CHALLENGES DESIGNING INTELLIGENT TRANSPORTATION SYSTEMS

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ABSTRACT: The IT complexities gave birth to Human Computer Interaction (HCI) to ensure that the products would be usable for the intended users. The problem with HCI is that the breadth of knowledge and its fast expansion has lead to fragmentation that undermines the positive effects of the multidisciplinary nature of HCI. Designers face a difficult situation with no simple solution and fast paced technological advances lead the way increasing the gap between research and development. In the area of intelligent transportation systems the designers face a tougher challenge due to the driving domain complexities. To understand the work domain, ecological interface design and the abstraction hierarchy is used. However it is the designer's responsibility to understand that there is no Holy Grail methodology. They should get a deeper understanding of the HCI disciplines and use variations and combinations of methods to understand the driving domain complexities.

1 INTRODUCTION

Today in the 21st century information technology (IT) has been integrated in our daily lives.

The IT product market ranges from toothbrushes to automated vehicle systems and it is a competitive market where different companies use different strategies to ensure that their products are bought and liked. Many of the IT products complexities gave birth to Human Computer Interaction (HCI). HCI is a multidisciplinary praxis that focuses on the design, evaluation and implementation of interactive system and to further study their effects of usage [1]. Human computer interaction has existed about 30 years and is concerned with understanding human behaviour and usage of devices and how these can be more useful and usable [2]. There are several disciplines that contribute to HCI - Computer science, Artificial intelligence, linguistics, philosophy, anthropology, design and engineering, ergonomics and human factors, social and organizational psychology, sociology and cognitive psychology [1].The already multidisciplinary nature of HCI and its expansion over the years has also in a way lead to its demise due to the comprehensive breadth of knowledge needed from the practitioners to really understand the foundations of HCI. This has led to the problem of fragmentation that undermines the positive effects of the multidisciplinary nature of HCI. Fragmentation occurs when practitioners have deliberately isolated themselves in a smaller portion of HCI. This leads to negative effects on the designer's otherwise creative role, leading to a lack of foundational understanding of HCI which keeps the average expertise among practitioners low [2].

There is no single or simple solution for the problems that designers have to face in designing usable IT products, especially since the fast paced technological advances lead the way and increase the gap that exists between research and development. To somehow not let products be driven by technological advances, experienced designers try to transfer knowledge and skills to inexperienced designers with design methods, philosophies and guidelines [3].

2 DRIVING WORK DOMAIN

The driving work domain is a complex environment. When designing for complex and safety critical environments there is a greater responsibility for the designer. They need to attain a deeper understanding of the work domain and activities surrounding the usage of these systems [4]. In the driving work domain the critical aspect is the driver's collective behaviour with the traffic environment and includes constraints that are both physical and intentional.

The physical constraints are the laws of physics that constraint the drivers possible directions. Intentional constraints reflect the driver behavioral laws and etiquette [5] Human behaviour is an unpredictable individual trait that leads IT usage to be used in places where the designer might not have intended the usage. One example is nomadic devices (mobile phones, PDA's, MP3's) and that they are used while driving, a context which they were not specifically designed for [6]. This is not a simple problem, it is a safety issue and wireless devices have been identified as one of the leading causes for accidents while driving [7]. It is therefore important that intelligent transportation systems are developed to fit the driver's safety and needs. Designers of intelligent transportation systems (ITS) are faced with understanding the complex context of driving that involves a continuous adaptation to a changing traffic environment.

To understand the driving work domain the ecological interface design (EID) framework is used. EID focuses on designing an interface to reflect the work domains different constraints and make them perceptually available to the operators. Leading the operators to take effective actions based on the real time information and sees how these actions move them towards their intended goals [8]. EID aims to support adaptive responses to routine and unexpected events [9]. EID is often used in complex system design e.g. for nuclear power plants, aviation and more, recently it has also been used in the automotive setting.

2.1 Related research

Results from a study showed that the use of EID improved decision making compared to regular design methods [10]. In another study it supported situation awareness [11]. In a third study the interface was found to be less cognitively demanding compared to other approaches [12]. A fourth study showed that it improved the operator response ability [13]. A fifth study showed that EID was a good way to structure driver information to find requirements for design [14]. Other work focused on using EID in combination with other principals to further support user needs in a iterative user centered design process [15], [16].

Work domain analysis is the first step in cognitive work analysis (CWA) framework which is a constraint based approach divided in five layers of constraints: The work domain, control tasks, strategies to solve problems, constraints in the social organization and worker capabilities [17], [18].

To describe the work domain and understand information processing both the EID and CWA frameworks describe the conceptual tool abstraction hierarchy [19], [17], [18].

