Virtual fitting trails using SAMMIE and HADRIAN

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ABSTRACT

Fitting trials are a common technique employed in ergonomics evaluation. Fitting trials employ a panel of users carefully selected to be representative of the population at which the product, or environment, has been targeted. The panel are then used to evaluate the design against a set of criteria in order to determine a level of suitability of the design. Whilst traditionally this process has taken place with real people and full size mock-ups, increasingly the process is becoming computer supported and makes use of CAD models and human manikins in a 'virtual' fitting trial. The use of these technologies can clearly play a key role in supporting user-centred design, however, there are a number of shortcomings in the current technology, data, and infrastructure used for computer aided ergonomics evaluations in design. This paper will introduce HADRIAN, a computer aided ergonomics analysis tool developed at Loughborough University. HADRIAN works together with the existing system SAMMIE. The paper will focus on the novel aspects of the systems demonstrating how, together they may be employed to not only make virtual fitting trails more efficacious but also encourage empathy with the end user.

INTRODUCTION

A common technique used during product development involves the assessment of the proposed design by users. This technique, known as fitting trials, involves individual users evaluating the design against a set of ergonomics criteria in order to investigate the suitability of the design. One important aspect of the trials involves the selection of the users. Care is taken to select a panel of test subjects that are representative of the target population for the product. The panel is then asked to assess a full-size mock-up or prototype of the design against a number of predetermined criteria. From these assessments a level of suitability of the design can be determined and any user issues identified before the product goes into production (Porter & Porter, 2001).

Fitting trails are an extremely important part of the product development but are, by necessity, performed late in the process when the design is sufficiently mature to allow physical models to be made. Thus, any findings from the trials that require design changes require a considerable amount of work to be redone introducing costs and time delays. Whilst this is relatively efficient in comparison to the costs of introducing a product to the market that has not been assessed by users, it is still desirable to push the process upstream.

To address this need fitting trials are becoming increasingly CAD based, using CAD models of the design and human manikin users in a form of a 'virtual' fitting trail. A range of human modelling systems exist such as SAMMIE, JACK, SAFEWORK and RAMSIS (Porter, Case and

Freer, 1999) with the trend towards the integration of human modelling capability with existing high-end CAD systems.

The use of these systems is not advocated as a replacement to fitting trails with prototypes and real people but instead they provide an opportunity to assess product ergonomics when changes to the design are much simpler to investigate and implement. However, a number of concerns arise when performing virtual fitting trails. As the process is pushed upstream it is increasingly likely that the users of these systems will be designers with little or no ergonomics expertise. In addition, the current data available for these systems or to the designer employing them is often unsuitable for the job at hand. These two concerns are the main drivers for the development of a new system, HADRIAN, that includes improved and more relevant data in addition with a tool to simplify its use and provide a more accurate reflection of a real person performing the trial.

ANTHROPOMETRY AND HUMAN CAPABILITY DATA

The use of human modelling systems during the early stages of design is clearly a powerful tool in achieving designs that meet the needs of the target users. However, such systems are not always used by experienced ergonomists. Even when the systems are used by ergonomists there are concerns that the computer human models may be treated simply as ‘articulating components’ of three different sizes of people – small female, average male and large male. In addition, the necessity of multivariate analyses during the fitting trails is hindered by the decomposition of the data, and often the trial itself, into univariate elements. This, clearly, is not a satisfactory approach and may actually lead to product being designed that effectively excludes potential users.

Information sources for designers are very fragmented. Virtual fitting trails require access to a large library of publications in order to compile information on the physical size and abilities of people of all ages. This is necessary so that the designer or ergonomist can construct a variety of 3D human models to represent the wide variety of envisaged users of the product or service being designed within a CAD system. Current anthropometric and biomechanics databases present information typically as univariate percentiles with a separate table of numbers for each variable, such as eye height, arm reach or hand grip strength. These percentile tables are prepared for either a healthy population aged 19-65 years or for specific populations, such as people who are older and with disabilities. Sadly, most of these databases do not promote the need for multivariate analysis.

