

# Virtual Task Analysis In ‘Design For All’.

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## ABSTRACT

‘Design for All’ or ‘Inclusive Design’ is an approach to product, environment or service design that aims to maximise the applicability of a particular design. However, the concept is not to tailor designs in a bespoke fashion, but rather to provide a single solution that accommodates the needs of all users including those who are older or disabled.

In order to educate and support the designer in their endeavours to ‘Design for All’ a computer aided design and analysis tool has been developed. The tool, known as HADRIAN, has been developed to meet two key areas of deficiency in existing approaches. HADRIAN provides improved data for the designer with a sample database of 100 individuals across a broad spectrum of ages and abilities. HADRIAN also provides a means of using this data for ergonomics evaluations through a task analysis tool. Working in combination with the existing human modelling system SAMMIE the system allows the designer to assess their designs against the population in the database to determine the percentage who are effectively ‘designed out’.

**KEYWORDS:** Design for All, Simulation, Task Analysis, Ergonomics

## 1 INTRODUCTION

‘Design for All’ or ‘Inclusive Design’ [1] is an approach to the design of products, services or environments that attempts to meet the broadest range of user needs from the outset. The breadth of requirements to be met include those of older and disabled people who traditionally may need to look for bespoke products rather than purchasing or using more mainstream designs.

In addition to the social argument for such an approach there is an increasing legislative and economic impetus to address the needs of this increasing population. In Europe 25% of the population will be aged 60 or over by 2020 [2]. Estimates suggest that world total will be more than 1 billion people aged 60 or over by the year 2025 [3]. Socially, accommodating these people will allow them to lead much more normal lives without the stigma and cost associated with specialised products. Economically, developing a product or service that is equally suited and appealing to younger able-bodied people, in addition to older and/or disabled people, hugely broadens the potential market. It has also been estimated that 36 million disabled people in the U.S. spend 40 billion dollars on special products and the population over 50 purchases 60% of all domestic cars and own 50% of all homes [4].

## **2 DATA NEEDS**

For designers attempting to ‘Design for All’ current anthropometric and biomechanics databases show a number of limitations. Information sources for designers are very fragmented. ‘Designing for All’ requires access to a large number of data sources in order to compile information on the physical size and abilities of people of all ages. Even when the data has been collected its application is not trivial. Most current data are presented as univariate percentiles with a separate table of numbers for each variable, such as eye height or arm length. These percentile tables are prepared for either a healthy population aged 19-65 years or for specific populations, such as people who are older or with disabilities. Clearly this format does not promote multivariate analysis that is necessary for most product user trials.

An additional complication is that many databases present data only for the male and female 5th, 50th and 95th percentile values for each variable. This encourages the designer in designing out up to 5% of females and/or 5% of males for every important dimension of the product or environment. In practice this leads to a much greater percentage being designed out in a typical multivariate analysis when a number of dimensions are considered in unison, as those designed out for variable 1 will not be the same as those designed out for variable 2 etc.

