User Interface and Interaction Design in Future Auto-Mobility

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Abstract. This paper focuses tendencies and developments in HMI design in regard of automotive and human mobility in general. By providing two perspectives, one design theoretical oriented one system development related, we want to contribute to a systematic mapping this particular field of Human Machine Interaction.

Keywords: User Interface Design · Auto-Mobility · Human-Machine-Interaction · Layer-Like Boundary · Individual transportation · Dashboard · Adventure of driving · Augmentation · Manual gear shifting · Automotive "toys" · Targeted to a smaller group of enthusiast · 3D look · Tracking · Gesture based interaction

1 Context and Tendencies

Considering the term interface today, evokes the idea of a layer-like-boundary between areas governed by varying principals. Supplemented with the image of the iconic wipe on the ultra smooth surface of a touchscreen, the leading metaphor of the interface becomes condensed in a planner stratification, orthogonal oriented to the direction the interaction is pervading it. Relating this Information-Industrial-Age concept to user interfaces within contemporary cars evokes a contradiction. Identifying steering-wheel, gearstick, levers, pedals, various types of switches and analog gauges as the location where the Human-Machine-Interaction takes places while driving, renders this setup in an odd picture. Asking further about the interaction basically needed to achieve a satisfactory performance in the vast majority of individual transportation tasks (e.g. the daily drive to work and back home) reveals at once, how obsolete actually this setup is and how more interesting the resilience of the design concepts applied to individual mobility today. Simply the facts: that after a century of automotive development no consensus about the best position of the steering wheel (left over right) could be achieved, that the dashboards are still dominated by circular analog gauges (physical or nowadays even more bewildering as screen-graphics) insinuates, how retrogressively and sentimentality are about to suppress substantial innovation in this domain. Providing an USB-port underneath the dashboard, a touchscreen operated navigation or a homelike entrainment system does not contribute to a forward oriented mindset ether.

A. Marcus (Ed.): DUXU 2016, Part I, LNCS 9746, pp. 161–171, 2016.
DOI: 10.1007/978-3-319-40409-7_17

Actually at this edge, where two generations, two doctrine in User Interface Design meet each other, the underlying dilemma becomes even more evident.

The following explanation is based on the outcome of a summer school conducted 2015 at the Technische Universität Dresden (TUD, Faculties of Mechanical Science and Engineering and Computer Science) in cooperation with the American University in Dubai (AUD, Department of Visual Communication). The summer school was supported by AUDI AG.

2 Methodical Approach

Originating from this position we want to conduct deliberations about varying aspects of User Interface and Interaction Design in regard to future mobility and transportation. By creating distinctions along boundaries defined: by objective needs in individual and commercial mobility, by emotional and esteem correlated facets of the Auto, by the disintegration of monolithic design paradigms, by modern tendencies in urban design and sustainable thinking, by implications due to fundamental changes in the industrial production to come and more aspects, we want to create a framework where in a variety of approaches can be related each other in order to gain momentum for demand driven thinking and innovation.

2.1 Analysis 1

The fist distinction we want to undertake focuses the actual motivation of mobility and driving. Recalling the contemporary claims the automotive industry uses to emphasise their core values e.g. BMW: “Freude am Fahren” / “Enjoying Driving”, Audi: “Vorsprung durch Technik” / “Advantage through Technology”, Mercedes Benz: “Das Beste oder nichts” / “The Best or Nothing”, VW: “Das Auto”/“The Auto” it becomes conspicuous, that nothing of this is a need related argument. Refereeing to American or Asian automotive bands from Chrysler over Tesla to Kia Motors no claims at all are used, Lamborghini (belonging to Audi) on the other side talks about “Enjoyable Technology”. If we wouldn’t know it better, the automotive industry under the aspects could be seen as a peripheral matter, meant to content ephemera desires of a smaller peer-group of enthusiasts and not as a major factor in national economies. The ambiance which is to perceive through this wording appears to be from the very past, when driving a car was an adventure, which only could be mastered by having the best possible equipment, when the advantage through technology was a essential e.g. round the globe by car as Clärenore Stinnes did in 1927/29.

