Towards Cross-Cultural Adaptive Driver Navigation Systems

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Abstract:
Driver navigation systems are becoming more complex in functionality and interaction possibilities. Furthermore, due to the expansion of global markets, their usage potential must also be world-wide. One possible method of coping with intercultural complexity is to apply adaptivity. In this paper the concept of cross-cultural adaptivity in driver navigation systems is discussed. First the functionality of driver navigation systems is explained. Then the advantages and problems of adaptivity are addressed. Finally, the influence of culture on driver navigation systems and the Use Cases of cross-cultural adaptivity in driver navigation systems are presented.

Categories and Subject Descriptors:
H.5.2 [Information Interfaces and Presentation]: User Interfaces, ergonomics, graphical user interfaces (GUI), input devices and strategies (e.g. mouse, touch screen), interaction styles (e.g. commands, menus, forms and direct manipulation), screen design (e.g. text, graphics, and color), theory and methods.

General Terms:
Design, ergonomics, human factors, adaptivity, psychology

Keywords: Cross-cultural human machine interaction design, adaptivity, driver navigation systems.

1. Introduction

Generally, the design and development of user interfaces for vehicles includes manifold aspects e.g. information visualization, haptic technology etc. which are challenges to software developers. However, in addition to the traditional human factors, the cultural diversity and the corresponding emotional appeal includes one inescapable factor: Driving a car is often a matter of life or death [14]. Especially today's driver navigation systems are highly complex systems having more than 1000 functions. Within the infotainment systems of a car, alongside other components - including radio, telephone and CD or DVD player - the driver navigation system demands many highly interactive activities from the driver.

Interaction between the driver and the navigation system takes place not only previous to travel, when the destination is specified, but also whilst driving. This interaction includes observation and reaction to the maneuver guidance and making decisions about a desired alternative route in the case of traffic jams.

During stressful situations, the Human Machine Interaction (HMI) of the driver navigation system can be made adaptive to reduce the mental workload of the driver [16] [19], depending on the driver's cultural background. According to the principle of cross-cultural adaptation of HMI, the culturally dependent behavior of the driver has to be measured and recorded over time in order to obtain information about the parameters necessary to be able to culturally adapt the HMI [4].

Within the process of cross-cultural HMI design, the most challenging step is to bridge the gap between cultural aspects and HMI design by determining relevant cultural variables and their values in order to derive practical guidelines for cross-cultural user interface design. One promising method to accomplish this task is to observe and analyze the interaction of users, from different cultures, with the system by an appropriate automated analyzing tool [3] [4]. From this cross-cultural usability, metrics can be deduced, which can be used for cross-cultural adaptivity.

Several steps are necessary to make driver navigation systems culturally adaptive:

- First, the cultural differences in using driver navigation systems have to be determined during the design phase as stated above.
- Second, the system architecture has to be modified and extended according to the cultural needs of the user.
- Third, at runtime, the system has to detect the user preferences in different driving situations in order to model the tendency of the cultural attributes of the driver and to adapt the HMI accordingly.

This paper elucidates some aspects of cross-cultural adaptive driver navigation systems in general.

2. From Driver Navigation Systems to Cross-Cultural Adaptive Driver Navigation Systems

Driver Navigation Systems

The architecture of a driver navigation system consists of several components grouped into the following units:

- The system application includes the positioning module (Global Positioning System (GPS) input) as well as the route planning module (input from database and dynamic traffic information sources such as Traffic Message Channel (TMC)).

- User guidance (by voice announcement and graphics) and optional adaptive map presentation are parts of the user interface.
- Integration into the car user interface is achieved via generic I/O channels (keys, microphone, ...) and indirect interaction with telephone and entertainment applications via driver preferences and workload.

Input data (via GPS, TMC, microphone, hard- and soft keys, etc.) is collected and stored so as to be available to the business logic. In order to compute the optimum route, it is necessary to take into account all factors relating to the driver, for example: preferences, mental and physical state, and outside aspects, for example, weather, road conditions, etc.

