INTERNATIONAL DESIGN CONFERENCE - DESIGN 2010
Dubrovnik - Croatia, May 17 - 20, 2010.

TOWARD A MODEL OF PRODUCT-USER INTERACTION: A NEW DATA MODELLING APPROACH FOR DESIGNERS

A. Mieczakowski, P. Langdon, R. Bracewell and P. J. Clarkson

Keywords: modelling approach, inclusive interaction, mental models

1. Introduction

Many daily living products are laden with a variety of features which are largely inaccessible and unusable for less capable users. At present, there are two design approaches that allow to extend the accessibility and usability of consumer products. The first approach uses special aids to adapt existing product to specific requirements, whilst the second approach is concerned with attuning product design to the needs of heterogeneous users from the beginning of the design process. Inclusive design strongly promotes the latter approach and focuses on expanding the boundaries of product usage by guiding designers in designing products that are accessible to and usable to people with varying degrees of sensory, cognitive and motor capabilities. It has been shown that inclusive interaction in products can be achieved by a means of minimising the sensory, cognitive and motor effort required for product usage, facilitating simplicity and intuitiveness, containing perceptible information and enhancing user satisfaction [Langdon et al. 2009]. Currently, many companies are opening up to the ideals of inclusive design and start to adopt a more inclusive approach to design of their products and services. The adoption of inclusive design ethos is led by a twofold moral and financial incentive as studies show that well-designed products and services have the potential to improve customer satisfaction and this in turn allows companies which value good design to exhibit high growth.

1.1 Current Design Practice

Designers tend to design products that are targeted at people that exhibit similar sensory, cognitive and motor capabilities to their own demographic. They, furthermore, consider working with users as valuable and inspirational, but they often do not do it due to time and cost constraints and instead rely on personal instincts, preferences, experiences and self-observation and act as both designers and customers. Also, designers frequently evaluate the usability of products and services based on their personal preferences rather than a careful consideration of issues associated with usability evaluation. It is believed that without a systematic evaluation approach, designers are often evaluating the usefulness of product functions instead of the usability of relevant interface features. Further evidence on current design practice can be found in a wide range of articles from well regarded academic and industrial writers. Goodman-Deane et al. (2009), for example, argue that designers have an inclination towards informal, exploratory, visual, quick and simple ways of working and they place particularly high emphasis on information provided by the client and the company's marketing or research department. Krippendorff (1989) goes farther to suggest that although designers intend to design self-evident products, the reality is that artefacts often constrain sense-making activity and are interpreted as something quite different from what was intended by the designer.

1.2 Good Design Practice

Time after time it has been shown that products designed for people with declined capability are also easier for everyone else to use and so when designers create products for heterogeneous users they should reconsider the relationship between individuals' visual wants and their functional needs. Unfortunately, the reality is somewhat different as multi-functional and complex products often alienate niche populations who lack the visual acuity, cognitive reasoning or manual dexterity to operate them. Consequently, many researchers in interaction design and usability accentuate that designers need to raise their awareness of how people understand and use everyday products, and what role those products play in their daily lives. The main difficulty that users experience while operating product features is primarily attributable to the exertion of force and so the amount of force required to operate control features should be kept as low as possible. Also, users should not be required to make two manipulations at the same time, such as simultaneously pushing and rotating a control device, and pushing is generally preferable to rotating. Other research findings indicate that older generations often experience problems with operating certain technological products, such as microwaves, electronic alarms and computers, because such products bear little resemblance to the products manufactured in the past [Freudenthal 1999]. For example, features of current household products are generally classified into two categories – 'hardware' and 'software'. Two design issues arise from this classification. The first addresses the overwhelming amount of knowledge that users are required to have about a large variety of hardware and software product features to be able to correctly understand and operate a given product. It is worthy of note that as more and more of the everyday products contain microprocessors and become more integrated and intelligent, the proportion of software-based products is consistently increasing and outweighing hardware-based products. The second issue addresses the prevailing incapability of designers to appropriately evaluate and compare what hardware and software features are intuitive, simple and easy to use and what features cause unnecessary or excessive problems, particularly to older and disabled people, and consequently choose from a variety of features the ones which are accessible and usable to a wide range of users. Other researchers point out that people with decreased sensory, cognitive and motor capabilities are frequently slower at carrying out complex cognitive tasks with parallel activities, make more errors, and they often develop certain compensation behaviour in order to get things done. For example, one of the better known compensation solutions is the provision of not only visual information but also tactile, acoustical and verbal information in product design [Krippendorff 1989]. Another coping behaviour, which users adopt when they have not yet developed stored long-term automatic processes and chunked procedures in working memory, is the 'trial and error' method [Langdon et al. 2009]. This method is, however, perceived as slow, repetitive and error-prone.