Thinking about key technologies today, engineering only becomes eminent, when the iPhone tends to bend in the back pocket or when a product cycle is about to end, in order to prevent buying an outdated model. We expect contemporary technology just to work and if it crashes we want to be able to solve the problem with a reboot not with a wrench or a wrecker. This difference in the appreciation of technology becoming evident here helps us to understand why the HMI’s in the automotive sector are still so strongly committed to the past. Yes, to drive on an empty mountain-road in Haute-Savoie, in an

autumnal forest is an experience, which hardly can be exceeded by anything else and it is legit to have such a paradigm in mind while thinking about user interfaces in the automotive domain. This backdrop of course delivers sentimentality at it's best, if any possible one would like to drive this scenario in a classic Gran Turismo car, chrome rimmed instruments, veneers from most precious woods, hand stitched upholstery form noblest Italian lather, manual gear shifting … a scenic route during the blue hour before sunset. But while this metaphors echoing away, I'm almost afraid to say, this is barely the situation what Automobile User Interfaces are made for. They are or they should be designed to help people to master their tasks under worst case conditions such as a rain covered highway, jammed with commuter traffic or driving under time pressure in a convoy while a snowstorm hits the road.

Comparing the HMI's of ordinary private owned automobiles with trucks, forklifts, and busses, with vehicles where the driver-seat is considered to be a working area - the situation becomes significantly different. Here it is much more likely to encounter more contemporary user interfaces (touch-screens, communication and observation devices) meant to help the driver in a sublime manner to do the job. This situation gives us cause draw the first line to map the cosmos of Automotive Interaction Design. By separating the concept of the workplace from experience-oriented design, the widespread conviction in automotive marketing, that the customer would not accept more contemporary solutions in HMI Design is forfeiting its paradigmatic charter. Moreover it becomes clear on one side, that this reminiscence centred approach gets even more emphasised in regard to the domain of expensive automotive "toys", targeted to a smaller group of enthusiasts who are able and willing to spend "comprehensive" expenses. On the other hand it becomes evident, that this doctrine is not universal and does not suit the contemporary appreciation of technology in general. Yes, to create a screen-graphic of a tacho- or rev-meter in a circular layout is au fond nothing to criticise. It is obvious, that depicting a rotation related value in a circular form helps to establish a sublime dispatching [1], helping the person in front of the instrument to interact highly efficiently due to a subconscious cohesion. But actually why do digital gauges need to have a 3D look, why it seems to be necessary to ad drop-shadows, highlights and reflections to create a "realistic" look, despite all the efforts done in the past to suppress precise this kind of distractive influences form the automotive HMI's?

2.2 Analysis 2

But this is not the main direction this article is aiming to. After distinguishing the experience form workspace related domain in automotive HMI-Design we now can go the next step in mapping this territory. Seeing the drivers seat as a workstation and understanding the efforts in HMI-Design done her as mostly need driven, as aiming to provide the best possible interaction between human and technology, while waiving unnecessary narratives and connotations we can extrapolate this thoughts further.

This will lead us to the glass-cockpits, head up and helmet mounted displays, pragmatic for military and increasingly also in commercial aviation. Here the basic concept is to understand the human as the supervising instance, controlling and managing complex streams of varying information. The human as seen an Inter-agent, is part of an highly

integrated system, working together with air traffic control, weather forecast, ground handling and so on. Despite it being probably possible to operate the commercial air traffic fully automatically, the human factor still matters here. Not at first for sentimental reasons, but in order to sustain mastership upon technical installations (whether and how to adhere this concepts is apparently more a cultural problem then a question of HMI-Design). Turning the attention further to the field of military aviation we are confronted with a much more serious situation. Flying an airplane into hostile air-space is without question a highly risky undertaking for the pilot. Within the economics of war therefor it is apparently reasonable to separate the pilot from the warhead. Instead of equipping the airplanes with armour plating, life supporting systems and emergency equipment to increasing the pilot's survival odds and in the light of the performance provide by contemporary information technology, the use of the UAV, seems to be increasingly the mean of choice in modern air combat. Although we should denial the application of violence in any means, the example leads us further. By establishing a remote-relation between the human being and the area were the actual mobility takes place another distinction can be made.