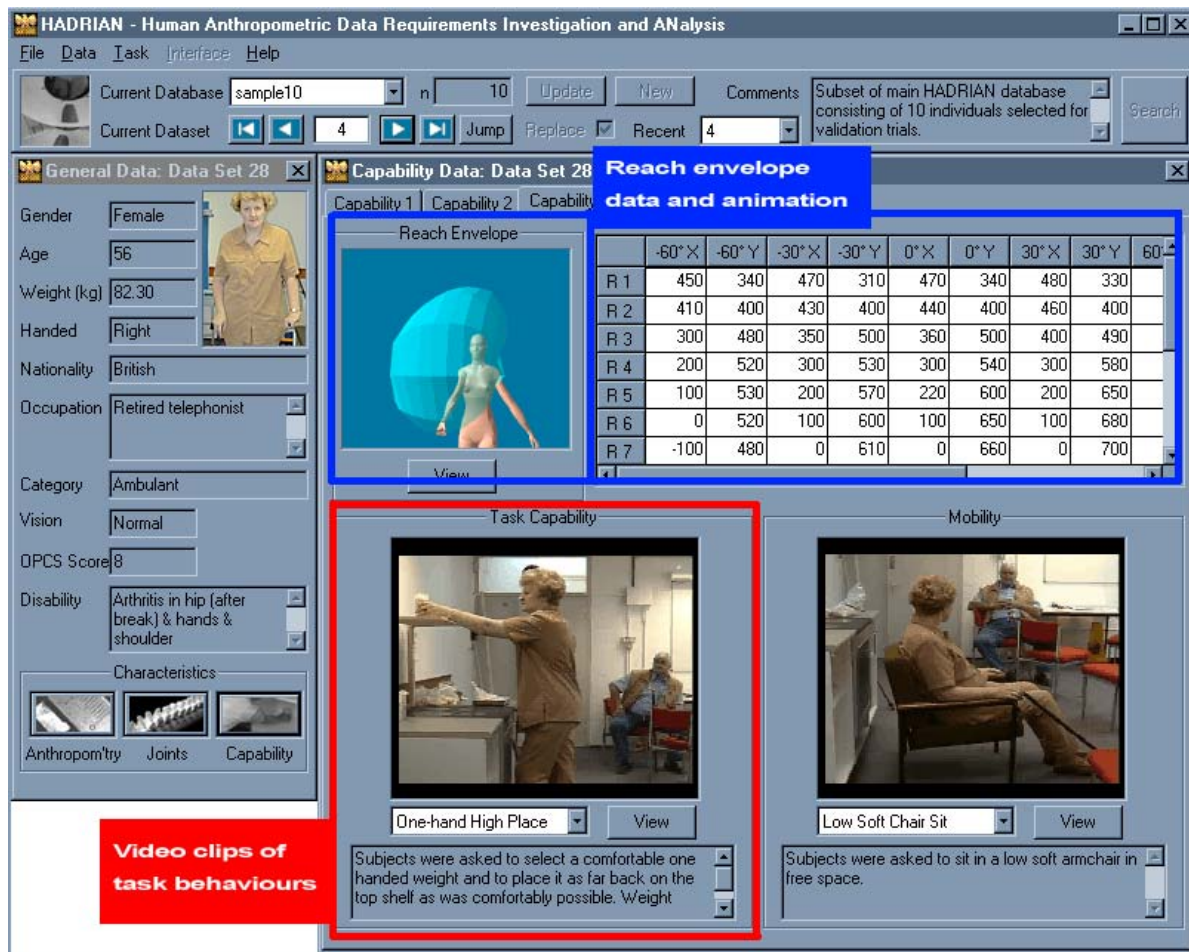
One further issue is the need for task and environment specificity. Most data available has been taken in a generic manner to aid data collection and presentation. However, this generic nature makes it much more difficult to apply to the non-generic situation that the designer will no doubt be designing for.

Our approach to these data issues is to capture a broad range of data on individuals from a range of ages and abilities. This differs from the more widely available population data by providing a holistic and robust data set that is ideally suited to the complex multivariate analyses that must be performed to assess the capabilities of the user [5].

From our survey of 50 UK designers it was identified that there is a need to provide ergonomics data in a highly visual form that can be used efficiently in combination with existing design tools and practices. Most existing information is summarised in the form of guidelines. These are prescriptive evaluation tools rather than predictive tools which are necessary for supporting concept design. As most designers now use CAD tools extensively, it was considered to be highly appropriate to provide support through this medium.

### 3 A DATABASE OF INDIVIDUALS

In order to address many of the issues raised with current data we have developed a computer database of ‘individuals’. This database facilitates multivariate analysis by providing a readily available virtual user group than span a breadth of 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 dataset is primarily aimed at constructing a unique virtual human model for each individual including correct anthropometry, joint mobility and flesh shape. In addition to these physical characteristics data is available on capability including strength and task behaviour.