The route has to be presented to the driver in accordance with the driver's mental workload in the current situation: easily comprehensible, multi-modally integrated and cognitively adequate. The configuration of the interface between the driver and the navigation system must **prevent** the driver experiencing an excessive mental workload [15].

The information presented to the driver needs to be suitable for the specific driving situation and the driver workload. In this case, adaptivity is reasonable because the driver does not have the opportunity to manually adapt the setup of the information presentation according to the special situative requirements.

Hence, either the system suggests the *adequate form of information presentation* to the driver (Computer Supported Adaptation) or it *adapts it automatically* (Automatic Adaptation) whilst the driver is actually concentrating on driving [11].

Adaptive Driver Navigation Systems

For all adaptive systems the following questions must be answered [6]:

- *Adaptation means:* What has to be adapted? Adaptive parts of the HMI can be, for example, the number of the Points of Interest (POI) per map page.
- *Adaptation information:* According to what has to be adapted? The number of POI can be adapted according to the different cultural preferences of the users (e.g. China versus Germany).
- *Adaptation process:* How is the adaptation done? Adaptivity can be achieved by adjusting the domain model as well as the system-model to the user model by generating decision models from the interaction model [1] [6]: by recording and analyzing the dialogs as well as the user interaction with the system, inference mechanisms trigger adaptation mechanisms, which are deduced components, that implement the adaptation performance. Inference mechanisms are matching current interaction patterns with stored, culture-dependent ones, i.e. inferring components make decisions regarding the adaptation performance on the basis of decision models. Evaluation mechanisms are research components that collect information about the user by observing the user behavior. They are used to verify whether or not the performed adaptation corresponds to the user-model by checking whether the system model and the user model match.
- *Adaptation objective:* Why adaptation? The ultimate objective is to avoid cognitive overload and low (intercultural) usability.

There are at least three ways of adapting a system to the user-specific requirements to optimize HMI [1] [13]:

- Manual *Adaptation* means that the user adapts the system manually to set his preferences, i.e. the driver adapts the parameters of the system in accordance with his wishes. The driver keeps control over the system on that occasion. However, the possibilities of adaptability of the system are pre-determined in this case. Hence, the driver has to learn them and is tied to them. Driver preferences which are not covered cannot be adapted. Furthermore, the driver workload is not taken into account. The likelihood that driver model and system model do match over a long time is relatively low.
- Automatic *Adaptivity,* on the other hand, is the ability of a computer system to automatically adapt itself to user-specific peculiarities by generating a user model to fulfill the usability expectations. The main advantage of this kind of adaptive HMI in the vehicle is the reduction of the mental workload of the driver (by taking into account driver preferences and the driver workload in the actual situation) to adapt the system correctly and automatically. The interaction between driver and system improves and becomes easier, which optimizes the HMI in general and increases driving security. This effect is even more amplified when aspects are taken into consideration in the user model. The system adapts itself automatically to the cultural preferences of the driver. The advantages of this possibility are that the driver doesn't have to know the system. The driver determines the type and degree of adaptivity by his interaction with the system. Thus, the HMI is continually being simplified and the likelihood increases that driver model and system model continue to match over long periods of time. However, the system can over-adjust or can adjust incorrectly.
- The third alternative is *semi-adaptivity*. The system recognizes the interaction behavior of the driver and deduces the necessary HMI adjustments using its collected knowledge about the driver. The system then automatically suggests possible adjustments to the driver, which can then be manually approved or rejected. Thus the driver is made aware of system changes. This hybrid solution unites the advantages of the two preceding approaches described above and avoids their disadvantages as far as possible. The driver retains full control over the system and does not need to know the system. The driver workload, as well as the driver preferences, is taken into account. The HMI is simplified and the likelihood is high that driver model and system model completely match over a longer period of time. Therefore unfulfilled expectations of the user are avoided and usability is optimized.