Findings of previous research indicate that designers can design good interaction in products by paying greater attention to: (1) mental models of users [Krippendorff 1989, Freudenthal 1999, Norman 2002]; (2) prior experience [Blackler 2006, Langdon et al. 2009]; (3) interface metaphors [Krippendorff 1989]; and (4) affordances and mappings [Krippendorff 1989, Norman 2002]. This paper focuses only on mental models and prior experience as they are the most critical concepts in understanding how people interpret and use everyday products and in adequately modelling user information.

1.2.1 Mental Models

While there is no commonly accepted definition of mental models, over time the term mental model has been given different names and meanings by different authors. Accordingly, throughout cognitive psychology and artificial intelligence (AI) literatures, mental models have been referred to as schematas, internal representations, frames, scripts, mental models, and conceptual models. Most notably, in 1943 Kenneth Craik, a British philosopher and psychologist, laid the foundation for the concept of a mental model by postulating that it is a small-scale model of external reality that people carry in their heads and use it to take various actions, conclude which is best and utilise this knowledge for future problem-solving. Forty years later, a cognitive psychologist, Johnson-Laird, further developed Craik's theory by suggesting that individuals construct internal models of the external world that enable them to make inferences and predictions, understand and explain phenomena, decide what actions to perform and control their execution.Yet another psychologist and arguably the biggest advocate of mental models, Norman (2002), postulates that mental models allow people to understand and anticipate the behaviour of a given product through the application of inference or procedural derivation. However, applied researchers offer more functional (rather than descriptive) definitions of mental models. In particular, they argue that mental models are representations of a given product/system that users form in their heads and contain information about this product/system's purpose, its inputs and outputs, internal structure and operations, and overall functioning. The work carried out in the 1980's on functional mental models by various applied researchers, led Persad et al. (2007) to suggest that people's mental models of products contain two forms of knowledge: (1) knowledge of how a given product works (declarative knowledge) and (2) knowledge of how to perform a task with a given product (procedural knowledge).

Following the assumptions that people solve problems by the immediate recognition of their last successful actions regardless of whether these actions are correct in a given situation, it is also believed that a mental model represents the primary constraints determining the possible behaviour of the environment. Freudenthal (1999) notes that there are major differences in the properties and forms of mental models that individuals bring to a task and their development in users' minds. Similarly, others have pointed out that mental models can be constrained by users' technical background, previous experience with similar products and the human information processing style. Also, mental models are assumed to be abstract, general, dynamic, incomplete, unscientific, parsimonious, unstable, have limited applicability and lack firm boundaries.

For quite some time now Norman (2002) has been arguing that accessible and easy-to-use products can be designed by a means of matching the designer's conceptual model of a product with the user's mental model of that product through the use of the system image. Following this line of reasoning, Persad et al. (2007) suggest that a good representation of users' interaction with products should capture declarative and procedural knowledge of both designers and users. However, so far there is a significant lack of a support tool which would guide designers in capturing and comparing their understanding and intended use of products with users' collective understanding and use of products.

