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# HADRIAN: An Integrated Design Ergonomics Analysis Tool.

Russell Marshall<sup>\*1</sup>, Keith Case<sup>2</sup>, Diane E. Gyi<sup>3</sup>, Ruth. E. Oliver<sup>1</sup> and J. Mark Porter<sup>1</sup>

<sup>1</sup> *Department of Design and Technology.*

<sup>2</sup> *Mechanical and Manufacturing Engineering.*

<sup>3</sup> *Department of Human Sciences.*

*Loughborough University, Leics LE11 3TU, UK.*

**Abstract.** In order to support the philosophy of ‘design for all’ within the design community two key areas have been identified that are critical to success. The first is the provision of accurate and relevant data on the target users. The second is the efficient and effective support in the use and application of this data during product development. This paper details the approach taken to this support through the development of our CAD tool: HADRIAN. HADRIAN provides an integrated database together with a task analysis suite that can be used to simulate and assess virtual ‘what-if’ scenarios of human interaction (fit, reach, vision, strength etc.) with the product or environment being developed.

## INTRODUCTION

Current design methods are dominated by computer tools with a significant proportion of product development being managed and performed in a three-dimensional digital environment. This paper describes the research being undertaken to address designer’s needs for more relevant and accessible data, and in addition, the tools to use this data for ergonomics analysis during the early stages of design. A particular focus of the work is an approach to design, driven by the ongoing ageing of populations across the world (PRB, 1999), which addresses the needs of older and disabled people. However, this approach does not look to address the needs of these people in isolation, but instead seeks to encourage the design of products that meet the needs of a broader range of the population, and where possible the whole population under the theme of ‘design for all’.

Providing the designer with appropriate data about their target ‘users’ is an important requirement if we wish the user’s needs to be addressed in the product design. Our approach to the collection and provision of these data takes a novel approach through the capture of a broad range of data on *individuals* from a range of ages and abilities (Oliver et al, 2002). 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 (Porter et al, 2002).

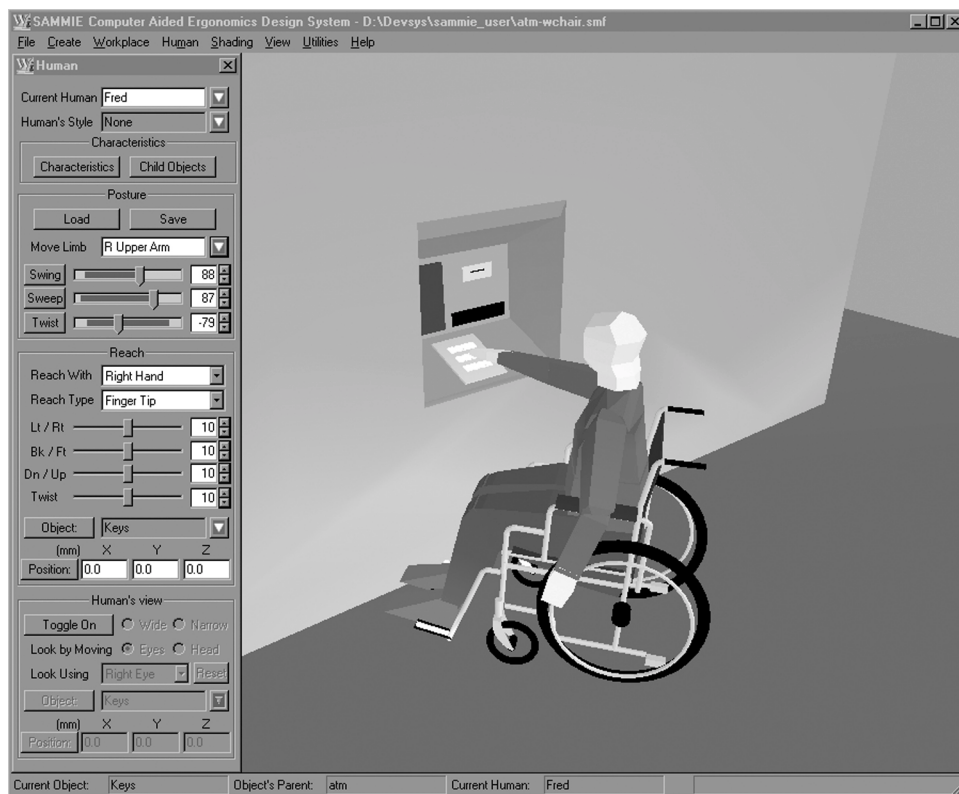
Whilst acknowledging the need to address the lack of relevant and accessible data it is not sufficient to merely supply these data to the designer without consideration of support. Support must be given in understanding and applying these data appropriately. Whilst ergonomics data are not complex they are easily misunderstood or misinterpreted and often are difficult to apply. Typically, the designer is faced with having to use highly generic data for a highly specific task. Thus, our database of individuals is also supported by an integrated ergonomics analysis tool.

