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Digital Human Modelling for Virtual Fitting Trials

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Abstract

A recognised difficulty with the conventional use of Digital Human Modelling (DHM) systems is that they typically use percentile data to describe anthropometry and joint constraints. Hence any model is a synthesis of the set of data rather than a representation of any particular human. Implicit in this is that an acceptable degree of correlation exists between body dimensions whereas it has long been known that only weak correlations exist. The consequences are obvious in that products are designed/evaluated against models of humans that do not exist. An alternative approach is to use pre-defined families of manikins that together 'enclose' and represent the necessary diversity of human form.

In the real world, rather than the digital world, ergonomists use real people in 'fitting trials'. These people might be selected on the basis of the need for diversity covering the range of anthropometry that is thought necessary for the product evaluation but the practical considerations rarely allow an exhaustive evaluation.

This paper describes an amalgam of the two approaches where the anthropometry and other aspects of more than 150 people has been collected experimentally. This data is used within the HADRIAN system as discrete sets of data rather than as the basis for a percentile representation. i.e. the data is maintained as sets relating to each individual and used to construct digital models of individuals. This is combined with a task description language that is used to drive the product or workplace evaluation in a way that is analogous to a physical fitting trial.

The approach is being used within AUNT-SUE (Accessibility and User Needs in Transport – Sustainable Urban Environments) a wide–ranging research project looking at exclusion in public transport systems. The use of the HADRIAN approach is illustrated through a focus on the creation of a journey planner that meets the needs of a diverse range of people including the elderly and disabled.

1. Introduction

There are many issues connected with the collection and application of anthropometric data within digital human modelling systems. Much of the data has been collected for other purposes (usually direct application rather than incorporation in a modelling system) and so there is a need for some transformation before the data is useful for modelling. For example, the external body dimensions normally collected in anthropometric surveys have limited use in modelling where the internal joint-to-joint dimensions form the basis of most models. When applying the data to design problem there is a tendency to use 'percentiles' in a way that ignores the multivariate nature of anthropometric data. For example the 5th and 95th

percentiles might be used with an implicit assumption that perfect correlation exists between body measures. However, it has long been recognised that this correlation does not exist. Thus Hertzberg (1960), in a survey of a very homogeneous population of over 4000 Air Force personnel found that there were no examples of men who fell within the 30 percent central (average) range on all of a series of ten measurements. This is to say that the man who is average in all dimensions, and thus an 'average' man, just does not exist, because the correlation between different dimensions is not sufficiently high. In the human modelling world handling this problem is frequently left as an issue for the user of modelling systems to deal with raising the question as to whether all users are sufficiently aware of the difficulties to deal with them satisfactorily. Alternative modelling approaches have constructed ‘families’ of models which try to encompass the multivariance within a limited number of models such as the 17 manikins of A-CADRE (Bittner, 2000) or the 45 manikins of the RAMSIS Typology (Bubb et al, 2006). Hogberg (2007) gives a graphic comparison of these two families (figure 1).

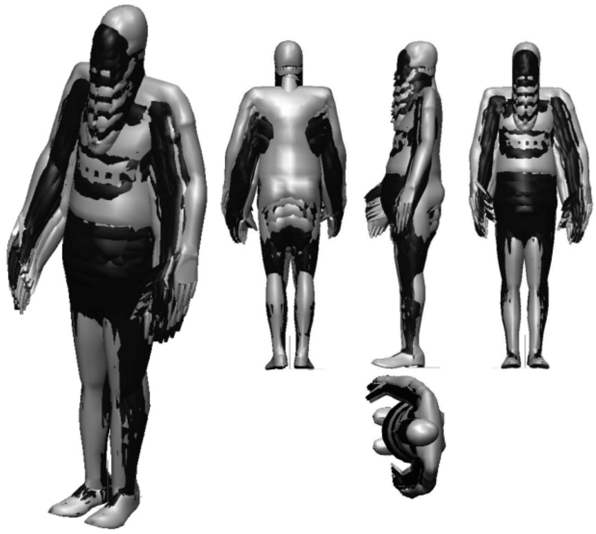

Figure 1. Skin compositions of RAMSIS Typology (black) and A-CADRE (grey) male manikin families (Hogberg, 2005)

In the real rather than virtual world the multivariate nature of the user population of products is often dealt with by ‘fitting trials’ where a number of people interact with the product or a prototype. This can be replicated in the virtual world of human modelling only if anthropometric data is available as a set for each individual (rather than population statistics such as percentiles) and if there is some way of describing the interactions with the product (a task description). The HADRIAN system provides these two crucial aspects.