1.2.2 Prior Experience

Another leading concept in the area of interaction design and usability is prior experience. Blackler (2006) and Langdon et al. (2009) argue that experience is a critical factor of how easy a product is to learn and use. New products are often an evolution of previous designs or make strong reference to products from different companies and product families. There is strong evidence that people's cognitive activity during interaction with products is greatly influenced by their prior experiences with other products and product features that allow users to quickly match their existing knowledge to what is presented to them at the product interface are easier to understand and more intuitive to use. It is also assumed that the more practice individuals get in using a given product interface, the faster they will complete tasks at the interface and progress from being novice users to becoming expert users. Following Rasmussen's trichotomy between skill-based, rule-based and knowledge-based levels of human information processing, it is believed that in the transformation from novice to expert performance a person gradually builds up a knowledge-base and moves from predominantly knowledge-based to rule-based and skill-based performance and in doing so decreases levels of cognitive workload [Freudenthal 1999]. Others have pointed toward the application of skill-based or rule-based behaviour to complete tasks with products in situations when users lack previously acquired mental models of similar products [Freudenthal 1999, Blackler 2006, Langdon et al. 2009]. It is, furthermore, maintained that user interfaces that tap into subconscious use of prior knowledge are significantly more intuitive to use. Blackler's (2006) study supports this view as it found that people's interaction with products was faster and more intuitive whenever they were presented with familiar interface features, however, it needs noting that people's memories were based on features' appearance rather than location. Overall, to design more inclusive products designers should exploit what people already know and subsequently base the appearance and behaviour of new interface features on previously well-learnt and transferable features, as well as clearly identify key visual features associated with function [Blackler 2006, Langdon et al. 2009]. Good design practice also involves reducing complex alternative options and providing users with clear feedback of the effects of their actions. Another useful advice is that designers should refrain from changing the function of a familiar feature from one model to another as this may cause certain amount of confusion and the inability to learn the 'new' function of that feature for experienced users.

2. Existing Design Support Tools

A great emphasis is given to understanding how people think of and use everyday products and subsequently devising ways in which that information can be used to inform the decisions of designers. Although the most valid technique for gathering user information is to have users interact with the product in question, a variety of constraints mean that this is not always possible. To compensate for time, cost and other restrictions incurred in collecting real-time user information, Norman (2002) advises designers to consider the framework of interaction, which concentrates solely on a single user's view of a given product interface. There are also inclusive design simulation toolkits for designers that allow them to convey the effects of people's motor and sensory impairments. Other models for simulating human capability come from the fields of ergonomics, human-computer interaction (HCI) and AI. For example, the Design Ergonomics Group at Loughborough University in UK developed SAMMIE (System for Aiding Man-Machine Interaction Evaluation) and HADRIAN (Human Anthropometric Data Requirements Investigation and Analysis). Both systems are to be used to identify inclusivity issues for a range of designs at the concept stage of design in situations where performing user trials is not possible, however, they are limited in sample size and addresses mainly anthropometric issues. Relatively few attempts have been made to accurately model and simulate users' cognitive capabilities during interaction with products to make estimates of design exclusion. One such model, GOMS (Goals, Operators, Methods and Selection Rules), helps designers to represent procedural knowledge of users that is required by a product or system to get the intended tasks accomplished. However, GOMS analyses only error-free behaviour and there is some doubt as to whether it should be used to make generalisations about real human performance which is prone to errors. Other examples of representations which model cognitive capabilities of humans include ACT-R (Adaptive Control of Thought – Rational) and SOAR (Symbolic Cognitive Architecture). ACT-R can be of great assistance in evaluating user interfaces but it does not provide guidelines on how to develop user interfaces and is difficult to implement and apply. SOAR is useful for developing systems that exhibit intelligent behaviour (AI) and modelling different aspects of human behaviour (cognitive science), however, its main limitation is that it does not capture other aspects of HCI such as user preference, aesthetics and emotion and it has a reputation as being difficult to implement, learn and use.

