

HADRIAN: Supporting Design for All.

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Abstract

HADRIAN is a software tool developed to support designers in their efforts to 'design for all'. Current research is expanding the tool to transport related tasks. This includes supporting investigations of the whole journey environment. This development is moving towards a journey planner that allows each stage of a journey to be assessed against an individual's physical, cognitive and emotional abilities. This journey planner will then support both individuals wishing to make a journey, and also designers and planners wishing to investigate the inclusiveness of a new design. Much of the data collection has been completed and a concept for the journey planner is outlined. The development of this work also poses a number of significant challenges which are discussed.

Introduction

The case for products, services and environments to be 'designed for all' has never been clearer. Reports by organisations such as the World Health Organisation (WHO, 2006) highlight the ageing global population and the increase in people with disabilities. This growing number of people provides a strong impetus to design for the broadest range of consumers. Recognising this need, or opportunity, is important; however it is equally important to provide guidance and support for those who wish to design for all. Our approach has been to look at ways to integrate Design for All philosophy into existing good practice, such as the use of ergonomics design tools.

SAMMIE is a computer aided human modelling system that represents a widely used tool to accommodate the needs of a broad range of differently sized and shaped people into the design of products (SAMMIE, 2007). SAMMIE has been successfully developed and employed in a large number of industrial, commercial and government projects through SAMMIE CAD Ltd., a UK Ergonomics Society Registered Design Consultancy (Porter et al 1999). However, the successful use of such tools is often constrained by the need for 'expert' users. Many difficulties are encountered accessing the correct data, and then applying the data correctly. The de-facto standard of designing for 5th to 95th percentile clearly highlights this issue and also illustrates that ergonomics tools can be used to support poor design decisions just as easily as good design decisions. This has led to the development of HADRIAN.

HADRIAN (Human Anthropometric Data Requirements Investigation and Analysis) is our inclusive design support tool. HADRIAN was developed as part of the Engineering and Physical Research Council's (EPSRC – based in the UK) Design for All element of the EQUAL (Extending Quality Life) programme. The main focus of the work was to address two core concerns in the areas of design and ergonomics that were directly relevant to informing and supporting designers in their efforts to design for all (Porter et al, 2003). These concerns relate to the need for designers to be able to predict multivariate accommodation, and can be summarised as follows (Marshall et al, 2005):

- The provision of relevant, accessible and holistic information on people of a broad range of size, shape, and ability
- A means of utilising the available information to assess the inclusiveness of a proposed design.

Assessment of design for all, or inclusive design problems is very complex. Even relatively simple products such as a common ATM or cash dispenser have a significant number of issues that must be addressed. Firstly there is the core functionality, requiring the user to view and interpret the screen, to reach and operate the controls and to collect the cash and receipt. However, all of this is done in the context of needing the cash which leads to how the user accessed the cash dispenser, where the cash dispenser is situated, and what they might encounter when they come to use the cash. All of these activities present multivariate accommodation problems for the designer. If any one element of these tasks cannot be completed by the user they are effectively 'designed out'.

In response to these concerns HADRIAN consists of two main elements. The first is a database consisting of physical and behavioural data on 100 individuals covering a broad range of ages and abilities. The sample is deliberately skewed towards the older and disabled population to offset the relatively well understood younger / able bodied population. Data are available on anthropometry, joint constraints, background information and also notes on any disabilities and problems experienced with activities of daily living (Gyi et al, 2004). A key feature of the database is how the data are presented. The database is effectively a catalogue of individuals, allowing the user to browse through the people in the database. This approach fosters empathy between the designer and the people who they are designing for, and attempts to minimise the dehumanizing effect of the virtual environment in which the design is being created. It also moves away from decisions to deliberately design out a proportion of the population based purely on the numbers.



Figure 1. The HADRIAN database contains information on a broad range of individuals.

In addition to the range of anthropometry and joint constraints the system also contains task based data. This covers a range of kitchen based tasks and a number of seating scenarios which can also be broken down into more generically applicable elements. Where possible the data collected reflects real-world application. Thus, comfort maximums were recorded to

reflect what the subject would be likely to do in their own home where absolute maximums would not normally be used. In addition, tasks that represented hot loads such as lifting items into and out of the oven were performed using oven gloves to represent their effects on capability and behaviour.