An even more concerning issue is that many databases present data only for the male and female 5th, 50th and 95th percentile values for each variable. This, erroneously, encourages the designer (both practically and morally) in ‘designing out’ up to 5% of females and/or 5% of males for every important dimension of the product or workstation. Roebuck et al (1975, page 268) perfectly illustrates the problem with using univariate percentiles. They document that nearly half of a population being designed for (cockpit design for aircrew) were actually 'designed out' when the 5th to 95th percentile range was used on a large number of body dimensions in a safety and performance critical workstation. The aircrew that were designed out because their backs were too long were not the same as those aircrew designed out because their legs were too short, their hips too wide, their thighs too long, and so on.

Statistical methods do exist which can be used by specialists to conduct multivariate analysis, such as Principal Component Analysis and Monte Carlo simulation. Both are complex and these approaches lack face validity, literally. Whilst many designers have doubts about the validity of combining different percentile body parts based upon statistical calculations, the fact that there are no actual faces that can be put to these anonymous statistical creations is a bigger problem. Designers need to have empathy with the people they are designing for – they find it difficult to

design for statistical calculations. Empathy comes from seeing people and getting to know and understand their needs and desires.

The data also need to be task and environment specific. For example, when performing some every-day task it is unlikely that there will be data available that reflects the reality of an individual performing this task. Data is often standardised and sanitised to such an extent that it becomes practically inapplicable to most fitting trails. Existing reach task data will reflect right handed users in a fixed and predefined posture reaching to a specific location with the tip of their fingers. When it comes to applying this data to a person reaching into an oven using both hands and oven gloves there is clearly no correlation. The appropriateness and applicability of the data is further compromised when a design might include older and disabled users amongst its target population.

A DATABASE OF INDIVIDUALS

In order to address many of the issues raised with current data we have developed a computer database of 'individuals' so that multivariate analysis can be conducted on a wide range of real people of all ages, abilities, shapes and sizes. As opposed to tables of percentiles for each body dimension the database preserves the information for each individual as a complete dataset (Figure 1). This allows each individual's anthropometric dimensions (and percentile values), joint mobility, strength capability and coping strategies (task behaviours) to be integrated by constructing a unique virtual human model for each individual. This literally enables us to 'put faces' to the data and makes multivariate analysis more straightforward, at least conceptually.