3. Modelling Design Activity

In the last few decades several design methods have been developed for guiding and aiding designers in creating products and services for a wide range of users [Goodman-Deane et al. 2009]. However, a long-standing issue is that product designers are provided with very little help in adequately representing, analysing and comparing functional, conceptual and user information during the design of products and services for as many people as possible [Mieczakowski et al. 2009]. Following a number of years spent researching the design activity at a large aerospace company in UK, Aurisicchio and Bracewell (2009) argue that designers tend to capture and analyse design information in personal journals and summarise it briefly in technical reports at the end of projects. This leads not only to poor communication within the design team but also to ill-defined and poorly documented product characteristics and a lack of consideration of the impact of the chosen product features on the diverse capabilities of users. Thus, documenting the structure of design information has the potential to deliver more comprehensive descriptions of design processes and lead to creation of more accessible and usable products and services. Two common ways of documenting design information include linear text documents and diagrams. Linear text documents are widely accessible and very simple to use but are very weak at capturing "the complex and fast-flowing nature of design activities" and are a rather poor help in noticing patterns and gaining insights [Aurisicchio and Bracewell 2009]. Diagrams require more knowledge of the nature and structure of their underlying graphical elements, annotations (symbols, words or short phrases) and relationships between different elements. Yet, diagrams provide a rapid mapping of design activities, can be supported by a wide range of computer-based diagramming tools (i.e. Visio, SmartDraw, OmniGraddle, Mindjet, Compendium, P3 Signposting, etc.), and since they are more visual than linear text documents, they are better for spotting patterns and gaining insights. However, previous research on the use of diagrams [Salustri et al. 2007] has concluded that no single diagram can visualise the different types of information managed by designers during the design process. Following this line of reasoning, Aurisicchio and Bracewell (2009) put forward the idea of using a set of diagrams including mind maps, fault trees, fishbone diagrams, bond graphs and function means diagrams to represent behavioural and functional thinking in design and proposed the use of the Design Rationale editor (DRed) to represent these diagrams. Collectively, these studies provide compelling evidence on the importance of using a diagramic/modelling approach to represent the different types of user, design and engineering information managed by designers and engineers during the design process. Moreover, our previous research [Mieczakowski et al. 2009] reviewed a number of different representations widely used in the field of engineering, including state transition diagrams, statecharts, object-oriented analysis, Thimbleby-type state diagram and conceptual graph analysis, in order to investigate which ones of them have the representational capability to capture three critical elements of users' interaction with products, specifically: (1) goals, (2) actions, and (3) their impact on the functional parts of a given product (which were called 'objects'). Alongside proposing the conceptual graph analysis (CGA) as a possible candidate for a model of product-user interaction, our research has also concluded that perhaps incorporating elements of different models on one representation could be key to interaction modelling. Since this earlier work, we found that a fourth element – people's beliefs – should be captured by a model of interaction because, as it is described in sections 1.2.1 and 1.2.2, it is necessary for designers to recognise what types of mental models of the underlying product functions (skill-based, rule-based or knowledge-based) are influencing users' actions during interaction with everyday products.

4. Requirements for a New Data Modelling Approach

There is strong evidence of the importance of good interaction design to intuitive use of products and services. However, there is also a strong indication that despite this evidence, the understanding of how people interpret and use everyday products and services is given a low priority in many companies. A recent survey of industry practice [Goodman-Deane et al. 2009] found that there is limited uptake of inclusive design and other support materials in design practice mainly due to a poor fit between the structure of many of those materials and the ways in which designers think and work. As well, there is a significant lack of quick-to-use and understandable tools that would raise designers' awareness on how people understand and use different product features [Persad et al. 2007, Goodman-Deane et al. 2009]. Together the aforementioned studies and also our earlier study of design practice provide convincing evidence that designers lack a tool that allows them to: (1) represent the engineering model of a given product indicating how its different parts interact with one another; (2) create a designer model of a given product and compare it with the engineering model to see what features should be mounted on the top of the underlying functional parts; and (3) investigate how users understand and use product features, represent that information in the form of a collective user model and compare the amalgamated user model with the designer model (influenced by the engineering model) to make appropriate design decisions based on similarities and differences between these models. Our goal for development of a new support tool for designers is that it should be visual, easy and quick to understand, implement and use, it should lead toward improvement in design practice to increase the chances of producing an accessible and usable product, and designers should find significant productivity and differentiation gains in using it.

5. New Data Modelling Approach

Since designers are in general comfortable and familiar with interpreting abstract visual representations such as models and diagrams because they are often involved in their daily work, it was decided that a new inclusive design support tool should be a data model containing information gained from user observations and engineering and design insights. Based on the results of our research, we propose a new modelling approach for designers to enable the assessment and comparison of designers and users' understanding and usage of everyday products. Elements of criteria for success and value to practitioners were combined to develop this approach and to effectively improve design practice through its application. The new approach to modelling has been developed through data-structuring and representing different types of information that designers currently consider and should consider during the design of everyday products and services and is supported by evidence from literature and user observations. This approach is aimed at encouraging designers to pay greater attention to users' understanding and use of products through representing: (1) goals that users want to achieve during interaction with products, (2) beliefs that they bring from previous interactions with other products to interactions with new products, (3) correct and incorrect actions that they exert on product interfaces, and (4) the understanding of the impact of their actions on functional objects. It is, moreover, meant to allow designers to capture the actual engineering model of a given product through the application of object elements and beliefs about the objects' functions and a model of designers' own goals, beliefs, actions and objects, and subsequently compare the areas of similarity and differences between that product's engineering model and what is intended by designers with what appears and is understood by the user. The new approach uses four distinct colour-coded graphical symbols to represent goals, beliefs, actions and objects and make them and their conceptual relations more visually explicit and thus allow designers to map and compare designers and users' understanding and use of products in simpler and more coherent manner. It is to be used during the prototyping and design stages of the design process to communicate crucial design information among designers and other stakeholders. The DRed platform has been used as a testing ground for representation and comparison purposes [Aurisicchio and Bracewell 2009]. In doing so, the new approach's goal, belief, action and object elements were assigned their corresponding DRed elements. Accordingly, the DRed's Task (Pending) element was used as a goal's symbol, the Issue (Open) element was given a belief's symbol, the Answer (Open) element was chosen to represent an action and the Block (Internal) element was selected as a counterpart for an object. The new approach's corresponding DRed elements are shown in Table 1.