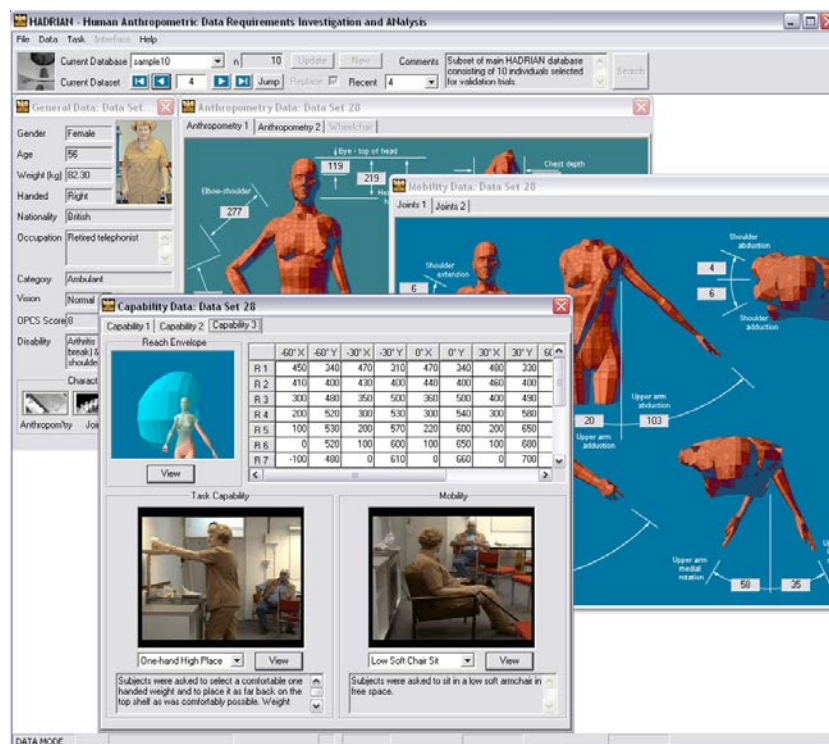


Figure 2. Data display from the HADRIAN database: showing anthropometry, task video clips, reach envelope data etc.

Task data stored within HADRIAN includes a success or a failure for each task element. In addition, the data not only records whether a task was completed, but also how it was completed. This behavioural element is a key part of the HADRIAN mechanism for predicting accurate postures in task situations. It could be argued that as long as the system predicts postures that the individual could adopt the results would be valid and useful. However, older and disabled people often develop coping strategies for dealing with their reduced capability. These coping strategies make it much less predictable what an individual might do and subsequently what they might be capable of for any given task. Thus, we believe it is equally important to capture and then predict the capability and behaviour of an individual in a virtual fitting trial (Marshall et al, 2004).

Accessible transport

Research is now being undertaken as part of the AUNT-SUE (Accessibility and User Needs in Transport for Sustainable Urban Environments) consortium. AUNT-SUE is part of the EPSRC's SUE programme. The consortium consists of UK academic institutions including London Metropolitan University, University College London and Loughborough University, together with local councils and other public and private bodies such as Camden Council, Hertfordshire Council, and the RNIB. The consortium's aim is to produce methodologies for sustainable policies and practices that will deliver effective socially inclusive design and operation of transport. Loughborough's role in AUNT-SUE is to expand the HADRIAN philosophy to transport, a key area in design for all.

The initial development of HADRIAN addressed localised design problems in response to surveys conducted with 50 older and disabled people (Oliver et al, 2001). The core of the

survey examined how design could improve their quality of life. The two primary responses were: in being able to prepare meals for friends and family; and being able to use local transport. This led to a focus on kitchen based tasks and a range of seating scenarios for initial data collection. Taking a pragmatic approach the data collection focussed on tasks that were sufficiently specific to be relevant to design needs, yet generically applicable so that we were not designing a kitchen design tool, or creating a system that required data on every possible task situation in order to be useful. In addition, ethical considerations and project resources required that we limit the scope of our study to a manageable size, both for the subjects and the researchers.

As part of the AUNT-SUE project, HADRIAN is being developed, to broaden the content of the database and to increase the functionality of the task analysis to incorporate transport-related data. This addresses a key element in attempting to design for all and responds to the second most common response from our user surveys.

The size of the HADRIAN database has been maintained at 100. Data collection is nearing completion and data have been collected from many of the subjects featured in the original study. For various reasons a number of subjects were unavailable for the AUNT-SUE project and so new subjects have been found. Also, some new subjects were required as we have slightly modified the profile of the subject group to include other transport users who are commonly designed out such as young mothers with push chairs.

