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Shadow-Scanned Human Representations for Car Seat Design

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Abstract

Modelling of the human body has a long history as an essential component of computer aided design systems which provide ergonomic analysis of workplaces and equipment. A current Brite-Euram project is concerned with life-cycle aspects of car seating from design through manufacturing and eventual re-cycling. Loughborough University is responsible for driver comfort assessment which is being carried out through road and laboratory trials, the results of which are to be incorporated within the SAMMIE computer aided ergonomics design system.

The human body is infinitely variable in shape and dimension and this leads to particular difficulty in generating initial shape representations and subsequently manipulating these to represent individuals or general populations. This paper is principally concerned with a method for capturing shape information and transforming it into a CAD surface representation. The capture method uses a shadow scanning technique where the human body can be scanned in a matter of minutes and ordered coordinate information provided. This information has been processed for input into the DUCT surface modeller where some data reduction can take place before being output in the form of IGES B-Spline surfaces. These surfaces are then processed into a quadrilateral mesh representation that can be handled by the PHIGS functionality implemented within SAMMIE.

1. Introduction

The modelling of the human body for use in computer aided design systems can be traced back to the very early days of computer graphics. Early research work was to be found in the USA primarily in military and aerospace applications (e.g. BOEMAN) and in the UK (e.g. SAMMIE, Bonney et al, 1972). Today there are a number of systems that have reached commercial maturity and also form the basis for further research (e.g. JACK, and SAMMIE, Porter et al, 1995). Most of this work has involved the use of solid modellers which though appropriate for analysis of interference problems, typically give a symbolic rather than realistic representation of the human body (figure 1). Although this is perfectly adequate for the evaluation of many important human factors such as reach, vision and to a lesser extent fit within the workplace, there are some situations where a more precise representation is required.

Our current Brite-Euram project is concerned with life-cyc1e aspects of car seating with the different collaborating universities and companies taking responsibility for particular aspects. Loughborough is responsible for road and laboratory trials related to driver comfort assessment and for the creation of a design tool within the SAMMIE computer aided ergonomics design system. Driver comfort is a subtle measure which in part is determined by pressure distributions across the seat. These pressures lead to deformation of the human flesh and the seat at their points of contact which in turn leads to movement in some important design locations such as the driver's eyepoint. The eventual accommodation of these effects has caused us to seek a more realistic representation of the human body using surface rather than solid representations.

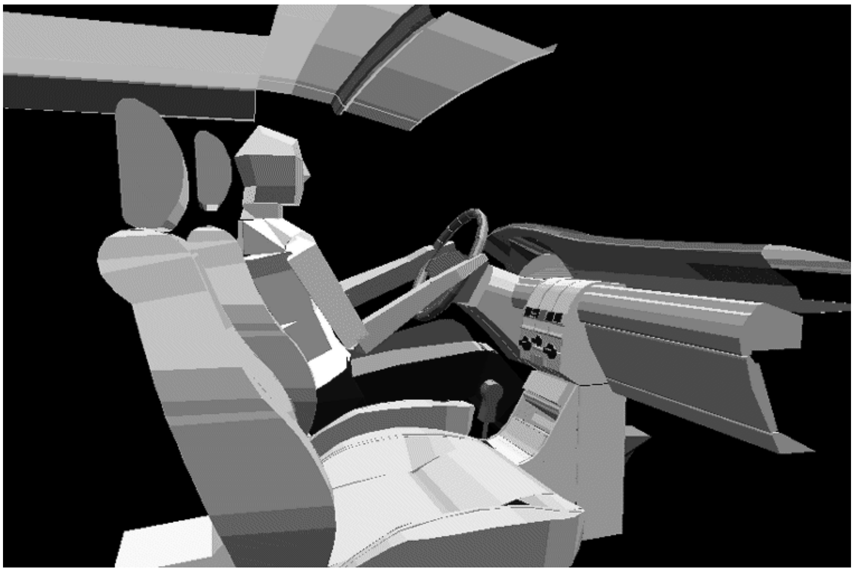

Figure 1. SAMMIE model used in evaluation of the Fiat Punto - Car of Year, 1995

The variety in human body shape and dimension makes it particularly difficult to determine initial shape representations and to subsequently manipulate these to represent individuals or general populations. A shadow scanning technique (LASS, Loughborough Anthropometric Shadow Scanner) developed by the HUMAG (Human Measurement and Growth) Research Group in the Human Sciences Department of Loughborough University was used to capture shape information. The entire human body can be scanned in a matter of minutes and ordered coordinate information provided. This information has been processed for input into the DUCT surface model1er where some data reduction can take place before being output in the form of IGES B-Spline surfaces. These surfaces are then processed into a quadrilateral mesh representation that can be handled by the PHIGS functionality implemented within SAMMIE.