Table 1. Four elements of the new modelling approach and their corresponding DRed symbols

New Approach's Element Types	Corresponding DRed Element Types
Goal	Task Name
Belief	
Action	
Object	

Quintessentially, the modelling of products using the new approach involves four stages. In the first stage, designers need to refer to a drawing of the actual engineering model of a given product to better understand what product elements and operations are functionally and structurally possible before they design interface features that will sit on the top of the engineering parts. Figure 1 illustrates an example of an engineering model of a simple toaster represented using the new approach in DRed.

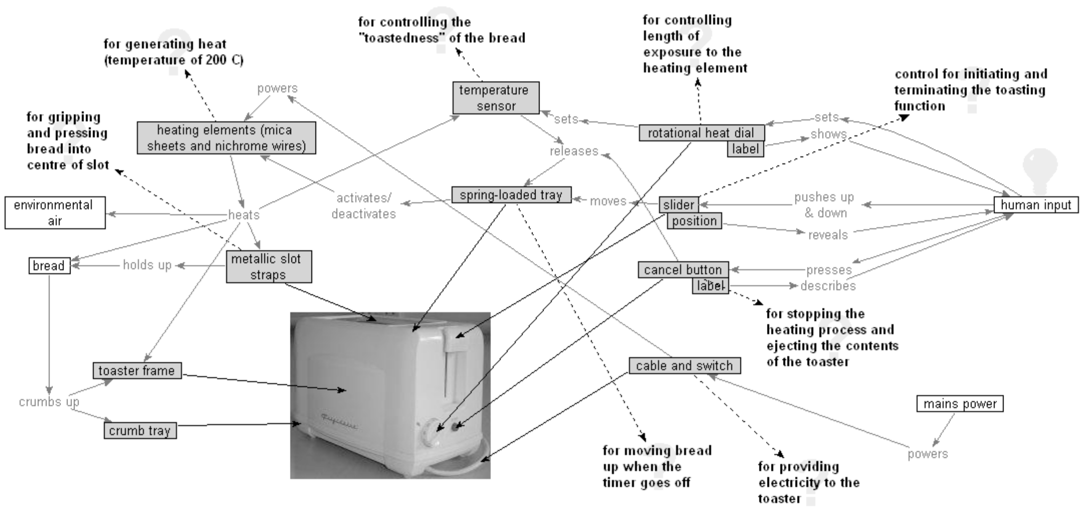

Figure 1. Engineering model of a simple toaster drawn using the new approach in DRed

In this example, a toaster's engineering model has been represented using the object elements (DRed's Internal Block element); the belief elements (DRed's Open Issue element) to explain the objective of each object; and the main relationships between different objects (DRed's Useful Relation element and Normal Strength Link element). Also, the action element (DRed's Open Answer element) was used to connote human input and DRed's External Block element to signify external entities such as bread, mains power and environmental air. In the second stage of using the new approach, designers are required to draw one collective product model using goal, belief, action and object elements and accompany each element with simple descriptive text. An example of a designer model of a simple toaster represented using the new approach in DRed in shown in Figure 2.