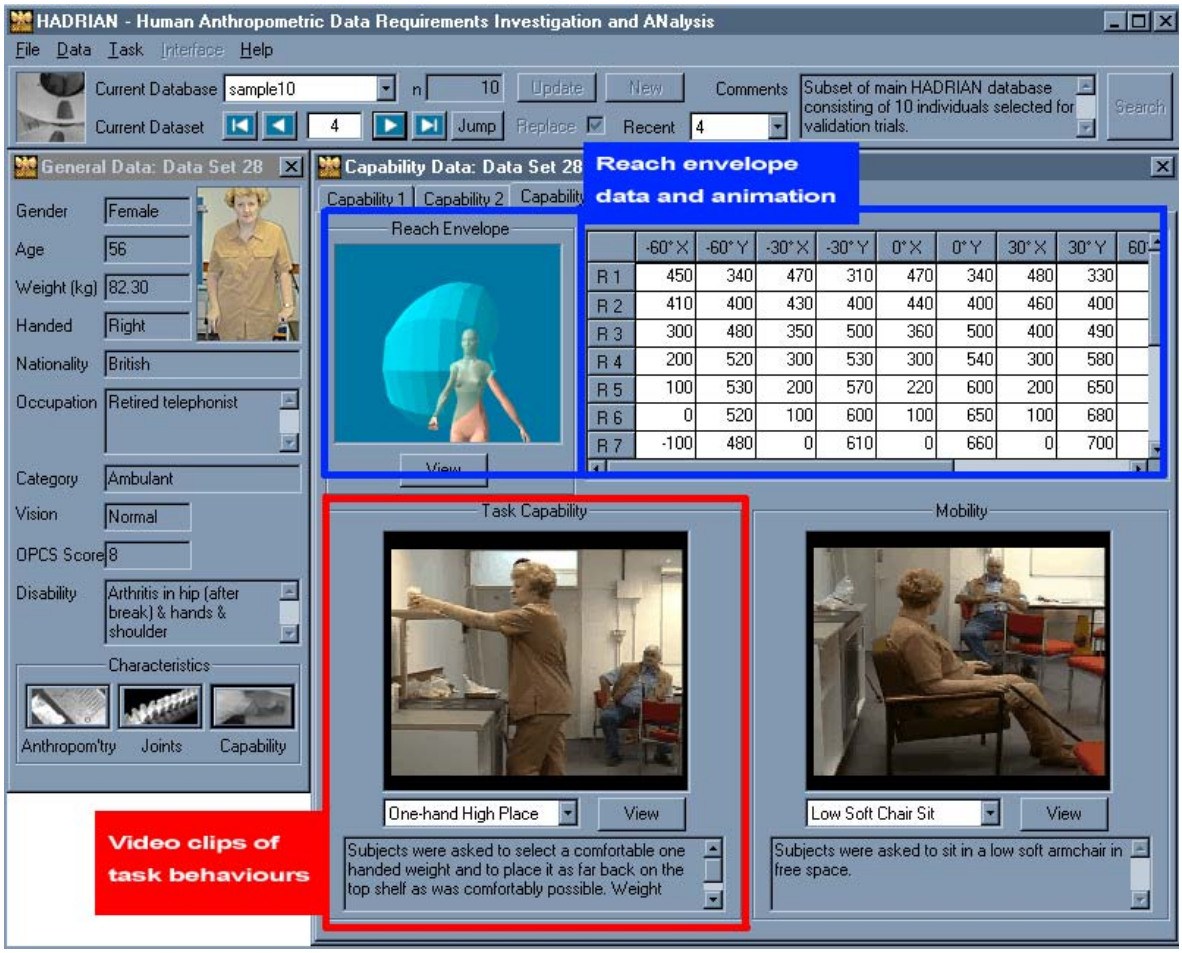

Figure 1. The HADRIAN system showing one part of the capability data for an individual.

The database currently comprises 100 individuals, including a large proportion who are older and/or disabled. This sample, whilst not strictly representative of the whole population, provides a useful measure of the extent of variation in physical characteristics and capabilities and forms a preliminary database for the development and validation of the predictive tool. HADRIAN's database features allow the designer to investigate the stored data on the individuals, not only for the purposes of determining a suitable user group for task analysis but also to allow them to become more familiar with the users. In addition to the range of anthropometric and mobility data, HADRIAN stores extremely rich and design relevant data on the individuals, including pictures, video of task behaviours and capabilities so that the designer may gain some empathy with the user they are trying to design for. We believe that this feature alone could be a valuable educational resource.

HADRIAN

HADRIAN (Human Anthropometric Data Requirements Investigation and ANalysis) is the computer aided design tool that integrates our database of individuals including their anthropometry, their mobility / capability, disability, coping strategies and a wealth of background data, with a simple but powerful task analysis tool.

HADRIAN has been developed to complement the existing computer aided ergonomics system SAMMIE. SAMMIE is a human modelling system with capabilities to represent humans with variable anthropometry, somatotype (flesh shape) and joint capabilities in order to use the resulting manikin in various assessments of fit, reach and vision. Together these systems provide a means of developing an understanding and empathy with the target users in addition to allowing task analysis and virtual fitting trials to be carried out on a design without the need for prototypes and user trials. However, it is not the intention to replace physical models and user trials but rather to complement them. HADRIAN provides the designer with a means of performing this kind of analysis, and getting a feel for some of the types of feedback that might be achieved through these processes, at an early stage in the design when the time and costs for real trials are prohibitive.

The two systems: HADRIAN and SAMMIE, provide the designer with the ability to:

- model a product / environment, or import a model generated on another CAD system,
- select a target user base – which should be the whole database when designing for all,
- quickly put together a task description with as much or as little data on viewing distances, which hand to use, etc.,
- run the task analysis with the chosen user base,
- inspect the results of the analysis including the percentage accommodated, who failed what parts of the analysis and why the failure occurred,
- modify the design / task parameters and re-run the analysis for comparative studies.