2. Data Collection

Important aspects of diversity arise from the users of products being older than the general population or through having some disabilities and these have been reflected in our data collection. This emphasis on older and disabled people comes from earlier work within the EQUAL (Extending Quality Life) programme which was a ‘design for all’ activity that recognised the needs and opportunities of an aging population, and similar considerations but focussed on transport in current work concerned with Sustainable Urban Environments (SUE). Details of the data collection can be found in Gyi et al (2004) and some indication of the variety of data available is shown in figure 2 (from Porter et al, 2006). The data collected includes anthropometry, joint constraints, reach and mobility which is presented to the designer/ergonomist as sets relating to individuals together with additional information such as video clips which illustrate particular problems that an individual might have due to a disability. This data and the form of its presentation has considerable value in its own right but becomes more potent when associated with a task-driven human model as described next.

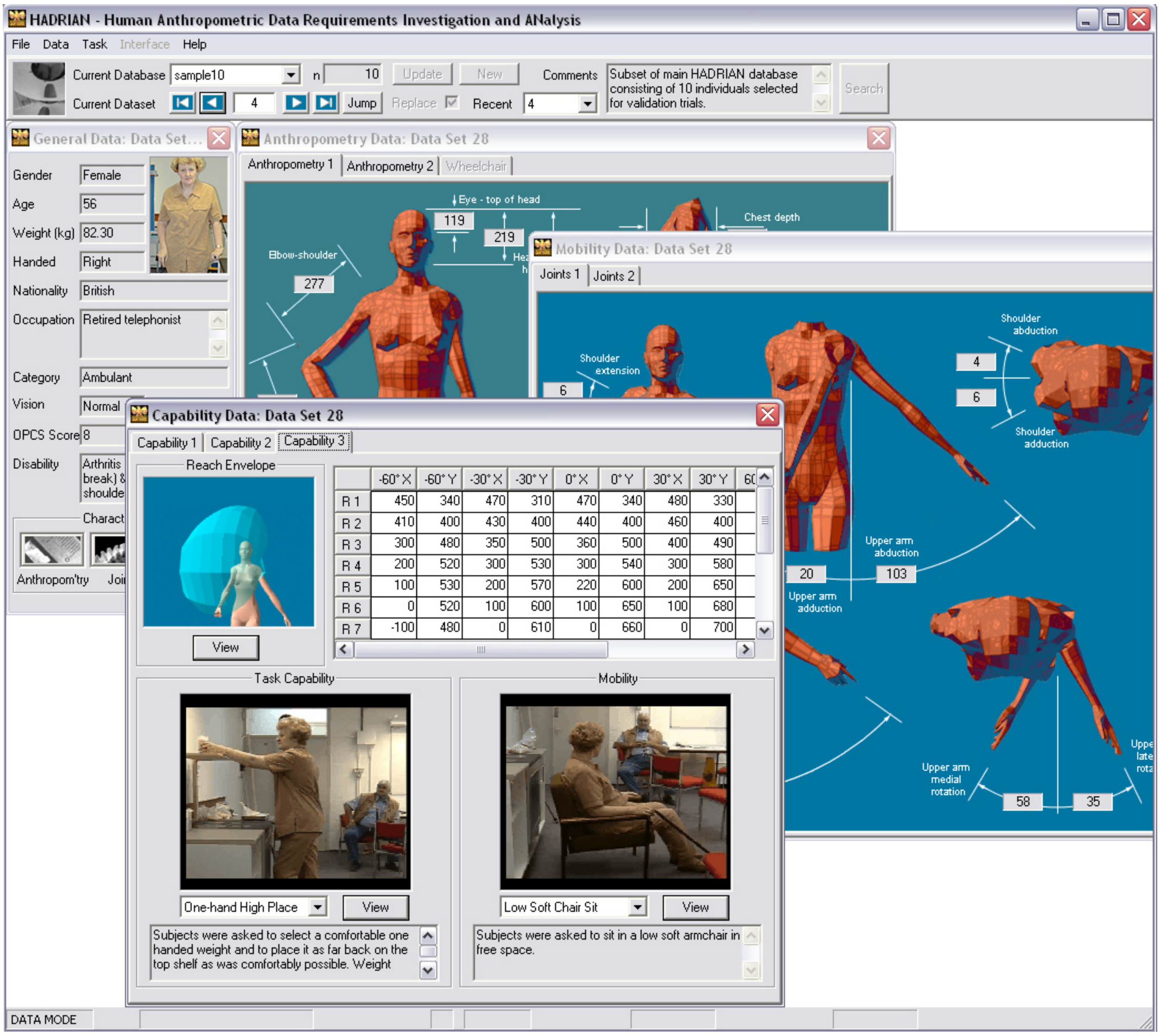

Figure 2. Example of various windows for a specific individual in the HADRIAN database