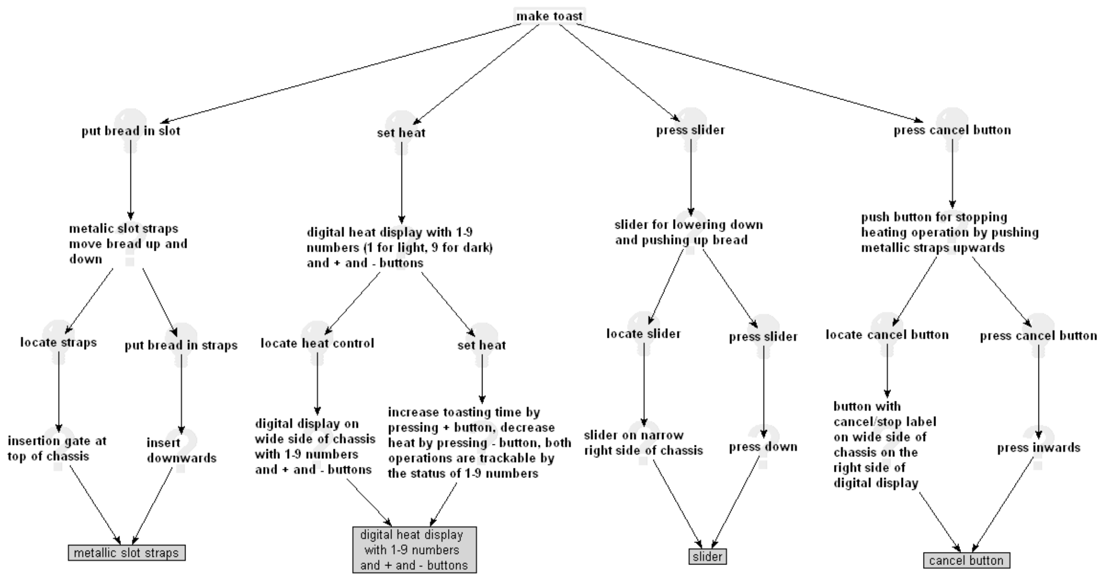

Figure 2. Designer model of a simple toaster drawn using the new modelling approach in DRed

In this example, the designers' model of a simple toaster has been represented using the goal element (DRed's Pending Task element) to signify the master user goal pertaining to a toaster's usage; the action elements (DRed's Open Answer element) to indicate the sequence of actions that designers think that users have to perform to accomplish their goal with a toaster interface; the belief elements (DRed's Open Issue element) to provide designers' description of the appearance, functionality and behaviour of toaster features which users are required to exert their actions on and to elucidate the position of different features and how user actions need to be taken to correctly operate them; and lastly object elements (DRed’s Internal Block element) to specify the functional features that are envisaged by designers to sit on the top of the toaster interface and be exploited by users. In the third stage of using the new approach, designers need to run observations with users of products using a verbal protocol (think-aloud) and keep a log of users’ goals, beliefs, actions and objects. Subsequently, designers should use the information collected from study participants to draw several individual user models by means of goals, action, and object elements and annotate each element with relevant description. An example of an individual user model of a simple toaster represented using the new approach in DRed in shown in Figure 3.

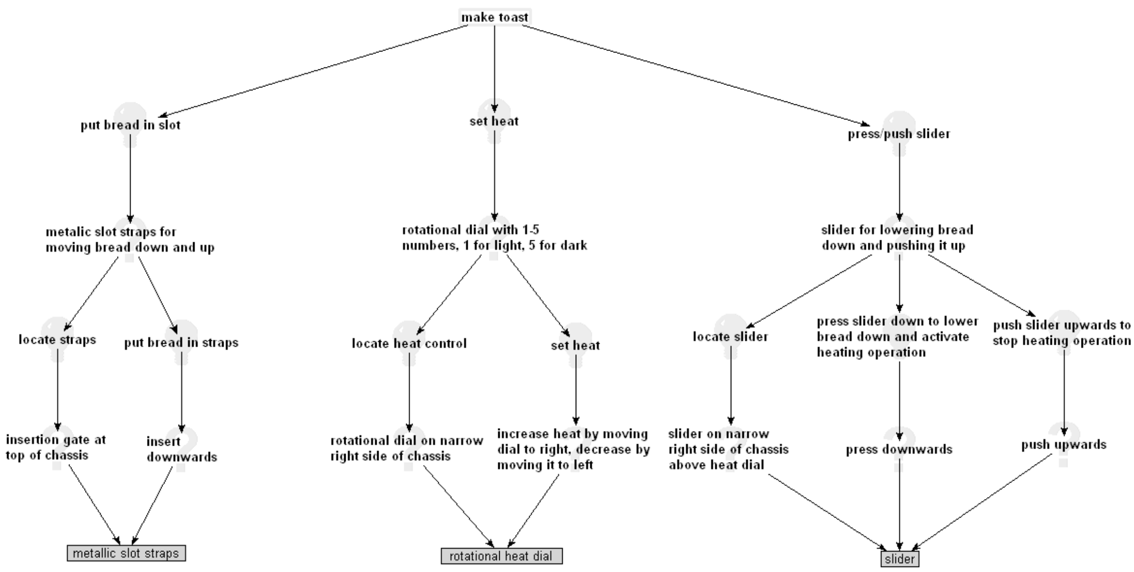

Figure 3. User model of a simple toaster drawn using the new modelling approach in DRed