VIRTUAL FITTING TRIALS

HADRIAN's task analysis features are aimed at providing the designer with a simple and flexible, yet powerful, mechanism for constructing a task description for performing virtual user trials. Whilst most of the actual tools for performing individual elements of a task analysis are part of SAMMIE's inherent functionality, HADRIAN attempts to simplify their use and remove the overhead of driving the system allowing designers to investigate their designs without the need for ergonomics expertise.

The mechanism of performing a trial has been outlined elsewhere (Marshall et al, 2002a & b) thus this paper will illustrate the principles through an example: the scenario of obtaining money from a cash dispenser or ATM. Early on in the design process two optimisation issues are highlighted: the first concerns the layout of the ATM components within the ATM frame; the second is the location of the ATM frame within its environment. Whilst conceptually the process of using the ATM is a simple one, both of these layout issues require a complex multivariate analysis of both the design and the potential users of the design. The only truly satisfactory method of obtaining the kind of feedback required would be to produce a physical mock up and perform some user trials or to simulate the problem using a human modelling system. This requires ergonomics expertise at many levels including selecting the correct data to construct the virtual user, creating appropriate postures for the tasks being performed and assessing these postures. These activities are non trivial and must be repeated an indeterminate number of times to address the whole population.

When using HADRIAN, the designer first loads the CAD model to be assessed. The designer then develops a task description (see Figure 2) using a combination of task commands (e.g. reach), task targets from the model (e.g. keypad, card slot) and a number of appropriate optional parameters (e.g. grip type). Once this has been done, the designer selects a user group from the database (age, gender, ability level etc), which ideally would include the whole database, and then sets the system running through each user and every task element in the task description.
During the analysis, techniques are used that reflect the multivariate nature of the analysis. The system employs a framework which overlays the task description in an attempt to more accurately represent a dynamic process (i.e. performing the task) from static task elements (i.e reach x, view y etc.). This task framework is used to provide the system with information on how task elements interact such that any particular key-frame posture is optimised related to the previous and future key-frame postures.