Further work (not yet started) is required within SAMMIE to provide a variational model that allows different anthropometric representations to be generated based on the scanned shape and driven by dimensions collected from field surveys. Finally it is hoped to utilise our empirically obtained pressure distribution maps to provide a design tool capable of predicting the deformations at the driver/seat interface.

2. Scanning Body Data

Use of the Loughborough Anthropometric Shadow Scanner (LASS) (Jones et al, 1989, Brooke-Wavell et al, 1994) involves standing a subject on a platform which is rotated through 360 degrees in steps of approximately 2.3 degrees in about 3 minutes. At each location strips of light are projected onto the body where they are measured by television cameras. This produces a 'raw' binary data file containing some 64,000 coordinates. This data is processed both to remove 'noise' created by stray reflections and to extrapolate for regions that are obscured during the scanning process (e.g. the part of the torso hidden by the arms).

3. Surface Modelling

The data supplied from the body scanner is used to generate a surface model in the DUCT surface modeller. Figure 2 shows a full resolution plot in both its rendered and wireframe forms and consists of 29 horizontal sections each of which is defined by 29 coordinate points.

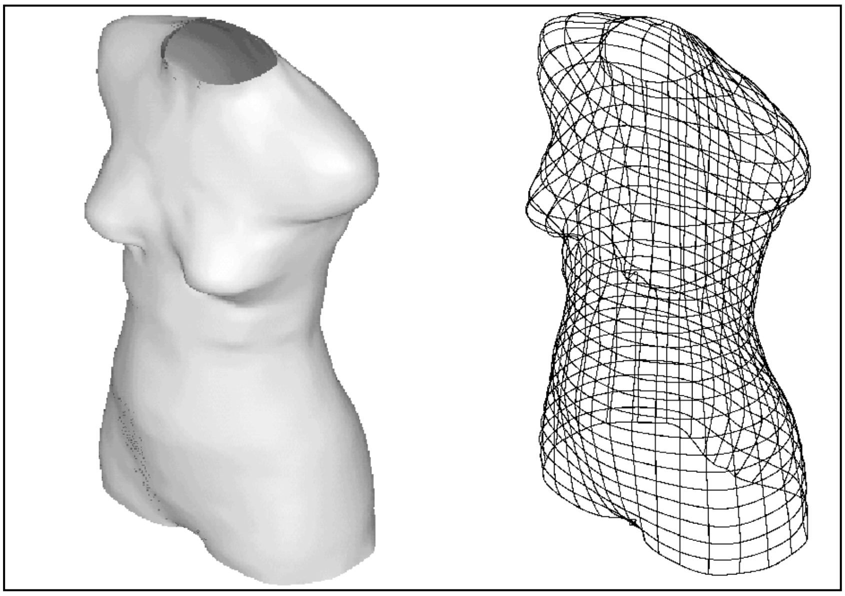

Figure 2. A female torso defined by 29 sections each containing 30 points

This provides an extremely realistic and accurate representation of the human form, but for our purposes of an interactive design system on modest workstations provides a burdensome graphical load of greater precision than our analysis techniques. The objective then was to reduce the information content in a way that maintains the anthropometric shape integrity and leaves us with suitable anthropometric landmarks (i.e. measures such as chest and waist circumferences that are typically collected in anthropometric surveys using more traditional techniques). This has clear significance for the anthropometric modelling described in the next section.

Reduction of the data is achieved first by the removal of appropriate sections. Anthropometric landmark sections are retained whilst removing those which do not contribute heavily to overall shape, and quite acceptable results are obtained. Further data reduction is obtained by progressively removing alternate points on each section. Figure 3 illustrates that these simple techniques are effective in achieving an eighty-five percent data reduction in data in comparison with the image of figure 2 whilst maintaining shape integrity.