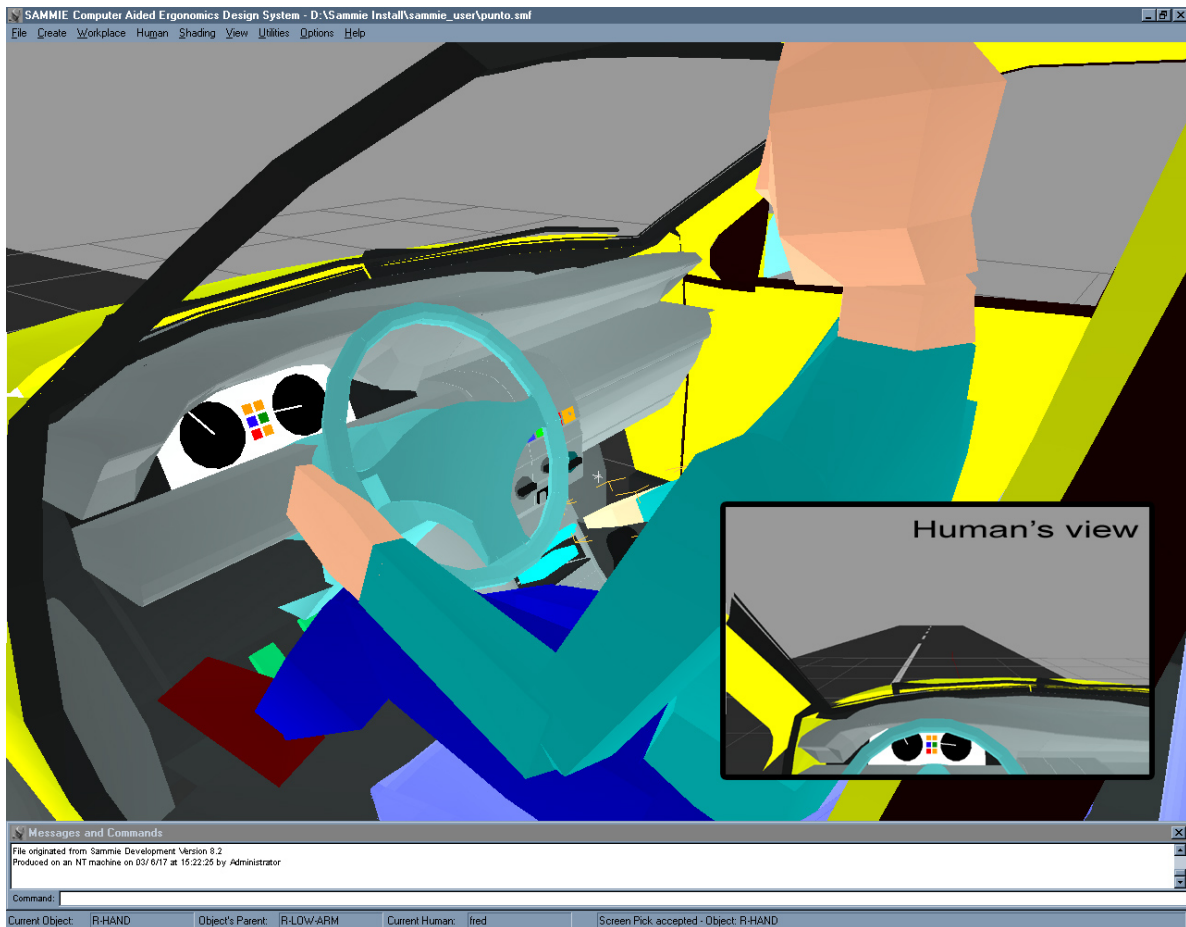
**Fig. 1 The HADRIAN system showing part of the capability data for an individual.**

The database was initially developed around 100 individuals, including a large proportion who are older and/or disabled. This sample, whilst not representative of the population as a whole, 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 allows the virtual user group to be investigated. Extremely rich and design relevant data can be examined in order for the designer to become more familiar with the users, their capabilities and behaviours for common tasks. Having gained some form of empathy with the individuals in the database the designer can then use the database features to determine a virtual user group for the task analysis of their design.

## 4 HADRIAN

Whilst acknowledging the need to address the lack of relevant and accessible data it is not sufficient to merely supply more appropriate data to the designer. Support must be given throughout the design process including application of the data in a more predictive environment.

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.



**Fig. 2 Performing a task analysis in the SAMMIE system.**

HADRIAN has been developed to complement the existing computer aided ergonomics system SAMMIE [6]. 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. Clearly this capability can be utilised to create virtual users and carry out virtual task analyses. However, the issues with creating humans from compartmentalised and inappropriate data and the knowledge and experience required to fit the humans into the environment, provide a realistic posture, and then to assess the accommodation of the design highlights the importance of ergonomics expertise in this activity. HADRIAN has been developed to aid the designer or

design team who may not poses all of this expertise by automating much of this activity, allowing the focus to be placed on the design and application of sound ergonomics as opposed to driving the system.

Together SAMMIE and HADRIAN 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 user trails with 100 (at present) virtual people to gain 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.