2.2 Abstraction hierarchy

The abstraction hierarchy (AH) is a useful way of structuring the work domain and has five levels of abstraction [20]. Functional purpose: Describes the main purpose or primary goal of the work domain and how it is determined. (E.g. Environmental friendly) ·

- Abstract function: Lists the constraints and principles that need to be satisfied to achieve the functional purpose goals. (E.g. reduce co2 emission).
- Generalized function: Explains how the rules and laws of the abstract function are achieved and the processes that are involved. (E.g. Inform about speed or co2 emission).
- Physical function: Explains all the devices and equipment that are involved (E.g. Show speed, co2 emission)
- Physical form: Explains the lowest level of the work domain, namely all the devices characteristics. (E.g. Speedometer, or co2 indicator)

Design of ITS in safety critical environments poses big challenges for designers. In this paper a discussion is held the importance of the designer's role in designing ITS. How important work domain understanding is and how it would benefit the design in a safety critical environment like the driving work domain.

3 METHOD

The work domain analysis in this study [21] focused on driver information and was performed during spring and summer 2008 with researchers and industry. The study was limited to the car manufacturer's available driver information today and focused to find driver information for a private car. The definition of private car was a car that was used in a non commercial way or work related, however the car could be owned by a company.

The meaning of driver information is that the main purpose of the system was to support the driver's goals and the information is not limited to the inside of the vehicle and could be shown before and after driving. In the analysis the car manufacturer's strategy documents were used when discussing the functional purpose of the system.

The main purpose of the study was to focus on studying gaps, overlaps, strong and weak relations between the purpose and the old and future functions and systems. Therefore it was chosen to keep the abstraction hierarchy in lower detail. The work domain process was iterative using focus groups and interviews to find and discuss strengths of the links between all the abstraction levels from the Functional purpose to the Physical form [21].

4 RESULTS

One AH from [21] results (see Figure 1) was the functional purpose “Legal” (for more complex hierarchies and functional purposes see [21]).

The AH identified in the study was to “reduce the penalty costs” of breaking regulations either if they were on purpose or due to an error. Errors can be handled by presenting information at making it visible to the driver for a longer period of time than the traffic situation at hand thus reducing the chance of an error. An example could be a system that informs and restrains drivers from committing speeding violations or errors by displaying the traffic sign or a speed limiter connected to the driver’s current speed.

The identified general functions were: inform about car status (e.g. speed), inform about traffic regulations (speed, etc), encourage legal behaviour, stop or limit violations of traffic regulation and inform about speed monitoring cameras.

Physical function would be to show speed, show traffic signs, restrain violations and show speed camera warning.

Physical form of these systems would be speedometer, traffic sign display, violation warning, intelligent speed adaptation, speed limiter and speed camera warning.