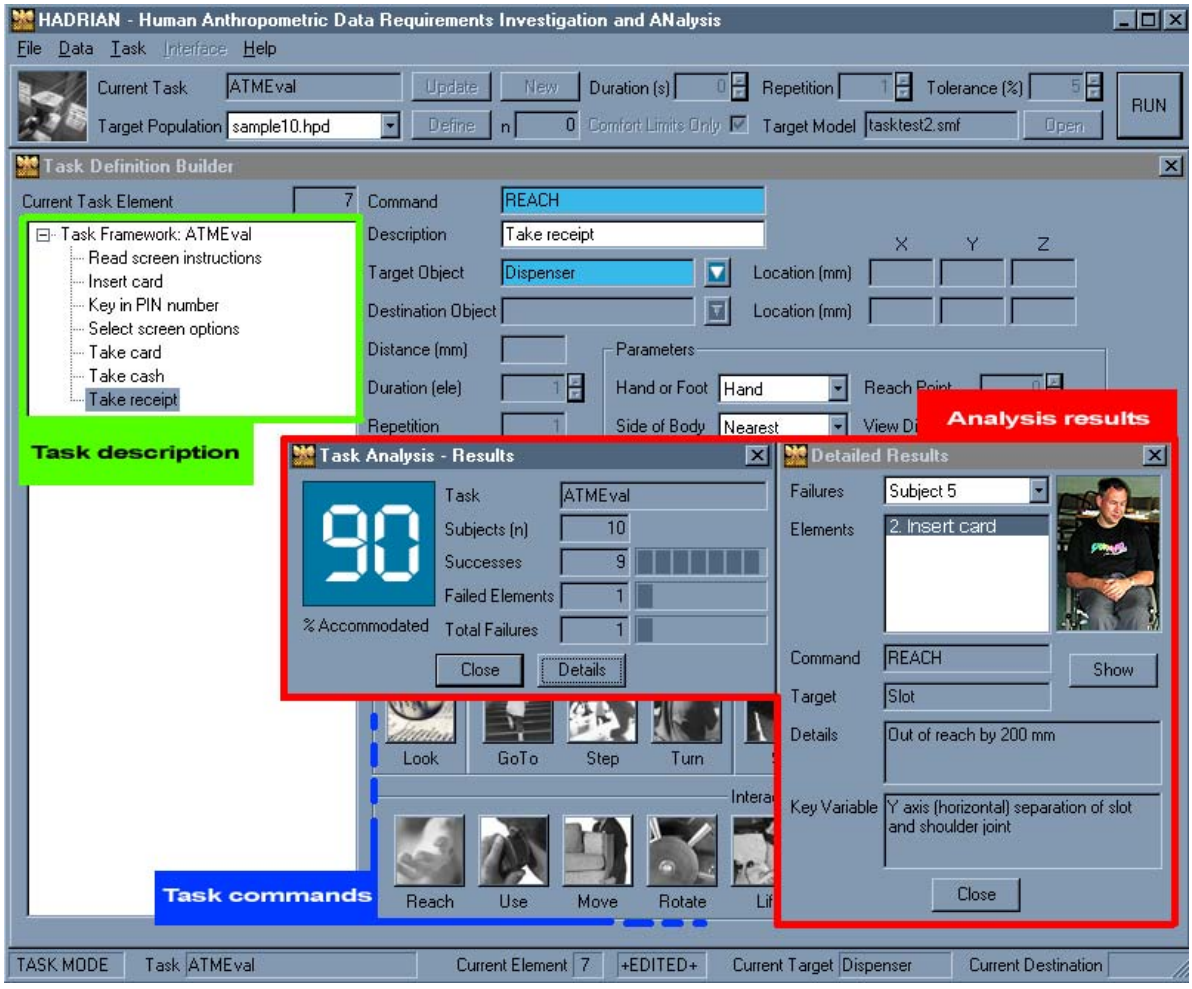

Figure 2. HADRIAN system showing task analysis interface and results of the ATM trial.

Once the analysis is complete HADRIAN presents a number of results to the designer. The primary metric is the percentage of the sample population accommodated by the design, or conversely the percentage designed out. Figure 2 shows the results from the ATM evaluation. At one level this might be sufficient information for quick analyses where a number of concepts are being roughly assessed. However, much more detailed information can be examined that stems from this result. For example, individuals who have been unable to perform the task can be examined. From the combination of their data and the data of the task element, the designer can see exactly the reason for failure. Whilst HADRIAN is not an intelligent design system and cannot tell the designer how to change the design of their ATM to improve accommodation, it can highlight the key variables that are involved in the failure and direct the designer's attention to the fundamental reasons for the problem.

To close the loop, the designer can then return to their CAD model of the prototype design and modify their design and perform 'what-if' type assessments to try to improve the percentage accommodated.

CONCLUSION

The HADRIAN tool has been developed to encourage and support designers in the use of human modelling systems for ergonomics evaluations such as virtual fitting trails. HADRIAN provides this support through the novel application of anthropometric and biomechanical data on individuals. This application improves both the appropriateness and applicability of these data, in addition to enhancing the empathy with user that the data ultimately represents. HADRIAN also addresses the use of these data, particularly by those who are not ergonomics experts. By automating the processes of manikin creation, posture creation, and assessments of fit, reach and vision, HADRIAN allows the designer to experience some of the feedback that could be obtained by user trials early on in the design process when the greatest impact may be had on the design for the least cost in both terms of money and time.

HADRIAN is a tool that is still in development and our research has highlighted many potential capabilities that could be included into its suite of tools. We aim to concentrate our efforts on two fronts. Firstly, to increase the size of our database, both in terms of individuals and task behaviours, to make it more representative of the population as a whole. Secondly, to concentrate on furthering the usability of HADRIAN to ensure that the minimum overhead is placed on the designer so that they may gain access to the data they require in the shortest time and with relevant and accurate results.

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