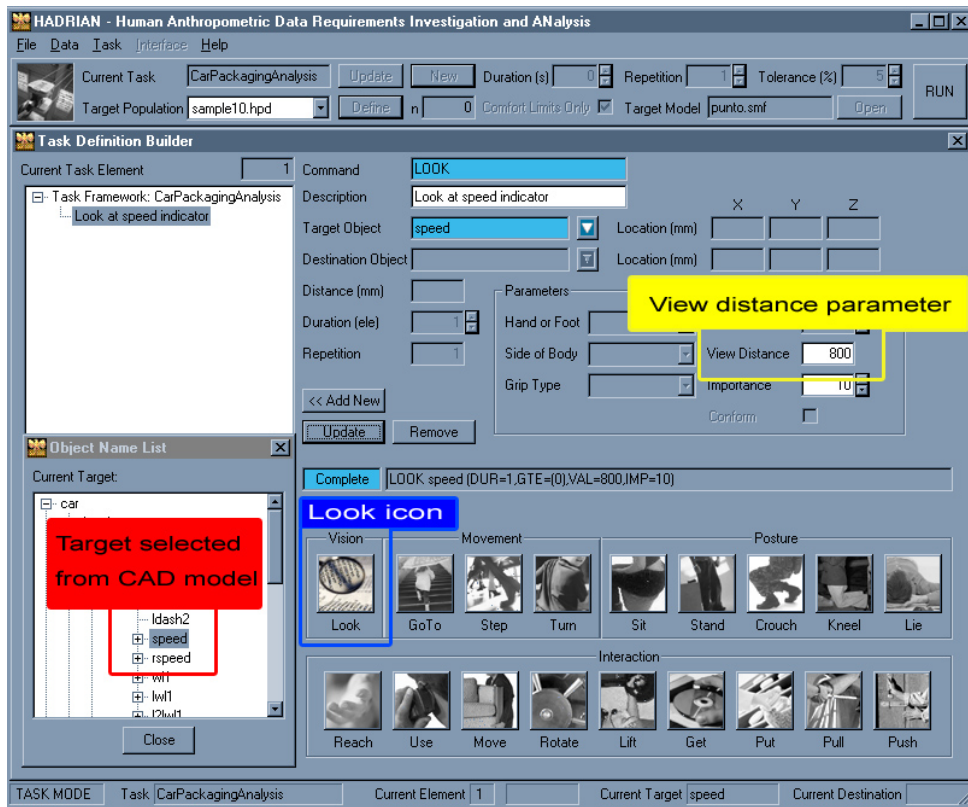
## **5 VIRTUAL TASK ANALYSIS**

If a designer wishes to carry out a user trial they would typically develop a task analysis, breaking the task down into a number of elements that the users are to perform. For each element assessments could be made on the performance of the design and the thoughts of the users. HADRIAN's task analysis features follow this protocol, providing the designer with a simple, flexible and 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 focuses on integrating with the existing working practices of the designer and simplifying the overall process.