2.3 Analysis

By dividing the field of commercial mobility into one which is related to transportation and delivery of goods and payloads and one other oriented to the mobility of persons we can describe another differentia specifica, helping us organising our thoughts more. Thinking the transportation of materials one step forward gives cause to sees this as a entire system of remote operating trains, trucks, parcel delivers and drones. All of these units will be supervised by a smaller group of traffic managers, using standardised stationary computers interfaces. None of the mobile units will be equipped with any individual user-interface meant to serve a driver, pilot or a captain. But of course, at least in the first instance HMI's used wile service and maintenance will give need for related design solutions. Thinking the next step in this direction, we will have to question the need of transported goods itself. Extrapolating the progress of the Internet of Things and the Maker Culture leads us to a thought experiment, wherein all or at least most of the things needed (e.g. furniture, foot or action hero figures) can be made at home or at a "Making-Centre" in the vicinity of the actual living place. In conjunct with the tendency of urbanisation, the incasing desire of the human beings to live in cities, now only blueprints, schematics and assembly instructions need to be transmitted by already to day existing, largely proven technology. Using recyclable filaments and renewable energy in the "Making-Process" - a new level of a sustainable society can be achieved, counteracting the threat the humans civilisation is exposing to our planet right now.

Thinking about the mobility of persons under the paradigm of business needs delivers in the first instance a similar picture of a highly diversified public transport system. Only the "payload" is less predictable, needs much more attention and safety precautions and is able to move shorter distances autonomous, seen from a system overlooking point of view. Due to presence of human beings with in the system the scope of needs and possibilities in HMI-Design is of course much wider. People who need to

spend time in travel and whom attention is not drained by dealing with stressful driving situation are interested in accessing entrainment and communication networks using various types of interfaces (cellphone, tablets, AR-Devices, holograms…). Whereby the spectrum of ideas can range for an individual solitude providing media-cocoon to wall covering digital signage and further.

Thinking the second stage of peoples need driven transportation delivers a picture, which renders the paradigm of mobility as imperative to meet the needs of the post industrial job market as going astray. Looking along the axis constituted by the development of telecommunication and telepresence systems shows how rapidly the things are about to change in this domain. Was video telephony in the past (as we can see in respective Si-Fi-movies) only revered to a very elite of global leaders and only worthy to be used in the instance of e.g. Godzilla doing weird things with styrofoam buildings in Japan, a world without Skype, FaceTime and co. today would deliver much more serious problems. How would my mother be able to finish the puzzle in the newspaper without asking me over 3 timezones distance for help?

Relating this to the needs of peoples future mobility, it becomes clear, that people who are flying half around the globe, just to attend a business meeting are less to admire, possessing less prestige then those who get the same task done without leaving the building. So, thinking the aspects to the extend; an end or a serious decent of need driven travel and transportation is to be on the cards. But how does this match with the numbers provided by the IATA, expecting a annual grow of passengers of 5.3 % [6]?

3 First Summary

Indeed, mobility is apparently for the most of us more than moving from A to B in order to achieve the thing that needs to be done. The human being is and has forever been on a journey, urged to approach the world out there and speed is a appropriate means in doing so. From Exploring the vicinity of the cave to the moons of saturn and beyond - our curiosity compels us at first to a movement within a simultaneous existence of the spatial extend and only then by assigning the concept of duration to an intellectual journey into the mind [2].

Opposite this egocentric first person point of view we need to recognise, that the extended world is about to shrink due to our obsession with speed and mobility. Since continents are only hours apart from each other the space in-between becomes congested with air traffic - in the same manner our urban environments are getting obstructed by automobility. But in comparison to the public transportation in the air the system of individual mobility on the ground operates even more far below its optimum. Considering the fact, that the wast majority of the private owned cars (this ones with the most sentimental HMI's) are only in use for a fraction of the day and if used then almost in the same time (generating rush hour traffic jam), while otherwise occupying extended parking lots; makes it eminent to rethink this situation on a systemic level. Doing this reveals the digressiveness of the idea of growing numbers, which was and still is paradigmatic for the industrial age and leads our attention to smarter solutions.