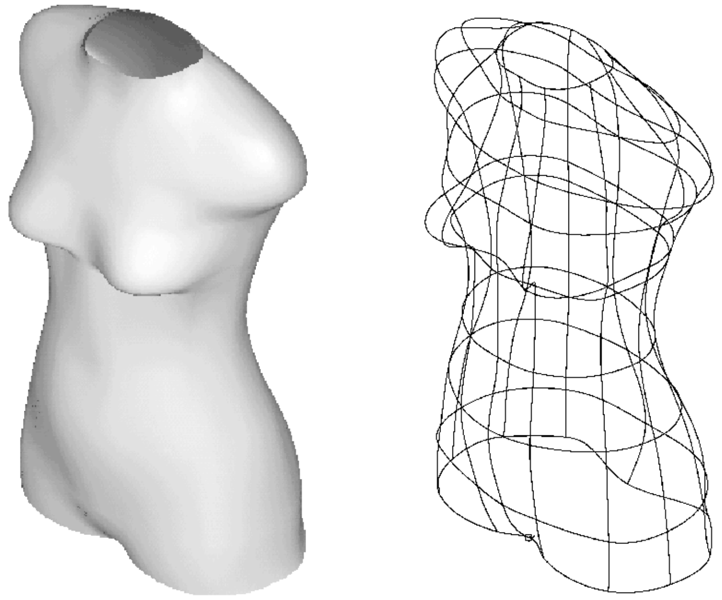

Figure 3. Data reduced to 10 sections each containing 12 points

4. Anthropometric Modelling

An objective of our work is to be able to represent a variety of human body forms through modelling rather than image capture techniques. i.e. the scans represent the shape and dimensions of an individual whereas we wish to be able to synthesise a model from a combination of scan data for shape and data from anthropometric surveys for dimensionality. For example 'Bodyspace' (Pheasant, 1988) contains the results of a number of anthropometric surveys for various national groups. Body shape and size are described by a total of 36 dimensions each of which contains information on the distribution (variability) of the dimension within the group. Other surveys may be more detailed with several hundred dimensions, but the problem still remains of modifying the dimensionality of scanned data whilst maintaining the shape. This remains to be done, but we are helped in this by knowledge of the relationship between scan sections and anthropometric landmarks. The scan data also needs to be modified to allow us to generate a model that has joint articulation. This has required some modification of the surface models in the regions where limbs connect with each other and the torso. Figure 4 illustrates the current status of this work with an 'armless' figure (we have yet to obtain arm scans).

5. Car Seat Modelling

A parametric approach has been adopted in modelling car seats within the DUCT system. Composite car seats can be constructed from elements such as seat pan, backrest, headrest, side supports, etc and some examples are shown as figure 5. Hence we have the man model from modified scan data and the seat model in the same form ready for transfer into the SAMMIE system.

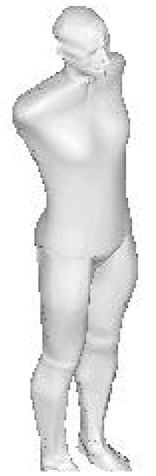

Figure 4. Current status of the complete man model

Figure 5. Examples of car seats modelled

6. Transfer 10 SAMMIE

SAMMIE is a boundary representation solid modelling system and its graphics is handled by a commercial implementation of the PHIGS standard. Although the standard includes a NURB surface representation, our implementation represents these by quadrilateral meshes. The transfer from DUCT to SAMMIE is achieved by an IGES file containing B-Splines that are readily convertible into these meshes although obviously with some loss of surface information. This reduces the visual realism of the image but is suited to the next stage of the work which is to use finite element work to investigate the compression between driver and seat.

7. Analysis of driver/seat interface

The creation of more realistic body shapes fulfils an overall objective of improving the performance of the SAMMIE system, but for our Brite contract we wish to investigate and produce algorithms for the way in which the flesh and car set deform when in contact. This work has not yet started but we propose to use the Patran finite element package, obtaining our geometric knowledge from the models described above. Information on the compressibility of the seats is available from earlier experimentation and although the compressibility of human f1esh is less easily determined, the HUMAG research group has determined this characteristics whilst creating physical manikins.. (An objective of HUMAG's work was to generate manikins for the fitting of underwear and this has involved the creation of a material that has many of the characteristics of human flesh). Our own experimental work has determined pressure contours for a variety of driver/seat configurations (figure 6) and these will be used in the validation of our modelling work.

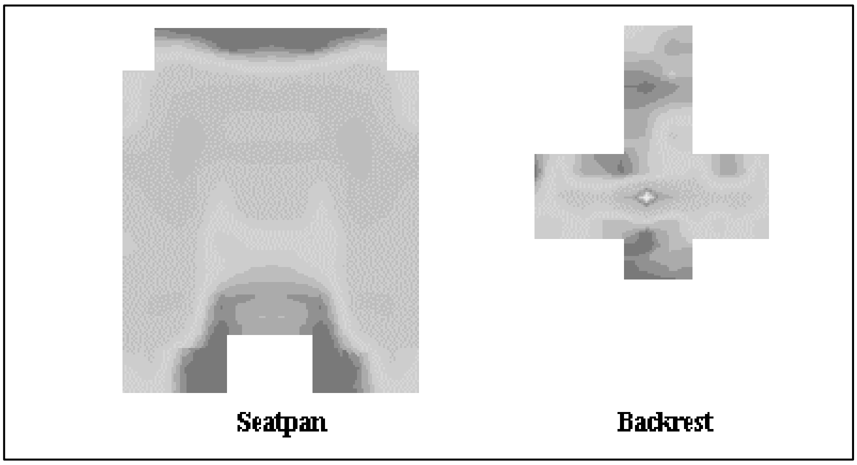

Figure 6. Experimentally determined pressure distributions across a car seat

8. Conclusions

There is a considerable way to go before we achieve our ultimate objectives of an improved and more realistic body shape for our man model and an understanding of the implications of seat/flesh compression on car interior design. However the work so far has clearly demonstrated the value of body scan data and how it may be transformed into a geometric model that is amenable to modification to represent the variability found in human populations.

9. Acknowledgements

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