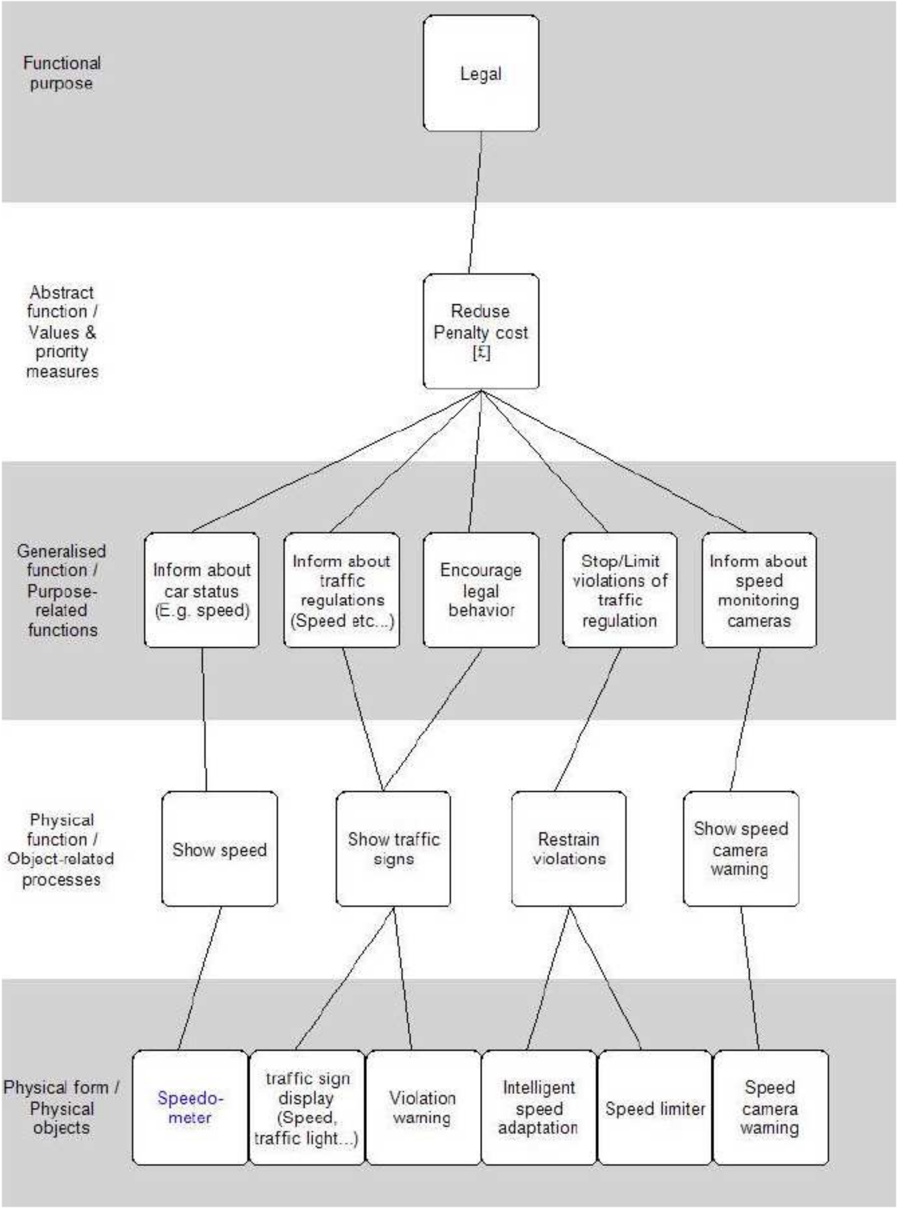

Figure 1: Abstraction Hierarchy – "Legal"

5 DISCUSSION

The purpose of the AH, was to study gaps, overlaps, strong and weak relations between purpose and functions/systems. The results show the functional purpose "legal", (Figure 1) with abstract purpose of reducing the penalty costs for the drivers. The physical form of the systems that would reduce penalty costs were identified as either informational systems (speedometer, traffic sign display, violation warning, speed camera warning) or automated systems (intelligent speed adaptation and speed limiter) that would reduce the illegal behaviour among drivers that causes penalties and costs.

The AH's generalized function describes the kind of information that would benefit the drivers in their goal to reduce penalty costs by informing about car status, inform about traffic regulations, encourage legal behaviour, stop/limit violations of traffic regulation and inform about speed monitoring cameras. The low detail in the AH, especially in the generalized function limits the range of physical functions and the physical objects associated to those functions. E.g. if the generalized function instead identified, inform about speed, inform about time to new speed, inform about speed in relation to the legal speed, etc. These would then translate to physical objects that would be different from a traditional speedometer and find other requirements for new technology and design.

A problem with the AH is that it could be biased, incomplete, or filled with faulty assumptions.

The AH uses common sense and it has difficulties in its expressive power of making tacit knowledge explicit. In the EID framework there is no clear statement on how to evaluate and validate the abstraction hierarchy [22]. In this study the AH is simplistic and low on detail, however many AH's often are more complex, depending on the functional purpose. In more complex AH's representations, it would be easier to find biases or false assumptions made by participants, mainly because the relations and connections become more complex. In addition "the results of any process will never be better than the people who participate in the process" ([23], p 14).

Nevertheless, the recent use of the EID, CWA and AH in the vehicle area has shown positive results in finding requirements which are otherwise overlooked in other approaches [14], [18], [21]. The AH results will show weak links in the relationships between the abstraction levels that raise design questions and improve understanding of the work domain that is being analysed. It could be argued that only focusing on the information from the AH to make assumptions on how to design ITS could lead to problems if the designers have over trust to the approach. No method or approach should be treated as the Holy Grail for design, but instead respected as a tool for understanding and learning about the problem setting. Design is in a sense much about finding a problem as finding or developing a solution to a problem [3]. It is the designer's role and responsibility to understand and have knowledge of other disciplines, philosophies and methodologies.

The information from the AH, might be common sense, however, the designer might still be able to extract ideas that could lead to design possibilities by adding his knowledge [21], since "the skills and abilities of the designer determine the quality of the final [product]" ([23] p 14). The notion of fragmentation plays an important role in how design is handled by designers, using the same guidelines, methods and approaches without expanding their views [2]. The role of the designer involves more than finding a problem and solving it, what people need and what they want are two separate things. If they need it but it does not fit their wants then they would just not use it [24]. Designers need to have a broader knowledge of HCI, aesthetics, emotional design, pleasurable design, and more to satisfy the users. "The role of design in HCI must not simply be seen either as a question of problem solving, as an art-form, or as a bustle with reality: it is on the contrary an unfolding activity which demands deep involvement from the designer" [3].

6 CONCLUSION

There is much focus on methods and guidelines could have negative consequences when dealing with safety critical work domains. The designer needs to take a leading active role and understand that no single method has the perfect answer. There is no Holy Grail approach. Methodologies and philosophies are tools to improve the understanding of work domain. In addition other disciplines are needed to fit the design to the intended user in the intended context. The phenomenon of fragmentation has led to intentional and unintentional blindness to the HCI knowledge available to practitioners of IT design. Designers should combine methodologies from other HCI disciplines or philosophies available. It is the designer's responsibility to explore, to be creative, and knowledgeable about the purpose of the design.

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