Adaptivity of the interaction also supports the identification and personalization of the driver by storing the type of interaction of the driver with the system in a database. The system must recognize these interaction patterns in order to be able to adapt its own interaction patterns to those of the driver and his situational needs. This can be done by adapting the HMI according to the user model but for this, the system has to know the different user models of the different drivers. Hence, a user model has to be built and kept up to date by observing the driver whilst he/she is driving. There are several methods of acquiring the necessary information/knowledge about the driver [11]:

- Primary acquaintance heuristics can be domain-specific (rules by direct interaction) or independent of a domain (correct and incorrect usage of objects, queries of explanations and details, feedback).
- Finding stereotypes in driver behavior is another method and involves three steps: determination of user group, identification of the key features of the user and hierarchical representation of stereotypes.
- There are many other methods such as objective(s) and plan recognition by libraries of plans or plan composition as well as error libraries or inferences.

In any case, the knowledge found out about the user must be kept consistent by complex but adequate forms of representation such as prolog, predicate and modal logic as well as neural networks or hybrid representation systems. For this purpose, and to simplify the realization of adaptive systems, shell systems for user modeling components have been evolved [12].

The driver navigation system has to integrate a lot of data from several models and sources e.g.:

- driving situation model
- driver preference model
- driver intention model
- driving history and
- vehicle data.

Driving behavior includes aspects such as fast, stressed, hectic, sporty, or curvy driving and depends on the experience of the driver (beginner, intermediate, professional, expert), or gender and especially on the cultural background (using bumpers for parking, buzzer frequency, interaction times, interaction frequencies, etc. cf. e.g. [20]).

The history of the driving tours contains important information about the preferences of the driver: the preferred type of routes, average speed, default tours, short or long tours, along rivers or hills, etc.). Moreover the interaction styles can vary strongly (e.g. reasonable, rational, arbitrary, sequentially fast, well considered, haptic, visual, auditory, linguistic, etc.).

By associating these aspects with the cultural models, implications can be made to culturally adapt the HMI. Automatic adaptation concerns country-specific aspects including:

- format
- modality
- menu structure
- content of menu
- alternative routes (scenic, sporty, short, fast…)
- guidance
- map display
- language

- advice for beginners or experts
- number of messages
- length of texts
- number of hints
- degree of entertainment
- ratio of information to entertainment, etc.

The different cultural background of the drivers requires that concepts of internationalization and localization need to be considered and integrated into the driver model in order to be able to adapt the system to the cultural needs of the driver.[1]

Cross-Cultural Adaptive Driver Navigation Systems

In cross-cultural adaptive driver navigation systems, cultural (and partially cognitive) aspects are taken into account in addition to technical and linguistic aspects.

Cultural aspects are not to be confused with individual aspects. Only one single user owns individual aspects as opposed to all users of a common culture who have cultural aspects at their disposal in common. Therefore, the main concept of cross-cultural adaptivity does not mean personalization but internationalization and localization at a national-cultural level.

Cross-Cultural adaptivity in this sense is therefore equivalent to adaptivity of national elements, i.e. the adaptation of national characteristics: all users who can be assigned to a certain national culture are consequently tossed into the same pot.

Here, the HMI is adapted according to the characteristics of cultural dimensions at country level, which are, for example, the five cultural dimensions of Hofstede [5] as well as those of Hall [2] or Trompenaars [18] including power distance, uncertainty avoidance, communication speed or universalism and their shaping which can be determined e.g. by the means of questionnaires.