In this example, the individual user model of a simple toaster has been represented, similarly to the designers’ model, using the goal element (DRed’s Pending Task element) to signify the master user goal pertaining to a toaster’s usage; the action elements (DRed’s Open Answer element) to indicate the sequence of actions that a user wants and thinks they need to perform to accomplish their goal with a toaster interface; the belief elements (DRed’s Open Issue element) to provide a user’s internal understanding of the appearance, functionality and behaviour of toaster features which they are required to exert their actions on and to convey the position of different features and how a user thinks their actions need to be taken to correctly operate these features; and lastly object elements (DRed’s Internal Block element) to stipulate the functional features that a user is familiar with, accustomed to operate and immediately associates with a toaster form. Once all the individual user models are adequately represented, designers are required to compare the similarities and differences between all models and construct one collective user model. In the fourth stage of using the new approach, designers need to compare similarities and differences between their own model and the collective user model, see how many commonalities and diversities between these two models map onto the actual engineering model and make appropriate design decisions relating to the inclusivity of future product features. Although we have not yet fully developed the comparison procedure, we assume that a semantic coding system for goal, belief, action and object elements will be used to pattern match elements of the designer model with the collective user model and generate a list of similarities and differences between these two models and map them onto the engineering model. At the moment, the engineering model represents human input (actions) in the form of arrows with verbs that link different object elements and so the development of a semantic coding system will have to tackle this problem in order to facilitate a more accurate comparison between human actions from the designer and user models and the engineering model. Also, we assume that the comparison procedure requires both computer assistance and human input. Computer assistance is needed for automatically comparing the new approach’s elements and generating a list of similarities and differences between the three models, while human input is required for creating data structures for each model and verifying at the end of the automatic comparison whether the models' respective elements have been compared correctly by the software system. One existing way of performing the automatic comparison between elements of different models is through the use of the transclusion function in DRed. For instance, by transcluding any coinciding elements from the designer model into the user model, designers can easily see through the presence or lack of little red triangle transclusion indicators in the user model whether there are any areas of agreement or disagreement between the two models.

6. Modelling Data

To trial the usage of the new modelling approach, modelling data was gathered from discussion with professional engineers about the functional structure of a simple-to-use toaster (for the purpose of the engineering model), discussions with two industrial designers about the design of an uncomplicated toaster (for the purpose of the designer model) and observations with thirty users of toasters (for the purpose of the user model). Engineers and designers were highly educated and had over two years of experience in product design, whereas toaster users had different levels of education and varying ranges of cognitive and physical capabilities. Two engineers were given a simple-to-use toaster and asked to discuss the functionality and structure of its critical components. Two designers were asked to design a toaster of their own choice by creating drawings on a piece of paper and think-aloud about any goals, beliefs, actions and objects that the toaster's future users would have during product use. Thirty users were asked to use the same toaster that was shown to engineers and think-aloud about any goals, beliefs, actions and objects that they had while using its interface. The discussions with engineers were captured in real-time using DRed and considered as the engineering model. Discussions with designers and user observations were recorded using a video camera, transcribed and included in a log of goals, beliefs, actions and objects. The log was useful for selecting information which needed to be fed into designer and user models.