In the domain of individuals mobility this can only mean to develop an system of autonomous cabins, instantly accessible by a smartphone app, able to reach any location

during an optimal timespan. This will lead to a much more optimised situation, requesting less resources, space, energy and a drivers attention. The only argument against this, might be the esteem and prestige related idea of having an individual environment while traveling (from precious woods or in carbon fibre optic). Reconsidering the contemporary resilience of major players automotive industry against progressive, need oriented developments (thinking about the diesel emission scandal) it becomes clear, that this is last line of defence in order obtain outdated structures. Thinking forward, it would be easy to develop a scenario where the interior of the autonomous cabin, the human oriented side of this technology can be designed to be a multimodal interface, the coauthor of the article is researching on. Having a individual mobility system, which operates accordantly contemporary paradigms in regard to technology, the hardware of the multimodal interface can be also separated from the individual demands of the passenger, who can create or purchase her/his individual user experience and submit this to the system with the same device she or he orders the cabin to the desired location, using the mobile phone.

4 Practical Approach

Following this philosophical introduction the question of practical and methodical consequences must be asked. For answering this question a look at the history of human machine interaction (HMI) might be useful, cause new concepts of designing and planning are based on specific tools. The term tool covers a wide range of meaning: Tools can be understood as software products as well as classical physical objects. In case of interacting with computer systems an interface is the general tool. The interface is placed between reality (R) and user (U), who wants to change his relationship with reality. This user-reality relation changes throughout technical history in terms of space and time depending on the tools used. The following graphic overview (see Fig. 1) shows the changing relation.

The development of HMI is performed in four steps. In the pre-industrial age the user is physical coupled to reality. Tools are just extensions of human physical possibilities and are handled in a direct way (e.g. on a bogie). In the age of industrialization the user is decoupled from energetic aspects of the machine (R). He is now free for control tasks by gear lever, button or signalling element. In the computer age user gains a large autarchy in space and time. He changes reality via the computer in indirect ways. The interface (understood as an interactive image, GUI) currently represents the reality (e.g. with a dashboard). Presently great efforts are made to control the created data flood. The domination of the visual moment turns out to be a problem. Therefor planar representations based on a static and one-eyed user, developed as standards and cultural techniques. The user's dynamic and body-based potential lies unaddressed. His inhered space-time behavior is not relevant.

This leads to deformation. McLuhan (cited by Culcin) notes: "We become what we behold. We shape our tools and then our tools shape us." [3] The new subject area »Behavior Design« promises support. A special design of interfaces is intended to change, develop or optimize the user's behavior, respectively behavior patterns. This method is based on a limited term of behavior, which is focused on control and