Personalization however, means an individual, quite specifically and a *single user* related and limited adaptation of the system driven by the preferences of one individual user. In the adaptive personalization mode, the system adapts to the individual features (personal characteristics) of the user, e.g. the four categories of Carl Gustav Jung that reappear in the *Myers-Briggs-Type-Indicator (MBTI)* [10]:

- extroversion vs. introversion
- sensing vs. intuition

[1] To reduce effort at creating complex user models we are the opinion that by using principles of neural language programming (NLP) driver (user) models can be avoided at very low interaction levels by using the following two rules: If the interaction speed of the user is high, the feedback speed of the system must also be high. If the interaction frequency of the user is low, the interaction frequency of the system has also to be low. Here the principle of "copying the strategies of the communication partner" is addressed. By such methods the "rapport" and "pace" between the user and the system can be established, which is necessary to get the "communication partners" onto the same level of mind [8,15]. Hence, at low interaction levels we can avoid much effort in building driver models simply by omitting them. But this hypothesis still has to be confirmed by further research. Some ideas also regarding these aspects can be found in [5].

- perceptive vs. judging and
- feeling vs. thinking [17].

Furthermore, user-individual adaptation requires a corresponding person-tied identification (for example by personalized car keys, password or fingerprint).

In contrast, cross-cultural adaptive HMI does not perform person-identification but applies an identification of the user's culture by the recognition of culture-specific interaction-patterns of the user with the system.

The cross-cultural adaptive HMI is neither an adaptation to a particular national culture nor is it an adaptation to a particular individual, rather it comprises the recognition of *culture-specific* interaction-patterns of the user with the system as well as the corresponding *culture-specific* adaptation of the HMI (either as suggestions to the user or automatically).

Yet, adaptivity can interfere heavily with personalization, e.g. Siemens Adaptive Transmission Control (SAT) and its further development *intelligent tip* which is an adaptive automatic transmission with personal grade[2]

The transmission automatically switches the gear according to the driving situation and to the driving preferences of the user in his current driving situation.

The adaptation can be situation-dependent or user-related (for example situation-referential personalization of haptic-visual interaction vs. free multi-modal dialogs). Adaptivity of the haptic-visual interaction contributes to personalization and is situation-dependent. Moreover, an optimal personalization of the system to the user, using automatic methods of adaptation, should also cover cross-cultural parameters, which can be determined by user-observation.

However, the objective of cross-cultural adaptive HMI is merely the situation-referential adaptation of *cultural* aspects of the Graphical User Interface (GUI) and Speech User Interface (SUI) (for example information dimming or multi-modal dialogs according to the different requirements in China and Germany respectively, according to the current situation and context).

Cross-cultural adaptive HMI only uses user models, which are averaged over all users of a cultural group. Hofstede proved that there are quantitative differences in human behavior averaged between countries [5]. These quantitative differences have to be transferred to differences at HMI where possible and to provide this knowledge to the system for adapting the HMI to the cultural needs of the driver.

3. Use Cases in Cross-Cultural Adaptive Driver Navigation Systems

According to the Use Cases, there are several areas in driver navigation systems where adaptivity is reasonable:

- event application process interface

[2] cf. www.siemens.com, PoF 1/02 Artikel 11 Verkehr Personal Car, 19.09.2005, URL = http://www.siemens.com/index.jsp?sdc_p=d1187140pFEcfi1193081l0mn1193082o1193100s5t15u20z3&sdc_sid=19211125899&

- maneuver generation
- voice guidance (instructions and timing)
- map displaying
- dynamic routing / dynamic traffic data handling e.g. via TMC
- telematics
- multimedia / multimodal HMI in general
- destination input
- speech recognition
- international help concept controlled by speech
- interaction management and
- dialog management.

A user enters data verbally (by speech), by pressing buttons and/or by touching screens. Auditory output is provided by speech and visual output by displays (e.g. screen, Head Up Display (HUD)).

The main interaction strategies in driver navigation systems are connected to their main functions: destination input, map display, route guidance, option choice and "screens". The most important Use Cases in driver navigation systems include:

- Destination input (with or without using an input method editor, number and kind of items in list boxes, widget positions etc.),
- Map displaying (color, details of map elements, number of information chunks, e.g. points of interest) and
- Voice guidance (voice guidance instructions, timing of voice guidance instructions, creation of voice guidance instructions, etc.).

All these parameters can be investigated in respect to their cultural dependence.