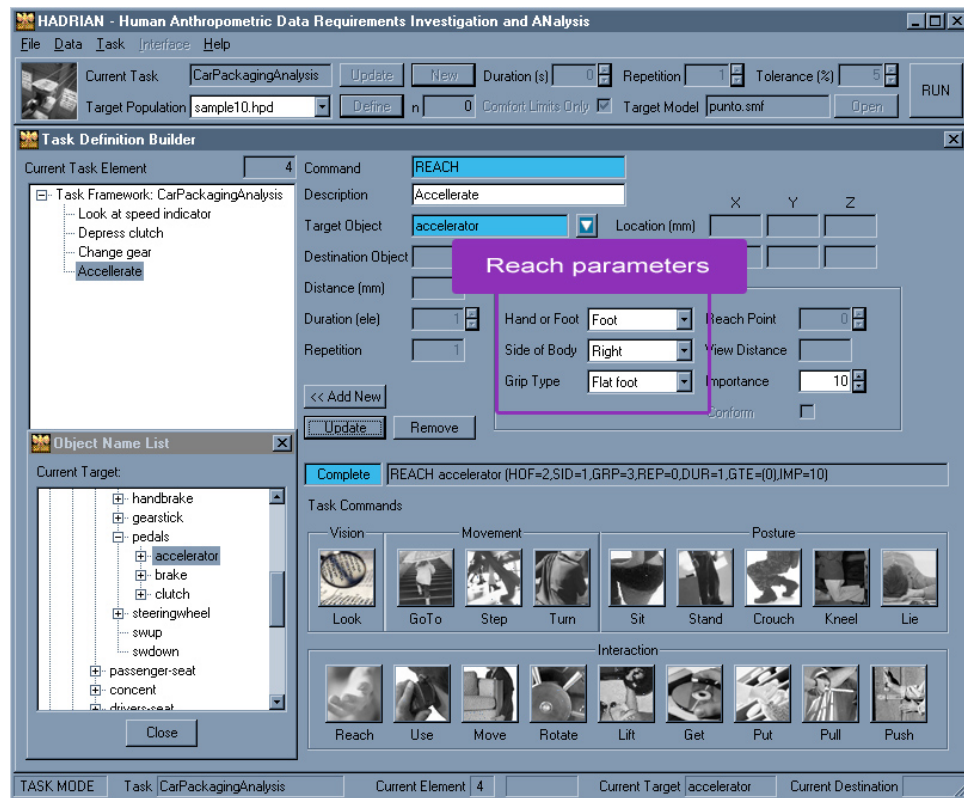
HADRIAN's task analysis capability as based around an analysis framework and an underlying structure that attempts to recreate realistic postures in the virtual environment [7, 8]. However, much of this complexity is hidden to the designer. From a design perspective it is important to understand how the system is making its decisions but ultimately it is features such as ease of use and speed of feedback that is important. The assessment acts upon a CAD model generated by the designer using their favoured system. This CAD model does not have to be complex, most ergonomics analysis is carried out for gross motion and view assessments, thus time spent on complex aesthetic features are not required at this stage. This is an important point as it allows quick assessments to be made at the concept stage before the details are defined.

Constructing a task consists of a familiar verb + noun pairing, 'reach keys' for example. This process is iconified and tied directly into the CAD model to be assessed. For each task element parameters may be adjusted to suit the level of data that the designer has access to. For vision task elements an acceptable view distance may be set, for reach task elements the type of reach grip may be set i.e. do we want the user to reach with a finger tip or a pinch grip etc. A variety of appropriate parameters are available and can be easily modified to try out the effects of different selections. If the designer does not possess the relevant information or has not yet made a decision as to how a particular feature is to operate than all parameters have a default. These defaults are not fixed, part of the underlying framework is to make assessments at each stage of the task as to the appropriateness of the task parameters. Thus, if the reaching hand parameter was not specified the system would take into account the nearness of each hand to the target to be reached, the handedness of the virtual user and the behaviour of that user who may use their favoured hand to hold a walking stick whilst performing tasks with their less favoured hand.