<sup>\*</sup> Russell Marshall (Email: [r.marshall@lboro.ac.uk](mailto:r.marshall@lboro.ac.uk), Fax: +44 (0)1509 223 999, Phone: +44 (0)1509 222 669)

## HADRIAN

HADRIAN (Human Anthropometric Data Requirements Investigation and ANalysis) is a computer aided design tool that integrates the 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 (Porter et al, 1999). SAMMIE is a human modeling system with capabilities to represent anthropometrically correct humans together with somatotype (flesh shape) and joint capabilities that can be utilised in various assessments of fit, reach and vision (Figure 1.). Together these systems provide the capability to investigate data on individuals 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.



**Figure 1:** A development version of the SAMMIE system on the WindowsNT platform running a HADRIAN task analysis.

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

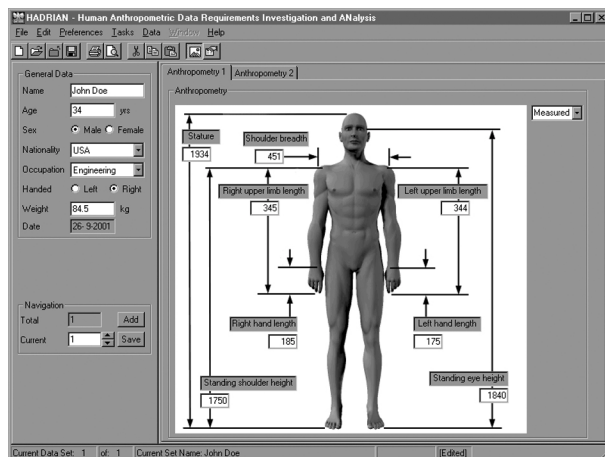
- model a product / environment, or import a model generated on another CAD system,
- select a target user base – which should be the whole database when designing for all,
- quickly put together a task description with as much or as little data on viewing distances, which hand to use, etc.,
- run the 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.

## DATABASE AND TASK ANALYSIS FEATURES

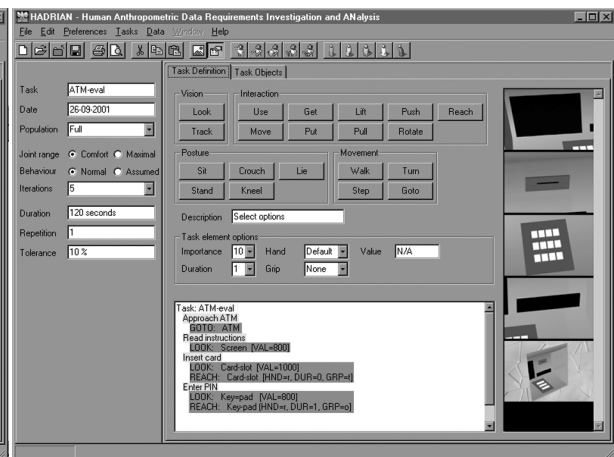
HADRIAN's database features allow the designer to investigate the stored data on the individuals not only for the purposes of determining a suitable user group for task analysis but also to allow them to become more familiar with the user (Figure 2.). In addition to the range of anthropometric and mobility data, HADRIAN stores extremely rich data on the individuals, including pictures of the real person (with permission) and video of task behaviours and capabilities so that the designer may gain some empathy with the user they are trying to design for.