Destination input methods such as keyboard, touch drive, touch screen, touchpad and speller can be adapted as well as the possibilities of selection (amount, arrangement) of information units using occurrence control (depending on frequency of usage).

There is a large amount of information to grasp and to choose from during destination input. The user has to select not only the destination but also all the related constraints (such as additional destinations on the route, kind of route (fast or short, highways or smaller roads, toll roads or not, routing through the city or around, points of interest, etc.)). Within the Use Case "destination input" the speed of interaction (system response time according to input time), information density (number and length of entries), frequency of dialogs (number, kind and complexity of dialogs during destination input) and information coding (positions of widgets, colours) can also be adapted.

Information frequency (frequency of the presentation of information over time), information density (number and distance of information units at the display) and other properties of information such as complexity, coherence, reference and relevance of the presented information are adaptable in the Use Case "map display".

In the Use Case "maneuver guidance by display and voice" the frequency of information (number of information units per time), information density (words per sentence or information unit) and the frequency of dialog presentation (number, kind and complexity of dialogs during maneuver guidance) are concerned.

The Use Case "dynamic presentation of information" covers visual cultural variables such as colors or arrangement of widgets. The dependence from driver situation can be regarded using several modes of information presentation (e.g. navigation, cruise or vigilance mode) which can be selected manually or automatically according to the driving situation *(cf. Groenland, F., Rühl, H.W.: personal communication within project "Drive-IT Adaptive HMI"; 2004).*

- Navigation mode is selected if navigation commands have to be taken or there are many maneuvers to execute.
- Cruise mode equals driving on highways where the mental workload of the driver is relatively low and the driver can e.g. listen to music and set up the equalizer to change the sound while driving.
- Vigilance mode will be activated if a dangerous situation emerges or mental workload increases dramatically, e.g. if phone rings while approaching an intersection.

Other Use Cases have to do with adaptive speech dialogs. Here the dialog strategy (kind of doing clarification dialogs) and style of dialog (detailedness and length of speech prompts) have to be regarded. Adaptivity of dialogs automatically means adaptation of dialogs to the desires and needs of the driver by adapting the logical sequences of dialogs as well as their content and meaning. Additionally, learning new adequate dialogs, by the system, in order to address the needs of the driver, finally leads to a certain "understanding" of the driver. This feature requires enhanced techniques such as *intelligent learning algorithms.*

Speech recognition can also be adapted to the speaker. First the language of the speaker has to be detected (either automatically or manually by user input).[3] Then the system can adapt to the originalities of the speakers (e.g. dialect, idiolect or even speech handicaps such as lisp or stutter). By this method, the driver can be identified since every speaker has an own "speech fingerprint" which supports personalization (by storing the *way of speaking* as well as the dialog characteristics of the speaker in a database).

Another Use Case is built up by adaptive interaction paths that can vary in frequency, length and structure and finally there are areas of adaptive interaction such as menus, soft keys and so on. Adaptive information presentation involves representation (form (e.g. color) and structure (e.g. arrangement)), meaning (content), adaptivity and personalization (automatic adaptation to the individual user preferences) as well as adaptivity and cross-culturality (having cross-cultural variables and their shaping as default-parameters for intercultural users before runtime – and

[3] One possibility to automatically detect the language of the speaker is to recognize the frequency and kind of vocals in the utterances of the speaker. This arrangement of vocals allows identifying the country [3].

henceforth also during runtime on the basis of the use of machine learning algorithms). All has to be adapted to the preferences of the driver in a certain driving situation.

Hence, there are enough Use Cases for adaptivity in driver navigation systems.

4. Discussion

It is interesting that all named Use Cases above do involve intercultural, international and interpersonal aspects. Internationalization as well as localization of HMI can be covered by using cross-cultural adaptation. The first presumption for this is that HMI application and adaptive HMI driving application already use Unicode. Furthermore, it is necessary for the design of cross-cultural adaptive systems to take the differences of the desired cultures where the product will be sold into account. The results need to be integrated in the whole cognitive driver model and implemented in prototypes. The represented cognitive models of the user (driver) have to be adjusted according to the desired country.