7. Results

This study documented work in progress relating to development of a new modelling approach for designers that allows to represent engineering, designer and user information and discussed possible ways of comparing similarities and differences between this information. To trial the usage of this new approach we conducted discussions with engineers and designers, and observations with users. Subsequently, using DRed software we fed acquired information relating to participants' goals, beliefs, actions and objects into three different models and, due to a current lack of a semantic coding system and automated comparison procedure, we manually compared and contrasted information from these models. We found distinctive differences between designers and users' understanding and usage of a toaster's heat control and slider. In particular, designers associated a heat control with a digital display with + and – buttons for fluctuating toasting time between numbers 1 to 9. Whilst most users associated a toaster's heat control with a rotational dial with 1 to 5 numbers for adjusting heating intensity. The main difference between designers and users' understanding and usage of a toaster's slider was that designers envisaged the use of a cancel button for stopping the toasting function, whereas most users thought that they can terminate the toasting function by pushing the slider upwards. Although our approach is still under development, since technical details for a semantic coding system and a comparison procedure need to be worked out, we believe that its application has the potential to alleviate the problems associated with matching designers and users' understanding and use of products and, therefore, assist designers in creating more inclusive products. Our approach attends to interfaces of different appliances and promises to provide an effective way of flagging to designers any discrepancies between their understanding and usage of products with that of users and also informing designers which product features users find easy or difficult to understand and use. Beside providing useful information to designers on what feature types should be included or excluded from product interfaces, it may also be of real interest to other design stakeholders because it provides a snapshot of what a current product form is and what ideally it should be like.

8. Discussion and Conclusions

This paper discussed people's cognitive representations of products required for complex product interactions and the role of prior experience in the inclusive use of products. It also reviewed current design practice, good design practice and existing tools for guiding designers in creating more accessible and usable products. Our results indicate that there is a significant lack of a support tool for helping designers to capture and compare designers and users' understanding and use of products. Based on the results of our research, we propose a new data modelling approach for designers to enable the assessment and comparison of designers and users' understanding and usage of everyday products. This approach consists of four stages in which designers: (1) refer to the engineering model of a given product to see how different product parts interact with one another; (2) create a designer model of that product and compare it with the engineering model to see what features should be mounted on the top of the underlying functional parts; and (3) investigate how users understand and use product features and represent that information in the form of a collective user model; and (4) compare the amalgamated user model with the designer model (influenced by the engineering model) to make appropriate design decisions based on similarities and differences between these models. The preliminary results regarding the application of the new modelling approach (supported by the DRed software) indicate that it has a great potential of contributing to the creation of more inclusive products. However, the major limitation of the new modelling approach is that designers may lack good diagrammatic literacy and not have the time, skills or motivation required to observe and analyse users' interaction with products. Moreover, the effectiveness and usefulness of our approach in real design situations is yet to be properly evaluated and so further work remains to be done.

References

Aurisicchio, M., Bracewell, R. H., "Engineering Design by Integrated Diagrams", Proceedings of the 17th International Conference on Engineering Design - ICED 2009, Stanford California USA, 2009, pp. 301-312.

Blackler, A., "Intuitive Interaction with Complex Artefacts", School of Design Queensland University of Technology Australia, 2006.

Freudenthal, A., "The Design of Home Appliances for Young and Old Consumers", Delft University Press The Netherlands, 1999.

Goodman-Deane, J., Langdon, P. and Clarkson, P. J., "Key Influences on the User-Centred Design Process", Journal of Engineering Design, 2009, in press.

Langdon P. M., Lewis T., Clarkson P. J., "Prior Experience in the Use of Domestic Product Interfaces", Universal Access in the Information Society, Springer, 2009, in press

Krippendorff, K., "On the Essential Contexts of Artifacts or on the Proposition that Design is Making Sense (of Things)", Design Issues, Vol.5, No.2, 1989, pp 9-39.

Mieczakowski, A., Langdon, P., Clarkson, P. J., "Specifying an Inclusive Model of Product-User Interaction". Proceedings of the 17th International Conference on Engineering Design - ICED 2009, Stanford California USA, 2009, pp 143-154.

Norman, D. A.., "The Design of Everyday Things", Basic Books London UK, 2002.

Persad, U., Langdon, P., Clarkson, P. J., "Characterising User Capabilities to Support Inclusive Design Evaluation. Universal Access in the Information Society, Vol.6, No.2, 2007, pp 119-135.

Salustri, F. A., Weerasinghe, J. S., Bracewell, R. H., Eng, N., "Visualising Early Engineering Design Information with Diagrams". Journal of Design Research, Vol.6, No.1/2, 2007, pp 190-217.

Anna Mieczakowski
PhD Research Student
Engineering Design Centre, University of Cambridge
Trumpington Street, Cambridge, CB2 1PZ, United Kingdom
Telephone: +44 1223 766960
Telefax: +44 1223 332662
Email: akm51@eng.cam.ac.uk