HADRIAN's task analysis features are aimed at providing the designer with a simple, flexible and yet powerful mechanism for constructing a task description for the use of, or interaction with, their chosen product or environment design. 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 whilst concentrating on the application of sound ergonomics principles (Figure 3).

To construct a task description the designer loads the model to be assessed from which the system extracts the interactive objects; those elements that will be sat-on, reached to, viewed, activated etc. The designer then decides what the user is to do by selecting the type of task element e.g. reach, and then selecting the object to be reached to e.g. keys. Whilst the system provides the user with ability to enter as much detail as they wish, it does not require it. Information that may be supplied includes: which hand should be used, the duration of the reach, the importance of this task element, any maximum viewing distances, and orientation information for objects (this way up). Any information that the system needs to perform the analysis that is not explicitly specified by the designer will be set to a default that is task specific. Thus, the system may decide to use the nearest hand to perform a reach, but this may be overridden if the individual being assessed has a limited capability with that particular hand or has specified a preference that tends them to only use a particular hand for a particular type of task.



**Figure 2:** A screenshot from the prototype HADRIAN database.



**Figure 3:** A screenshot from the prototype HADRIAN task analysis tool.

The techniques behind the analysis have been developed to be as robust as possible allowing for the multivariate nature of the analysis. The system also employs a framework which overlays the task description in an attempt to more accurately represent a dynamic process (performing the task) from static task elements (reach x, view y etc.) (Marshall et al, 2001). Such features have little or no impact on the designer but lead to a much more flexible and realistic analysis.

## FEEDBACK AND RESULT REPORTING

One of the most important aspects of the HADRIAN tool concerns the results obtained from an analysis. Again, the designer is able to configure exactly how the tool behaves and thus is able to customise the level and format of the feedback obtained. At one extreme the system can perform the analysis without any user intervention, logging results, making assumptions where required, and skipping any failures. The final results are then presented when the analysis is complete for the designer to examine. The other extreme allows the designer to be involved in any decision making processes where the system has to resolve some issue. Such issues may include what to do in the event of a failed task element, or an inconsistent task definition such as explicitly specifying a hand for a reach task, when the hand is already holding an item.

The flexibility of being able to intervene during an evaluation allows the designer to refine the task analysis during early runs and then run more autonomous analyses when the process is more robust. Alternatively this facility allows the designer to run through the analysis in a more step-by-step approach to understand the issues faced by a particular user at every stage and actively think about how all aspects of the design impact upon its usability. Figure 4 demonstrates one stage of a simple case study analysis performed on an Automated Teller Machine (ATM). The user has failed on a particular task element and the system has been set to report all failures immediately and report suggestions. Whilst HADRIAN is not an intelligent design system 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.



**Figure 4:** A HADRIAN task element failure report and suggestion dialogue.

A large range of results may be examined to determine who has successfully completed the task analysis and potentially more importantly, who has failed, or been designed out, and why. A particular statistic presented is the percentage accommodated by the design. Whilst this is a very loaded metric it provides a powerful indicator of the usability of the design when compared against alternative design concepts. Thus this is a valuable tool in the designer's process for ensuring that the design is targeting the user's needs from the very beginning.

## CONCLUDING REMARKS

The HADRIAN tool has been developed to support designers in their efforts to develop products that meet the needs of a broader range of the population including those who are older or disabled. HADRIAN itself is also supported by our database of individuals, comprising: anthropometric, mobility, strength, disability, coping strategies, behaviours and background information on a range of people with a range of ages and abilities. This approach targets the need for improved data on users for use in the digital design environment together with a means of simulating 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. As such it is likely that the tools will continue to be developed beyond the current work and it is aimed to concentrate our efforts on two fronts. Firstly, to increase the size of our database and 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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