Tables consisting of the differences between the desired *cultures* (countries, ethnic groups, dialects, gender, age, preferences etc.) must be created.

Cultural aspects include national (and international) aspects inlcuding formats and Unicode and lead to cognitive styles at the highest level of cognition in the TLCC-model.[4] A layer approach for intelligent services, which comprises the architecture and the priorities of the data-oriented driving situation model as well as the driver workload model, must be developed. The driver workload model could be an extension of de Waard's model by "sleepy" state to include drowsiness detection (micro sleep) *[cf. Groenland, F., Rühl, H.W.: personal communication within project "Drive-IT Adaptive HMI"; 2004].* Research should deliver further information to enable the development of these models in more detail and to generate an integrated adaptive HMI model.[5]

Solving Problems by Adaptive Driver Navigation Systems

There are several aspects that can be solved by adaptivity. Here are some ideas *[cf. Gall, W.: personal communication within project "Arriba Navigation"; 2003]:*

- adapting scroll speed of list boxes according to the speed of the touch drive usage;
- showing the right information (relevance) and the right amount of information (quantity) according to driving conditions;
- anticipative driving by virtual horizon;
- changing of light such that it automatically falls into the direction of the curve;

[4] The TLCC-model shows the historical growth of localization steps in HMI design represented by its four levels: technical affairs, language, culture and cognition [18]. Cognitive styles describe the types of human thinking e.g. problem solving or concluding [17].

[5] Finally, this could even lead to a universal mediator layer between basic navigation functions and the HMI. A step in this direction could be intercultural adaptive interface agent architecture (IAIAA) which has been developed within this dissertation project. Yet, cultural differences in HMI have still to be made measurable and integrated into this architecture to get the IAIAA working properly.

- using intelligent automatic gearing (especially on mountain roads);
- choosing routes according to the driver preferences e.g. differences by gender;
- compute destination time and optimize computation of routes according to fast or slow drivers;
- automatic showing of lanes; guidance in the head-up-display and system internally
- adaptive memory management to avoid lack of memory or memory overflow.

There is great potential for adaptivity in driver navigation systems.

Problems with Adaptivity

It is problematic that an automatic adaptation (adaptivity) depends on maximum data when observing new users: the system needs more data in order to be able to release information about the user as well as to be able to infer the characteristics of the user regarding information presentation, interaction and dialogs.

Furthermore the knowledge gathered about the user can be *misleading* or simply false: the reliability of assumptions can be a problem [13]. The user model has to agree to the system model to prevent unexpected situations for the user, which may confuse him.

Another problem is that legal restrictions also have to be taken into account. Because of legal restrictions, only the effects of driver actions in a driver model are allowed to be permanently stored, but not the log file of the personalized driving sessions themselves [1].

As long as no solution is available, by which meaningful adoptions from minimum data can be achieved automatically, it remains necessary to investigate standard parameters and their values very early in the design-phase, and long before runtime, in order to integrate them into the system.

Therefore, it is necessary that the system already has corresponding user-knowledge at its disposal (standard parameters) before the user's first contact with the system occurs.

Before using the system for the first time, it must be adjusted to the language of the user (which indicates the main affiliation of the user to a cultural group (country)) and the corresponding cultural parameters can be placed simultaneously as standard parameters for the desired countries. Furthermore, this way, the adaptive system also obtains adequate characteristics of the user more quickly at runtime, because there is "more time" to collect the culture-specific data for the user, since a basic adaptation to the most important user preferences was already performed before runtime (by putting the standard parameters into the system).

Designing an appropriate system according to the user in the design phase avoids the problems rising due to adaptivity.

Adaptivity is achieved by adjusting the correct user models (already available from the design phase) according to the context of the actual driving situation at runtime.