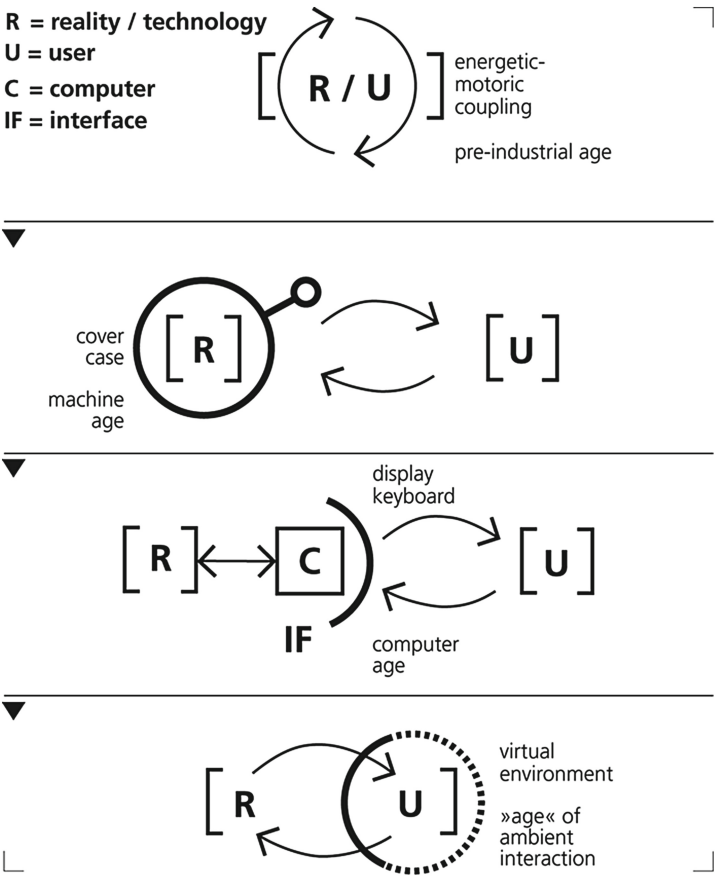

Fig. 1. Development of interfaces

guidance of interaction. [4] The short term change of behavior in this method is the main problem. The purpose of behavior patterns are, of course, based on their steadiness. They are part of the conditio humana. Within this mind, it is right to research behavioral techniques, by giving attention to the acting and exploring user. At this point it's possible to find hope. Driven by gaming and movie industry more and more techniques for tracking and visualization of the spatial behaving user are explored:

- Motion Capture Systems (body-, head- and eye-tracking)
- Kinect
- Leap Motion
- Oculus Rift.

These mostly inexpensive gadgets are equipped with a rich and disposable arsenal of software, frameworks and application programming interfaces permitting inclusion of game engines and other virtual scenarios. But not only tracking and recording

technologies are in progress, also qualitative data analysis and interpretation are developing rapidly. Nowadays modelling a formalization of human behavior is possible. The gap between behavior patterns and notation systems and languages is bridgeable. Concluding the described facts, it is possible to designate the emerging age as an age of ambient interaction. The user (as a car resident) is acting »unshaped« in his own environment.

5 Prototypical Implementation

Four projects (research prototypes and student work, that has been implemented at the summer-school) are intended to serve as examples. They were achieved by the further up described techniques.

1. *Aughanded Virtuality* [5] embeds the image of user's arms (real time track) into a virtual scene. The entire scenario is viewable by Oculus rift (see Fig. 2). Aughanded Virtuality (Augmentation + hand) provides experience of real hands (gestures, motion) in virtuality. The handling area is now »vitalized«. The felt and observed movements of user's hand provide feedback and scaling. Currently it is necessary to make efforts to duplicate the depicted hands by invisible virtual hands. Cause only these virtual hand models are »able« to interact with virtual objects.
2. Under the heading of gesture based interaction a concept was developed [7] to interact with virtual scenarios by head, hand and gaze movement (Example scenario: learn how to control a car and it's environment). The Oculus rift serves as visualizing system. The head movement is used for exploration of spatial structures and the eye/hand movement for the selection of menu items (after dwell time) and for triggering of functions (see Fig. 3).
3. *ESTER* (Eye-Tracking Science Tool and Experiment Runtime) offers the option to expand the idea of saliency maps. [9] A stereoscopic tracking system allows to

Fig. 2. Aughanded Virtuality (Photography: Franke, I. S.)

Fig. 3. Gesture based interaction (Photography: Müller, M.)

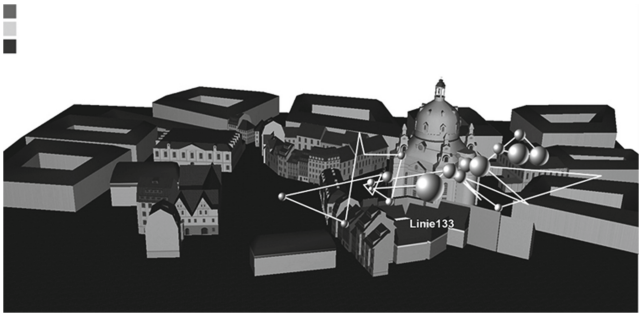

Fig. 4. ESTER (Screenshot, Source: [9] p. 382)

transform the eye gaze movements (gaze behavior, saccades, fixations) to a 3D diagram. ESTER can easily track and show the user's trails of observing in a sculptural way. In the end the student (user U) can be watched during gazing by the teacher (supervisor S) (see Fig. 6). An abundance of applications for training is imaginable (see Fig. 4).

4. The research framework *BiLL* (BildspracheLiveLab) enables the interlinking of powerful tools for creating, editing and presenting graphic information. [8] This is the condition to research and develop novel depiction principles. In particular new methods of perceptually realistic visualization (non-photorealistic projection) have been investigated (see Fig. 5).

