A New Approach of a Context-Adaptive Search Agent for Automotive Environments

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Abstract
The progress in electronic devices and therefore the growing amount of information in cars implicates the development of new strategies to cope with this amount of information for drivers. An intelligent search agent can help with navigation in deep hierarchies and in huge databases, and consequently has a high potential to increase the concentration on the primary driving task. The evaluation shows that a search agent concept reached a high user acceptance and the objective data proved observably acceleration in handling compared to deep hierarchical menu navigation.

Keywords
search engine, automotive, GUI design, menu, driver information systems, input devices

ACM Classification Keywords
H5.m. Information interfaces and presentation

Introduction
Nowadays, besides the function of merely a transportation system, automobiles take more and more the task of a multimodal information system. Due to the enormous increase of functions, especially over the last decades, the tendency to integrated menu-

driven displays and central handling concepts are predominant features[1]. Therefore, the car cabin is also characterized as driver's working environment. In this case, a major problem is the fast and efficient retrieval of information and functions within these interaction concepts. For this reason, in this contribution a new intelligent search agent concept for cars is introduced. The major aim of this development is to accelerate and simplify the interaction between driver and information systems, and for this reason the search agent has been implemented in a user-interface for cars. The new agent reduces the problem of information search in deep hierarchies and huge databases, and can reduce the distraction of the driver from vehicle guidance by fast and interruptible interaction.

Background

This chapter gives some background information about clustering in menu structures and the general function of search engines are explained.

Menu Structures

Generally, a menu is a list of selectable options, which after a choice of the user leads to a change of the system status [2]. If the number of options is too large to be presented efficiently in a single menu panel, it is often necessary to design a menu structure. *Hierarchical menus* are a series of menus which are structured in a hierarchical or "tree-like" manner, where the selection of an initial option leads to another menu containing additional options, until the desired results are obtained. *Network menus* are series of menus structured as a network providing redundant pathways to either all or some of the menus within the structure. A special application of network dialogs is the internet; the term Hypertext was created by Ted Nelson in 1965 to describe non-linear writing in which you follow associative paths through a world of textual documents [3]. The most common use of hypertext these days is found in the World Wide Web (WWW) pages and is the basis of the internet form today. The user of the WWW follows specially highlighted links on a web page to get from one node to another node within the network.

Search Engines

A search engine is a program that looks up documents for specified keywords, and returns a list of the documents, where the keywords were found. Although a search engine is a general class of programs, the term is often used to specify systems, like Alta Vista or Google that enable users to search for documents on the WWW. [4] Search engines are the key to find specific information on the vast expanse of the www. There are basically three types of search engines: those that are powered by crawlers, or spiders, those that are powered by human submissions, and those that are a combination of the two. Crawler-based engines send crawlers or spiders out into cyberspace. These crawlers visit a web site, read the information on the actual site, read the site's meta tags and also follow the links that the site connects to. The crawler returns all that information back to a central depository where the data is indexed. The crawler will periodically return to the sites to check for any information that has changed, and the frequency with which this happens is determined by the administrators of the search engine. Human-powered search engines rely on humans to submit information that is subsequently indexed and cataloged. Only information that is submitted is put into the index. In both cases, a search engine query to

locate information is actually searching through the index that the search engine has created and is not searching the Web. These indices are giant databases of information that are collected, and stored, and subsequently searched. The same search on different search engines produces different results, because not all indices are going to be exactly the same. It depends on what the spiders find or what the humans submitted. But not every search engine uses the same algorithm to search through the indices. The algorithm is what the search engines use to determine the relevance of the information in the index to what the user is searching for. One of the elements that a search engine algorithm scans for is the frequency and location of keywords on a Web page. Those with higher frequency are typically considered more relevant.

Concept and Implementation

The new developed search agent concept for cars supports the driver by rapid access to the relevant information and data under consideration of actual automotive context information. The information basis can be accessed via one graphical input mask on a central information display (CID). The entry of search items or words is supported with several input modalities which must be intuitive and easy interruptible for the driver to reduce the eyes-off road time. Especially the input of alphanumeric terms is facilitated via speech recognition, handwriting detection via touch pad, text over a numerical pad (T9), and a speller via a turning knob. For each hit, an individual and dynamic ranking for assignment of relevance is identified. After calculation of the ranking (a score-based algorithm) the search behavior of the driver (search history and frequency) and the distance to the actual location can be interpreted. Also a unit for error management is integrated in the search algorithm to increase the robustness of the system. Different spellings of search words or names (e.g. Meier or Mayer) and twisted letters (e.g. rsetaurant instead of restaurant) were also accepted and interpreted. The hit list can be browsed or navigated with the central turning knob or the speech recognition to reach the relevant information or function.