3. Task Description Language

HADRIAN contains the database of individuals described above plus a task description method for driving the underlying and long-established SAMMIE (System for Aiding Man-Machine Evaluation) system (Case et al, 1990). The task and its evaluation criteria are defined using a simple task description language (figure 3) and the subsequent analysis performs a loop that cycles through the individuals in the database to determine their capability in performing the task. The figure shows a small part of the task of obtaining money from an Automatic Teller Machine (ATM) where the first two elements are ‘look at screen’ and ‘reach to slot’. The complete task is evaluated for each individual in the database and a degree of intelligence is applied to the analysis – for example the reach to the card slot will be performed by the individual's preferred hand as handedness is an item in the database.

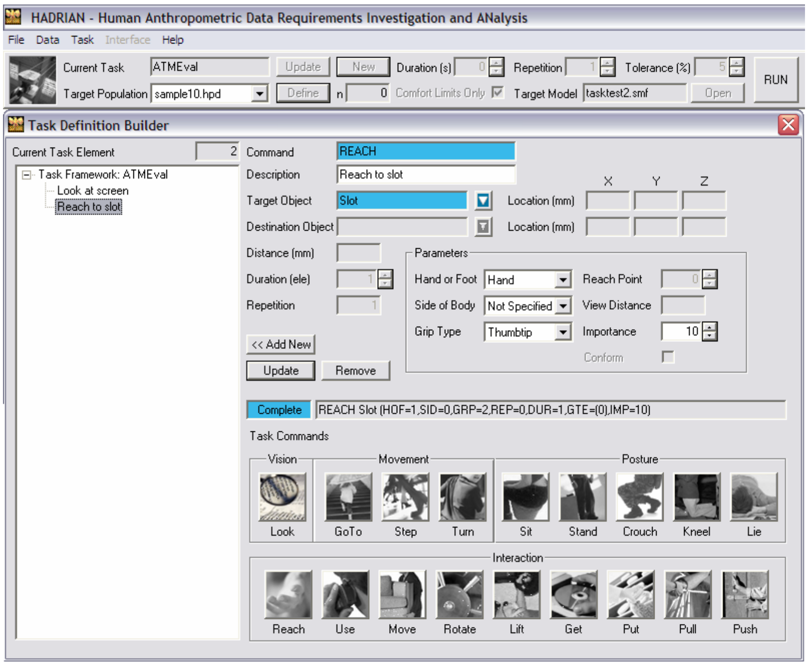

Figure 3. Constructing a Task Analysis in HADRIAN

On completion of the task analysis the percentage accommodated will be presented. This is the percentage of the individuals in our database that have been predicted to complete the whole task successfully. Should any individual be unable to complete the task then they will be identified and the situation causing the difficulty will be displayed (e.g. figure 4) together with a suggestion for improvement.

Figure 4. Best attempt to reach card slot

4. Accessibility and User Needs in Transport

Current research using HADRIAN is considering accessibility aspects of public transport systems. The work is focussed on the creation of a journey planner as the 'journey' expresses the need for individuals to complete extended tasks with failure in any one aspect making the entire task impossible. For example, a journey from home to a hospital followed by a visit to the pharmacy and a return home could involve walking, buses and trains with interchanges between the modes. Two test-bed sites in Camden (central London) and Hertfordshire (rural towns) are being used to identify a number of relevant journeys from which we can collect data. The journeys will be based on observation and real world experience from people and will include all of the accessible design elements that the individuals will have to deal with on those journeys. Potential barriers faced by the people who make these journeys are being identified (figure 5). These barriers may take many forms including physical, cognitive and emotional. The physical barriers (e.g. kerbs, lifts, escalators and street furniture) are the most easily assessed using human modelling techniques, but our data collection activity has included aspects of the cognitive (e.g. understanding of signage and timetables) and emotional (e.g. security concerns) characteristics of individuals. Many of these barriers may arise with in the course of making a journey and if any one prevents the user from achieving a relatively small part of the overall task it may well prevent the journey from being possible.

Figure 5. Potential barriers faced during a typical journey.

5. Conclusions

The work described in this paper has illustrated that it is possible to collect and use human data in a way that overcomes many of the difficulties that arise from the multivariate nature of such data. Maintaining data about the diverse aspects of individuals rather than forming statistical population data allows a virtual fitting trial approach to be used where an individual's particular capabilities and disabilities may be considered. The use of a task-based methodology allows for a more holistic approach to be adopted which is essential in our current area of interest – integrated public transport systems. The physical aspects of humans (e.g. anthropometry) are still the simplest to model but a start has been made in considering cognitive and emotional issues.

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