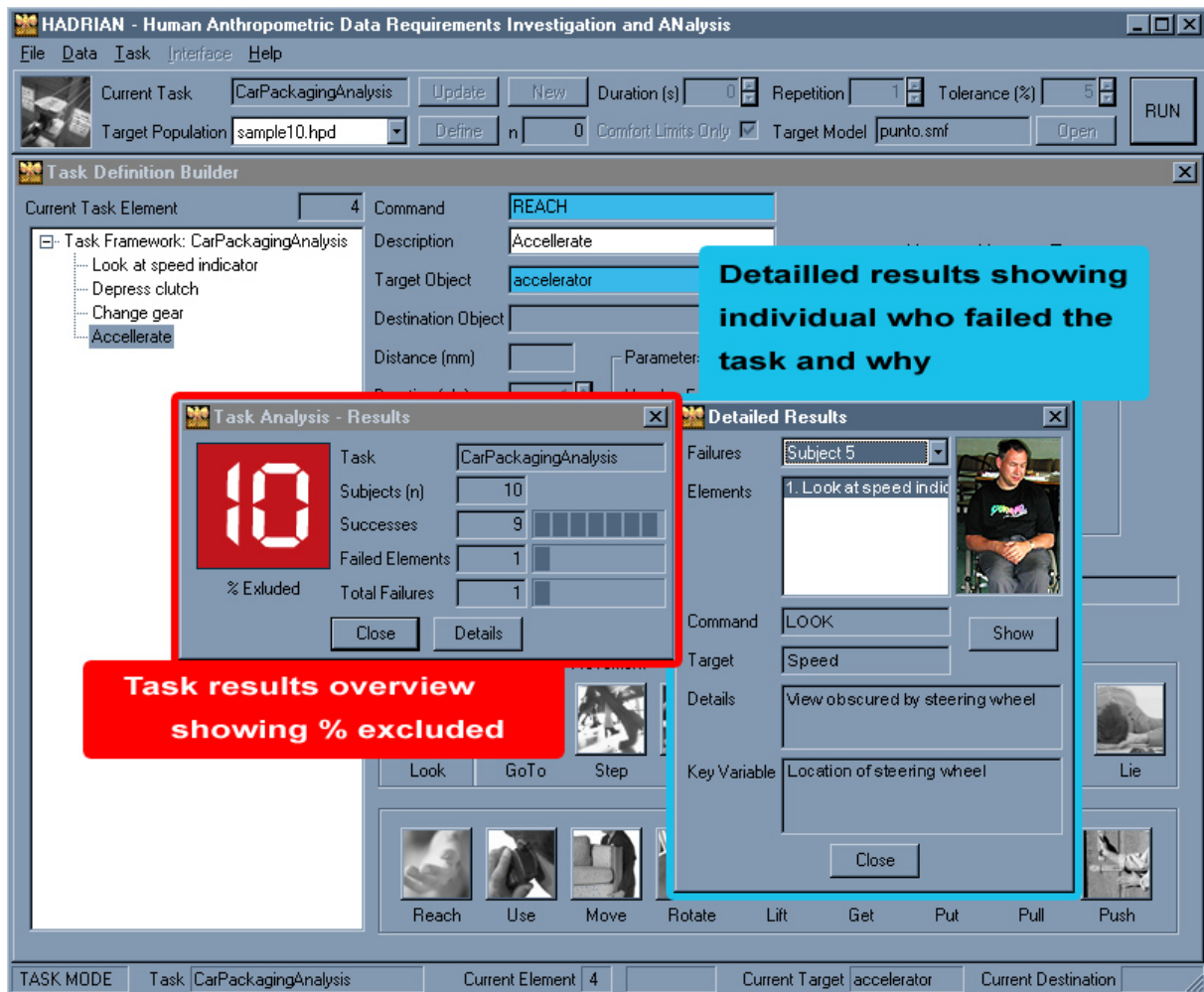


**Fig. 3 Defining a LOOK task element in HADRIAN.**



**Fig. 4 Defining a REACH task element as part of the same task analysis.**

When fully defined the task analysis is run. The system then puts the selected population from the database through each task element. On completion the system displays the overview results of the analysis. Figure 5 shows the percentage of the test population who have been excluded from completing the task. These results also make a distinction between a task element failure and an overall task failure as any one task element may not be critical to the successful completion of the task as a whole. Further results can be viewed where the designer may look at the individuals who failed, what they failed upon, and why. The system is not intelligent but can identify key variables or factors in the failure and thus guide the designer to the problem area. 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 excluded.



**Fig. 5 HADRIAN showing the analysis results.**

## 6 CONCLUSION

In response to the need to encourage and support designers in embracing ‘Design for All’, our design tool HADRIAN has been developed. HADRIAN promotes a novel method of data presentation making a move away from the traditional percentiles of ergonomics data to the storage and presentation of datasets on individuals. This method not only makes using the

data a much simpler process it also allows the designer to become much more aware of the individual as opposed to merely a set of data. In addition, the data is much more relevant to design. Task specific information and behavioural data allow the designer to be much better informed about how real users will interact with their design much earlier than physical product trials would traditionally allow. HADRIAN also supports the data by providing a tool for task analysis. Now the designer can automate many of the complex and time consuming tasks associated with computer based ergonomics evaluations such as manikin creation, posture creation, and assessments of fit, reach and vision. Finally the system provides some of the feedback that might be gained by real user trials at a stage when concepts are being investigated and physical mock-ups and user group selection would be prohibitively time consuming and expensive.

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. Much of the work has been done to allow us to investigate the capabilities of HADRIAN and test the underlying methodology. Future work is to look at broadening the database to make it much more representative of the population of users. Work is also being done on improving the interface, addressing designers needs and their way of working. Finally, other areas of endeavour are focussing on design optimisation from HADIRAN results using constraint modelling and also increasing the emotional content of the database with even richer data on the individuals.

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