Trial procedure

The clinical trial involved the manufacture and supply of shoes to four adults with diabetic foot problems and six children with severe orthopaedic foot deformities, mostly arising from spina bifida. In the case of two of the adults, the feet were not of particularly abnormal shape but extra clearance was required over the forefoot and extra depth needed to incorporate special inserts. Of the remaining adults, one had a forefoot amputation and another a large dorsal tuberosity which needed accommodation. The children's feet were generally short, bulky and outside a normal range of foot shapes: two had a pair of feet of markedly different sizes and two required the use of external orthoses. For example, the patient in Fig. is wearing moulded anklefoot orthoses under her socks. Full details of the clinical aspects of the trial are published elsewhere.

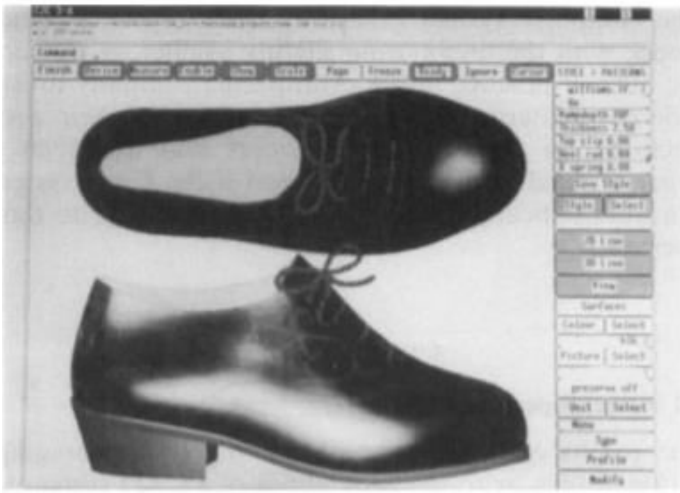
The established orthopaedic lasts for these patients were digitized with any cradle or special insert attached. To aid digitization, a thin drape was pulled over the rough last surface to present a uniform hard surface. A design session was arranged at the location of each orthopaedic company to which patients, orthotists, lastmakers, two experienced shoe designers and the research coordinators convened. The designers worked with the patient and relatives at the CAD station to achieve a style acceptable to the patient. Styles were generated either as complete originals (seven pairs) or by transfer of current Clarks' styles which had previously been identified as suitable (three pairs). In each case, the design was completed over one last and then transferred to the other last. In cases where the feet were of substantially different size, the design was first graded in three-dimensions to an appropriate size and then transferred. Subsequently the shoe uppers were cut and closed at Clarks Shoe factory, and lasted and fitted by one of the two orthopaedic companies involved in the trial.

A repeat order requested by a clinician for one patient was outside the protocol of this trial. However, a paper pattern was supplied from the CAD system and used in the conventional way at the orthopaedic company to manufacture a new pair of shoes. Both leather and lining patterns were supplied.

2581-4575
International Journal For Recent Developments in Science & Technology
Crossref
A Peer Reviewed Research Journal

The last is the basic industrial component in footwear manufacturing, from which product development starts. Correct last grading ensures the best fit for the intended group of users of the footwear model to be produced. The size marked on the last should respect the specific intervals defined in the different international sizing systems, like the European, UK, US or Mondopoint systems, which are all described in international standards. New approaches in the field of CAD/CAM have emerged over recent years towards the automation of this process. However, these are partial approaches that neither address the grading process according to the different standards nor consider the various parts of the shoe that are not affected by size increments. This paper presents a new accurate and efficient technique for the automation of the shoe last grading process based on the conjugate gradient method. Through this method, it is possible to obtain a graded shoe last that conforms to the international standards in force relative to shoe sizing and allows for the shoe parts that are not affected by size increments. This technique is based on the target measures of length and perimeter of the last to be graded and aims to minimise the quadratic difference between these values and those obtained from the graded last. This method has been evaluated through a battery of tests performed on a geometrically heterogeneous group of shoe lasts. The results obtained were accurate and the execution time was fast enough to be used for mass production.

Overall the CAD system proved versatile and able to meet the orthopaedic requirements. The shoes ranged from lace-up Derby styles through to trainer shoes and T-bars for the children. No insurmountable problems were encountered with the lasting and fitting of these shoes. Only one pair of shoes failed to fit due to inadequate depth to accommodate the cradle in the heel area; this was essentially a problem introduced at the time of lasting. Although it is not of direct relevance to this technical report, it can be noted that the trial shoes were well received in terms of their improved cosmesis and high-quality leathers.