Significant amounts of additional data are being collected as part of the AUNT-SUE study. This includes features such as ingress and egress capability and behaviour from a range of public transport types. An adjustable experimental rig was constructed that could be used to simulate entering and existing from UK rail, coach and bus vehicles with a range of step heights and handle locations. Participants were videoed traversing the rig at a range of step heights that represented what they were comfortable attempting.



Figure 3. Images taken from video of subjects using the ingress/egress rig.

To supplement, and potentially replace, traditional anthropometric measures the study has been collecting whole body scanned data. Using a [TC]² whole body scanning system, subjects have been scanned to capture their body form. This allows the extraction of many more measures than would be practicable using traditional methods, to reprocess the data at a later date if additional measures are required without having to try to recall all the subjects,

and also provides a computer representation of the subject's body form which could be used for human modelling purposes in the future.



Figure 4. An example body scan from the [TC]² scanner.

Whilst these data enhance the database and improve its applicability to transport they are still only applicable to physical design problems. The initial version of HADRIAN and indeed, most ergonomics design and human modelling tools such as SAMMIE, work within the physical realm. However, as part of the AUNT-SUE project our aim is to expand the database beyond the physical into cognitive, emotional and sensory data associated with travel. These data cover the individual's ability to deal with tasks such as route planning, dealing with crowds and the effects of crowding on the transport design, understanding signs and other public information under conditions of high visual noise, issues with lighting, and the effects of perceptions of crime and personal safety. All of these elements are complex problems to understand and, in particular, to manipulate into a useable data resource. However, they are often some of the most fundamental issues when people are excluded. Thus, if we consider the design of an ATM, the ATM may be highly inclusive accommodating a broad range of users yet when placed in its operating environment it fails to be inclusive due to the dark and secluded location dissuading users from attempting to access it. Alternatively, a perfectly accessible train design may exclude users who cannot reach the train due to poor signage, or timetabling.

We have addressed this issue through the development of a Transport Activities Questionnaire. Participants are asked questions concerning: their physical abilities; any problems encountered when using trains, buses, trams, London-style taxi cabs and minicab taxis; their ability to walk distances, as well as issues surrounding taking luggage on the different transport modes; the types and frequency of journeys made; problems in using stairs, lifts or escalators; and difficulties in understanding timetables and signs. The questionnaire also includes a request for information about problems experienced in the local area. Any local areas that participants identified as causing problems, when travelling, are visited by the experimenters to provide quantitative data to supplement the reports from the participants. For example, this may range from measuring the force required to open a heavy shop door, to assessing the cognitive and emotional issues at a transport node (e.g. changing from a bus to the train, involving crossing busy roads, walking through empty or crowded public spaces with poor street lighting). In short, the questionnaire aims to provide information concerning issues that may arise at any point during the whole journey process.

The whole journey approach

As mentioned previously, HADRIAN has been developed to address localised accessible design problems. However, the concept of accessible transport is not solely related to any single design, rather it concerns a network or system of designs. This network is part of the transport infrastructure, combining a number of directly related, and indirectly related design problems that must be addressed holistically if accessible transport is taken in the context of the 'journey'.

The journey is part of our perception that accessible transport is there to enable users to travel from one place to another. To succeed in providing accessible transport we must be able to ensure that our door-to-door journey for example, from home to the doctor, from the bank to the theatre, or from the airport to a relative's house, is possible at every stage.

As part of the AUNT-SUE consortium two test-bed sites have been identified: in the London Borough of Camden and in the County of Hertfordshire, both of which have council representatives on the project. As part of our whole journey approach we will use the test-beds 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 in the area and will include all of the accessible design elements that the individuals will have to deal with on those journeys. In particular we will identify the potential barriers faced by the people who make these journeys. These barriers may take many forms and are likely to include a range of: kerbs, pavements, slopes, steps, street furniture, cash dispensers, ticketing machines, lifts and escalators, toilets, transport types, and so on. Clearly, many of these potential barriers may be interacted with in the course of making a typical 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.

It is intended that developments to the task element of the HADRIAN system will also take this whole journey approach. Individual designs will still be the main focus of evaluation but they will be taken in the context of the journey and the designer will be able to evaluate the accessibility of a particular journey rather than have to consider each element in isolation. This approach should then provide a much more realistic evaluation of the social inclusiveness of any transport system.