Design Principles for Adaptive Driver Navigation Systems

The following formation principles in the vehicle context have to be taken into account if adaptive driver navigation systems are to be designed. The distraction potential (the mental workload) of the driver must be held as low as possible. The HMI must be simple and safe in order not to endanger the driving security.

Multi-modal dialog design requires that the driver can choose the modality freely anytime. Moreover, the possibility that all haptically usable interaction elements can be attended by verbal output has to be guaranteed in following the motto *"speak what you see"*. Finally, the interruption and resumption of dialogs and interactions has to be possible.

The reason for the adaptation (e.g. the current driving situation) and the kind of adaptation (e.g. structuring menus or renaming soft keys etc.) must be comprehensible for the driver in every case. Therefore, the frame of reference is not allowed to be altered too strongly. Furthermore, the frequency of the adaptation has to be kept as low as possible.

Technical Implementation as well as Feasibility of Adaptivity in Driver Navigation Systems

The technologies which can be applied involve a GUI-Toolkit and a dialog engine, which is able to process transaction-based application specifications as well as isle parsing with semantic grammars. Very small speech recognition modules for embedded systems with hidden Markov models (HMM) technology and graph-m-phoneme convertibility can be used to obtain dynamic adaptation of the vocabulary, language-model-adaptation and dialogue-step-dependent switching of predefined word repositories. Both prompt-based speech output and text-to-speech-components are available.

The following technologies can be consulted to implement adaptivity: The situation recognition takes place by soft-sensor methods (e.g. fuzzy logic, neural nets). The intention-model is implemented using causal nets. An adaptive dialog style is achieved using tabular preference scores with exponential forget-factors and causal nets with incremental learning mechanisms as well as neuronal fuzzy systems.

The following user interface functions must be implemented to reach adaptive objectives:

- multi-modality
- interplay between GUI and SUI (mapping)
- dialog engine
- GUI
- priority manager
- speech output
- speech recognition
- profile manager
- driver identification/verification and

- adaptive soft keys.

Possible higher development costs or increased effort is not an argument against such adaptive systems since adaptivity is usually to be found in the HMI roadmaps of all automobile manufacturers nowadays and the basic concepts of adaptivity for future projects must still be developed. Moreover, the engineering process, necessary to obtain adaptivity, promotes the usability of the apparatus. To achieve adaptivity at all, i.e. to be able to perform adaptation by the initiative of the system according to the cross-cultural differences in the HMI dependent on the user, the cross-cultural differences must be determined by intercultural usability engineering [8], where Usability Engineering Methods form a good basis [7]. Including such methods from the beginning also reduces costs in future international product development and product maintenance and increases intercultural usability.

5. Conclusion

The disadvantages of cross-cultural adaptive HMI are the same as those for all adaptive systems, as stated in 4.2 above. From these problems with adaptivity, some design rules can be derived [13]: The user must be aware of the user-modeling component and that the system can make errors or even pursue non-cooperative interests. Hence, he should be able to switch off the user-modeling component. The modeling of long-term user characteristics should be avoided and personal access should not be realized by recognition of the intentions of the user.

According to Jameson (2003), [9] it is possible that adaptivity goes along with good usability. The advantages of adaptivity lie in better usability by adapted user and system models, shorter training times by fast adaptation to the driver and in less distraction from traffic and mental workload by automatically optimizing and adapting the HMI. The acceptance of intercultural adaptive intelligent user interfaces is given, when the user is aware of the changes in the user interface driven by the system or the changes are very small and happen over a long period of time so that the driver does not recognize them because he is familiarized slowly[6]. Further research must show exactly how the concepts of cross-cultural adaptivity in driver navigation systems will look and which of them will survive and yield the greatest benefit in future.

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7. About the Authors

Rüdiger Heimgärtner is doing his PhD thesis at the University of Regensburg at the department of Information Science. He has a doctoral scholarship from Siemens AG in Regensburg to support the development of cross-cultural adaptive infotainment systems.

[6] To render familiar or accustomed; to divest of strangeness.

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