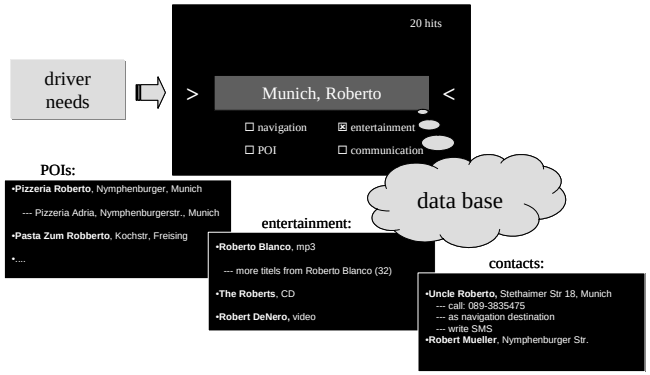

Figure 1. Search agent concept idea

Two databases are available for retrieval of relevant hits: a local (local onboard car data-base) and a global database (centrally administrated). The global database can be accessed, e.g., via a wireless telecommunication system. The database consists of point of interests (POIs), music titles, contacts, menu entries, handbook, etc. Beyond this, the system has the possibility to send inquiries to real internet search engines. To guarantee an integrated information management, the search system is connected with the vehicle functions and the conventional hierarchical menu structure. Thus, for each hit, connected and integrated functionalities can be used. It is, for example, possible to send an address

or GPS data directly to the navigation system, and let the system calculate a possible driving route. A phone number of an entry can be transmitted to the mobile phone system or shortcuts to menu items can be selected directly. This concept idea provides parallel function access to the user [5]. The driver can access all the information directly from only one initial point, which is the entry mask. From the result list, the driver can select the desired information or functionality by browsing. No paths for example through a menu structure have to be memorized by the driver.

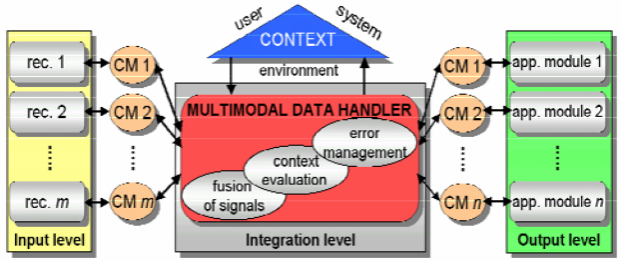

Figure 2. Multimodal framework based on a late semantic fusion of input

This search agent concept idea has been implemented on the basis of the FERMUS development framework [6] and a rapid-prototyping simulation software using an existent driver-information-system simulation. The system architecture basically consists of three main processing levels: the input level, the integration level, and the output level (see figure 2). The input level contains any kind of interface that is capable of recognizing user in-puts (e.g., turning knobs, buttons, speech recognizer, etc.). Dedicated command mappers (CMs) encode the information bits of the single independent modality recognizers and context sensors into a meta language based on a context-free grammar (CFG). In the integration level, the recognizer outputs and additional information of context sensors (e.g., information about application environment, user state, etc.) are combined in a late semantic fusion process that is extensively illustrated in [7].

EVALUATION

To verify, whether the concept idea has a real added value for the driver, the developed search agent was analyzed in a usability test using a driving simulation task.

Experiment

The automotive trial platform was a test car in a laboratory environment.

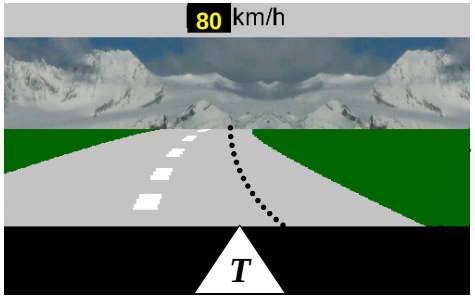

Figure 3. Screenshot of the 3D-driving simulation

Test persons had to follow a predefined street course in a laboratory driving simulation (see figure 3). This test was developed within the scope of the project FERMUS for assessing ease-of-use and distraction potential in a reliable, reproducible and economical manner [8]. In this study 14 test persons of higher qualifications

participated with the age of 19 till 48 (average age was 28 years). The test persons had to perform diverse tasks regarding the operation of the multimodal in-car system. The target application was a route navigation, address book and entertainment system, consisting of an MP3-player, navigation, and a POI database simulation. As tactile modalities, the user was provided with a central control unit integrated in the armrest and a 10" screen located at the center console (see figure 4). Input could also be delivered via command-based speech.