This part of the HADRIAN system will be available as a journey planner. Journey planners already exist (Transport Direct, 2007) and much of this common interface functionality will be adopted. A starting point and destination will be entered, dates and times of travel accounted for and the system will provide a number of options for completing the journey. What is novel about the HADRIAN approach is how the user can assess the individual journey options and the elements of each journey option. A particular journey can be examined and details about each component of that journey can be interrogated. A user can see that a short walk actually includes a number of steps, or a steep slope, that there are benches to sit on along the route of the walk, and that the route is often crowded at the specified time of travel. All of these factors would allow an individual to make a much more accurate assessment of their ability to complete that element of the journey. As a design tool, the journey planner will allow a designer to investigate typical journeys that make use of their design be it the infrastructure, a new train station, or just a ticket barrier that will be encountered along the way. HADRIAN will then assess the journey using the database of 100 individuals and record where each has difficulties and report back who would be designed out.



Figure 6. Journey planner interface highlighting the train station element of Travel option 2. Notes indicate possible issues with this element. Interface also shows 25% of the database's 100 individuals being excluded from this journey.

Future challenges

The aims set out for the HADRIAN component of the AUNT-SUE project pose some significant challenges. The first of these is the development of a technique to evaluate a journey. HADRIAN currently employs a task based evaluative mechanism that requires the designer to define a series of activities for the virtual users from the database to perform (Marshall et al, 2002a & b). The definition of a journey will then add an additional layer to this task framework. As with the initial development of the task definition, one key element will be the intuitiveness of the system and avoiding placing too significant a burden on the designer. It is possible that the system will take a template approach to common design evaluations, automatically providing a task definition that only requires checking by the designer. This then leaves the designer free to focus on any new or particularly complex areas of the design.

In addition to the actual analysis mechanism a further critical factor is the underlying data upon which the analysis is based. Initially the prototype journey planner will use data from the two test bed areas highlighted earlier. The AUNT-SUE consortium has already mapped these two locations in significant detail providing an ideal resource for HADRIAN. However, this level of detail is not widely available for all of the locations people would wish to travel. Assuming validation of the tool proves to be successful, methods of collecting this data can be envisaged. Firstly more research could be done to map key locations. Individuals could be encouraged to submit data to a central (web based?) source relating to areas that they frequently travel. Businesses may be encouraged to map areas near to their premises to encourage trade. It is likely that a long term view would need to be taken, adopting a centrally managed, user driven process that employs many different strategies in order to successfully provide the level of detail necessary for the journey planner.

The second significant challenge is the incorporation of non-physical evaluations into the process. Whilst presenting these data in the database is relatively straightforward and strengthens the empathy that the designer will be able to gain with the individuals in the database, it is the ability to factor these into the task evaluations that offers the greatest potential step forward. If HADRIAN was a significant step in improving the support for designers in an inclusive design context, then the ability to evaluate the emotional, cognitive, and sensorial effects on a design will be an even larger step. Initially, these effects are likely to be addressed through a look-up table arrangement where parameters are compared to a matrix of data in the database and a judgement made on the referenced value, with more advanced solutions left for future work. Whilst this is not an ideal evaluation of these important effects it does bring their attention to the designer and offers evaluation of various scenarios even if only to a limited degree.

The final challenge is in making the tool itself accessible. The original HADRIAN project got feedback from a number of designers but never really had the resources to fully implement suggestions to the necessary degree. However, the AUNT-SUE project provides an opportunity to address usability and, in particular, the interface towards the needs and working practices of designers. It is clear that any benefit that HADRIAN might bring to inclusive and accessible design is only as good as the take up and use by those who actually do the designing of these products, environments and systems.

Conclusion

HADRIAN has been developed to support designers in efforts to design for all. This novel approach has proven the concept of maintaining ergonomics data as individuals and supplementing this with additional background information to provide empathy with the people being designed for. In addition, the ability to then employ these individuals in virtual user trials provided a potentially quick and easy method for obtaining the kind of feedback you could expect from a real user trial. Furthermore, this feedback could be obtained during the early stages of design when the cost and time implications of finding a user group and building a full-size mock-up would be prohibitive.

The AUNT-SUE project draws together many initiatives with the single focus of accessible transport. HADRIAN is being developed towards this aim with an expanded database incorporating transport related data and an enhanced task analysis tool that will provide the ability to evaluate a whole journey. In addition to the physical data, HADRIAN will be further expanded to incorporate cognitive, emotional and sensory data that can have a significant impact on accessibility and the inclusiveness of a design.

Finally, the AUNT-SUE project also gives us the opportunity to develop HADRIAN beyond an initial prototype into a useable system. A system that not only addresses the need for

applicable data and a method for employing such data, but also one that is sympathetic to the working practices of the designers who will actually use the system.

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