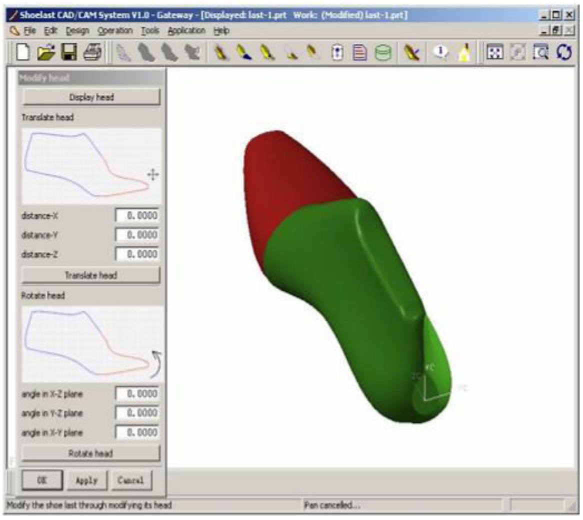


RESULTS

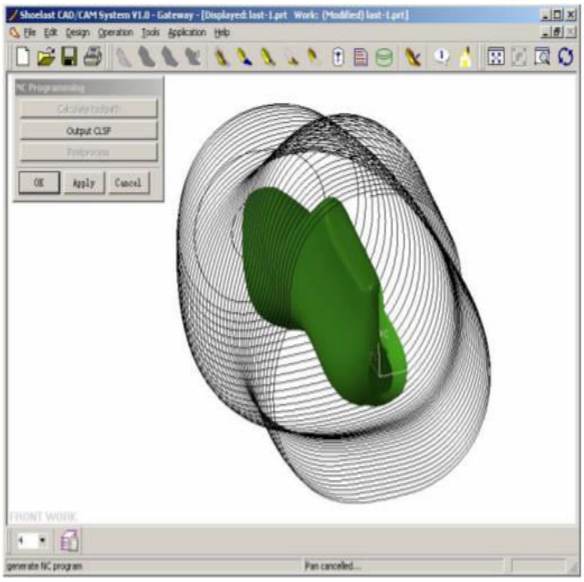
By use of the CAD and CAM methods presented above, shoe last CAD/CAM system can be realized. Visual

C++ is used to finish all the key algorithm and numerical calculations. UG/Open API and UG/Open++ are used to access Unigraphics objects and functionality to create, read, and modify graphic objects such as points, curves and surface models of shoe last. UG/Open GRIP NC enables the realization of CAM process of shoe last using programming code rather than interactively setting the dialog options presented in Section III. UG/Open MenuScript and UG/Open UIStyler are used to create custom menus and dialogs for the own purpose of shoe last CAD/CAM system in an integrated, seamless manner.

The system provides instruction windows to help the users finish all the CAD and CAM processes of shoe last interactively. After given certain parameters, selections and modifying operations by users, the system constructs the shoe last model and generates NC machining code automatically.



The interface window of modifying toe in Shoe last CAD/CAM System



The interface window of NC programming in Shoe last CAD/CAM System

CONCLUSION

A novel and practical approach for the CAD and CAM of shoe last has been presented and the integration strategy has been developed to a full system based on UG software. The system uses point based geometric modeling technique to realize the CAD of shoe last. The surface model of shoe last constructed in UG/Modeling is processed to generate NC program in UG/Manufacturing. The system has been applied to practice successfully. The contribution of this approach is that it can be used for the CAD/CAM system development of other complex shaped products.

REFERENCES

1. Wang CS (2010) An analysis and evaluation of fitness for shoe lasts and human feet. Comput Ind 61(6):532–540
2. Cheng FT, Perng DB (1999) A systematic approach for developing a foot size information system for

shoe last design. Int J Ind Ergon 25(2):171–185
3. Satyanarayana, P. and Subramanyam Pavuluri, D.A., 2013. PARAMETRIC MODELING AND DYNAMIC CHARACTERIZATION FOR STATIC STRENGTH OF STEAM TURBINE MOVING BLADES. International Journal of Innovative Research in Science, Engineering and Technology, 2(7).
4. PAVULURI, S. and KUMAR, D.A.S., 2013. „" Experimental Investigation On Design Of High Pressure Steam Turbine Blade"". International Journal of Innovative Research in Science, Engineering and Technology, 2(5), pp.1469-1476.
5. Sreenivas, P., Kumar, A.S. and Subramanyam Pavuluri, D.A., 2013. Investigations on transient dynamic response of functionally graded materials. a a, 1, p.2.
6. Pavuluri, S., Rajashekar, B. and Damodhar, B., Process of Press Tool Design and its Manufacturing for Blanking Operation.
7. KUMAR, S.S. and SUBRAMANYAM, P., DESIGN AND WEIGHT OPTIMIZATION OF OIL PAN BY FE ANALYSIS.
8. PAVULURI, S. and KUMAR, D.A.S., 2013. „" Experimental Investigation On Design Of High Pressure Steam Turbine Blade"". International Journal of Innovative Research in Science, Engineering and Technology, 2(5), pp.1469-1476.
9. Thompson ALT (2008) A South African podometric study—does the shoe fit the foot? (Doctoral dissertation)
10. Mochimaru M, Kouchi M, Dohi M (2000) Analysis of 3-D human foot forms using the free form deformation method and its application in grading shoe lasts. Ergonomics 43(9):1301–1313
11. Driscu M, Costea M (2013) Shoe last grading and experimental estimation of dimensional variation using Delcam Crispin 3D—Last Maker. Rev Pielarie Incaltaminte 13(2):125–138
12. Kim SH, Shin KH, Chung W (2008) A method for modifying a surface model with non-uniformly scattered displacement constraints for shoe sole design. Adv Eng Softw 39(9):713–724
13. Luximon A, Zhang Y, Luximon Y, Xiao M (2012) Sizing and grading for wearable products. Comput Aided Des 44(1):77–84
14. Xiong J, Zhao J, Jiang Z, Dong M (2010) A computer-aided design system for foot-feature-based shoe last customization. Int J Adv Manuf Technol 46:11–19
15. Tuan PN, Tuan HM, Hien TTT, Bong TD (2009) Research and development of a new grading software in footwear industry. Science & Technology Development 12(16)
16. Davia M, Jimeno-Morenilla A, Salas F (2013) Footwear biomodelling: an industrial

International Journal For Recent Developments in Science & Technology
2581-4575
Crossref
A Peer Reviewed Research Journal

approach. Computer Aided Des 45(12):1575–1590