The projects - although the topical focus is different – can be allocated to the diagram in Fig. 6. It's a positive impact that working on such projects only can succeed with an interdisciplinary approach. For example interpretation and analysis of tracking data is impossible without cognitive psychology. Interlinking of hardware components fails without knowledge on electrical engineering.

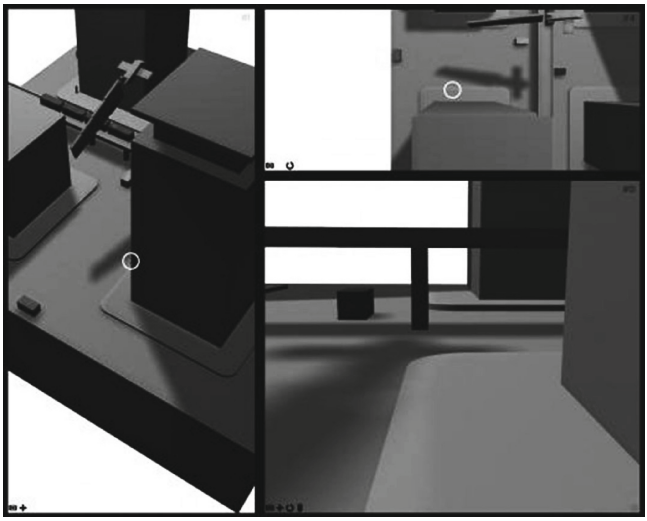

Fig. 5. BiLL (Screenshot, Source: [8] p. 71)

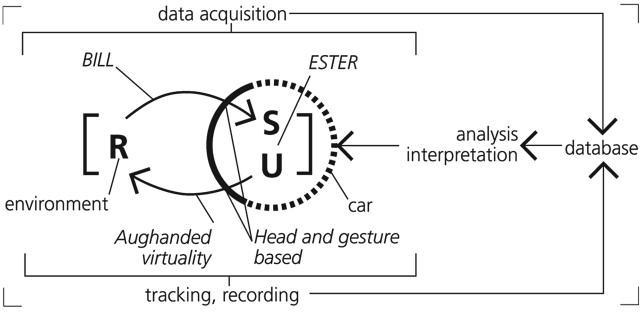

Fig. 6. Order of prototypes

6 Last Conclusion

Even if the contour of the field of research develops stepwise it is necessary to define the lines of research to overcome the period of experiment. Possibly a generalizing discipline should take the lead: anthropology or ethology? Finally you will notice: »First we define our behavior patterns, thereafter they shape our tools.«

References

1. Barthes, R.: The Rhetoric of the Image. Oxford University Press, Oxford (1964)
2. Bergson, H.: Matière et mémoire. Essai sur la relation du corps à l'esprit. Alcan, Paris (German: Materie und Gedächtnis. Eine Abhandlung über die Beziehung zwischen Körper und Geist. translated by Julius Frankenberger. Diederichs, Jena 1908, Hamburg 1991) (1896)

3. Culkin, J.M.: A schoolman's guide to Marshall McLuhan. Saturday Rev., 51–53, 71–72 (1967)
4. Fogg, B.J.: Persuasive Technology: Using Computers to Change What We Think and Do (Interactive Technologies). Morgan Kaufmann, San Francisco (2003)
5. Günther, T., Franke I.S., Groh, R.: Aughanded Virtuality – The Hands in the Virtual Environment. Research Demo and Poster IEEE VR 2015, Arles (2015)
6. http://www.iata.org/pressroom/pr/pages/2012-12-06-01.aspx
7. Schulze, E.: Virtuelle Realität - Kopfbasierte Navigation und Interaktion. Diplomarbeit. TU Dresden, Fakultät Informatik (2015)
8. Starke, M., et al.: Interactive panels - a tool for structured three-dimensional scene exploration and visualisation. In: Proceedings 3D-NordOst 2011, pp. 67–75 (2011)
9. Wojdziak, J., Kammer, D., Stahl, A., Groh, R.: ESTER - eye-tracking science tool and experiment runtime. In: Stephanidis, C. (ed.) HCII 2014, Part I. CCIS, vol. 434, pp. 379–383. Springer, Heidelberg (2014)