Figure 4. The cockpit interface

The subject was told to solve different tasks of interaction with an existing graphical menu structure and the new search agent. For evaluating the input modalities different instructions of usage were given. The test persons fulfilled the following tasks in several passes:

- entering a driving destination: e.g. using the turning knob as input modality for navigation in the menu structure or the search agent, and the speller for alphanumeric input of street and city
- entering a phone number: e.g. via numeric pad as input modality
- menu navigation to car functions: e.g. change of sound settings

For each task sequence, they had to proceed one ride by using the new search agent and one ride by using the ordinary hierarchical menu style. Afterwards, the persons were interviewed with a questionnaire about handling, acceptance, benefit, and distraction effects. For evaluation of the deviation from the lane keeping an error score has been logged [8]. Furthermore, interaction times and user behavior for each tasks were analyzed. When the test series had been finished, the constellation has been transcribed and filed in terms of test data sets.

Results

Regarding time data, it shows that through the newly introduced search agent, significant time savings have been reached. In the case of the task "entering a driving destination" an average time saving of 45,2 % resulted. The task for "entering phone numbers" can be absolved with an average time saving of 8,6 % compared to the menu structure. The deeper the menu points are located in the hierarchy, the higher time savings have been reached with the search agent. With regard to the average track deviation, the new functions evoked no verifiable irregularity. In the subjective rating, a high agreement of the test persons with the new search agent occurred: To the statement "This function makes sense", 12 of 14 persons (85,7 %) agreed with this statement, so that an average rating of 1.14 has been reached (1- I agree; 4 - I disagree). Evaluating the different modalities, the

command-based speech entry got the best rating with 1.36, the numeric pad got 2.79, and the turning knob 3.71 (1- very good; 6 - unsatisfactory). But all test persons considered a turning knob appropriate for scrolling and selecting in the result list. Every test subject classified the speech entry suitable for entering search items and 9 of 14 the numeric pad. As an additional input device 5 persons wished a touch screen or touch pad. According to the ranking of the POI search results the test persons (7 of 14) considered personal preferences as most important followed by distance to destination (4 of 14) and alphabetical order (4 of 14). Only two wished a consideration of the search behavior of other drivers. Four persons suggested to regard the time to destination instead of the distance. Summarizing, the new search agent concept for cars has reached a very high subjective acceptance by the test subjects, and the objective data has proved significant acceleration in handling.

Conclusion and Outlook

The major motivation of these studies was primarily to accelerate the intuitive retrieval of information and functions in vehicles. The results of the usability study have shown that the usage of an intelligent search agent, time savings concerning the HMI-interaction of about 30 % can be reached. The input of search items was easy interruptible while driving. But the subjects criticized the little transparency of the search criteria. For suitability while driving further investigations must be conducted under higher workload, error situations and more realistic databases. Further research will also focus on search algorithms, relevant context parameters and the adequate adaptation of the user interface in cars.

REFERENCES

[1] Niedermaier, B.: Development and evaluation of a rapid-prototyping approach for multimodal human-machine-interaction in automobiles. Munich, Technical University of Munich, Institute for Human-Machine Communication, Dissertation, 2002.

[2] Norm ISO9241 part 14: Menu Dialogues. In: Ergonomic requirements for officework with visual display terminals (VDT-s), 1996.

[3] Mulzer, W.; Zhang, S.: The Little History of The World Wide Web, FU Berlin, Department of Informatics, 2001. URL: http://www.inf.fuberlin.de/lehre/SS01/hc/www, 2003-08-12.

[4] Searching & Finding in the Internet or: “The Needle in a Haystack“, 6. edition, September 2001, Regionales Rechenzentrum für Niedersachsen, Universität Hannover

[5] Ablaßmeier, M.; Niedermaier, B.; Rigoll, G.: A New Approach of Using Network Dialog Structures in Cars. In: SCI 2004, 8th World Multiconference on Systemics, Cybernetics, and Informatics SCI 2004, 18.-21.07. 04, Orlando, Florida, USA. Publ.: N. Callaos; W. Lesso; B. Sanchez. IIIS Orlando 2004, Vol. XI, p. 227.

[6] G. McGlaun, F. Althoff, M. Lang, and G. Rigoll: Development of a Generic Multimodal Framework for Handling Error Patterns during Human-Machine Interaction, In: SCI 2004, 8th World Multi-Conference on Systems, Cybernetics, and Informatics, Orlando, FL, USA

[7] G. McGlaun, et al.: “A New Approach for Integrating Multimodal Input via Late Semantic Fusion,” USE-WARE 2002, Darmstadt, Germany; in: VDI Bericht 1678; pp. 181-185, 2002

[8] G. McGlaun, F. Althoff, B. Schuller, and M. Lang: A New Technique for Adjusting Distraction Moments in Multitasking Non-field Usability Tests, In: CHI 2002, Int. Conference on Human Factors in Computing Systems, Minneapolis, MN, USA