

iFlip: A Metaphor for In-vehicle Information Systems

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ABSTRACT

After the successful transfer of hierarchical menu-structures from the computer domain to an automotive environment, it is time to discuss the potential of 3D metaphors to meet the strong requirements for in-vehicle information systems (IVIS). The idea is to increase learnability, efficiency and joy of use of IVIS by providing a 3D interaction concept that is based on cognitive capabilities of humans. We present a 3D interaction metaphor, iFlip, which consists of displaying information on the reverse side of thin interaction objects and a preview to current submenu states.

A comparison with a traditional list-based 2D menu for IVIS has shown that iFlip fulfills automotive requirements and can even enhance usability and likeability of IVIS.

Categories and Subject Descriptors

H5.2. [Information interfaces and presentation]: User Interfaces – Graphical User Interfaces; Interaction Styles
H.5.1. [Information interfaces and presentation] Multimedia Information Systems - Artificial, augmented, and virtual realities

Keywords

3D interaction, automotive infotainment, 3D metaphor, spatial memory, vision-based UI.

1. INTRODUCTION

The transfer of menu-based systems from the computer domain to automotive environments, adapting them to the more demanding requirements, has been successful as latest IVIS products are showing [4][5][12]. As the computer industry has evolved various metaphors as followers of menu-based systems, it is time to evaluate their relevance for automotive environments as well.

1.1 State of the Art

In recent years, more and more functions which can potentially be used during driving have been added to the cockpit of cars. The concept of providing control buttons with direct access to each such function has reached its limits. User interfaces in cars are

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now changing from such classical concepts to approaches that integrate controls and displays in order to decouple the number of functions from the number of direct interaction devices. BMW has been the first car manufacturer to transfer the hierarchical menu concept from the computing domain into an automotive environment [5].

1.2 Requirements of IVIS

The design and use of IVIS imposes special requirements on interaction schemes, because the interacting task is secondary to the driving task. The need to combine interaction with a dominant task is an extension to the common requirements and rules of interface design. Therefore it is not possible to simply map well computer-suited menus one to one to IVIS. Criteria regarding the usability, learnability, efficiency, memorability, error handling and satisfaction of user interfaces [13], have been extended with the requirement that driver distraction must be avoided. ISO-Standards [8][9] state various compliance procedures for in-vehicle visual presentation and for principles on dialogue management. Today's menu-based systems satisfy those requirements successfully. Manufacturers of cars other than BMW have followed this strategy and have provided menu-based systems with multifunctional controllers [4][12].

1.3 Metaphors for IVIS

As successor of full screen menus, the computer industry has introduced graphical user interfaces with the desktop metaphor, WIMP technologies and direct manipulation to reduce learning cost and to give non-experts access to digital functionality in cars [13]. Additionally, several approaches utilize human cognitive capabilities such as spatial memory [14] and give orientation hints, e.g. via thumbnails [7]. Since IVIS users differ extremely in demography, skills and culture, it seems reasonable to base metaphors on very general, culture-independent, world knowledge to support the usability criteria *learnability* and *memorability* as well as to increase *joy of use*. The relevance of such metaphors for automotive environments needs to be discussed to see whether they are able to meet the special requirements.

1.4 Designing a 3D Metaphor

In this paper, we present an IVIS metaphor that is rooted in 3D concepts. There are several reasons: first, driving is a spatial task and could fit therefore to a 3D interaction approach. Second the third dimension offers a wide range of possibilities to create

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metaphors based on basic attributes and worldwide knowledge. Third, humans are used to orient themselves and to manage tasks in a three dimensional world. They thus possess strong cognitive capabilities in spatial environments.

2. Related Work

Metaphors for automobile environments build on approaches of the computer domain. The studies on Data Mountain [14] and Task Gallery [15] have shown that spatial memory works in a virtual environment similar to the way it operates in physical worlds. The work in [6] has proven the same for visual recognition memory of images. The Task Gallery is one of the first approaches that is based on a 3D metaphor for graphical user interfaces on a PC environment. The aim of the Task Gallery is to organize tasks. In the Task Gallery, outputs from running applications are presented on walls – as a virtual art gallery.

Several studies have been conducted to evaluate the performance and usability of 3D and 2D user interfaces in desktop applications [4][17]. Indeed, 3D applications haven't always increased the performance. But in all these studies users did prefer 3D interfaces. Not only usability, but also acceptance and joy of use were significantly better.

Althoff et al have compared a standard 2D user interface for IVIS to a 3D user interface [1]. The main interaction area of the 3D interface was a big barrel on which the selectable options were shown as lists. The results of the user study has shown that selective 3D elements could significantly increase overall usability and joy of use.

3. IFLIP DESIGN

iFlip consists of five thin application boards which display five submenus of an IVIS system. The approach mainly consists of two parts: 1) menus that are rotated by about 90 degrees give a preview of their current state. 2) Each menu has a flipside which provides access to further, context-dependent options. (see Figure 1)



Figure 1. Five thin application objects: 1 menu is situated in the middle. Four additional menus are rotated 90 degrees vertically like walls.

3.1 Preview Submenus

The most important menu, is placed in the middle of the application area. The other menus are placed at the four sides of the application area and are rotated about 90 degrees in space. This arrangement gives users the impression to look into a room. If users want to change something in a vertically rotated submenu, they can get to it like closing a door and the submenu swings into the application area to enable a comfortable interaction. The state

of vertically rotated submenus remains in the view of users. We don't expect users to read and manipulate submenus in their rotated state. Rather the rotated menu should give them rough information about the submenu's current state by shape, colour and formation cues. In general, these preview submenus are a realization of fisheye techniques in 3D.

3.2 Usage of Flipsides

The iFlip metaphor provides information on reverse sides of menus. This approach is not new in the computer domain. But thus far, there is no consistent implementation. In every realization the use of reverse sides differs. In [16] backsides are used as identifiers in a programming interface for children, designed for usability. The *looking glass* project of Sun [17] enables users to turn windows around to write notes on their back and to see submenus. Apple [2] is introducing flipping behaviour for their widgets in the new OS Tiger to set controls such as color. In order to decide which information should be displayed on reverse sides and to ensure a user-centred intuitive concept, we have analysed flipsides in everyday life. We have identified different categories for their classification (see Table 1).

Table 1. Categories for the usage of everyday life object's reverse sides

Name	Description	Examples
Detailed Information	Gives further and detailed information	Book, food, DVD
Related Information	Is related, but gives no special information	Magazine
Hiding Information	Hiding information of the front	Playing cards
Notice	Writing notices on the reverse	Handout, business card
Continuation	Continuation of the front.	Blank, contract
Equivalency	Same content in, e.g. other language	business card
Contextual Dependency	A contextual relationship to the environment	Postcard

We have also conducted pilot user study to ensure acceptance of using flipsides as interaction feature, as well as to judge the respective relevance of four different concepts what information to show on the reverse side. From fourteen participants, 3 female and 12 male, between the ages of 24 and 34, thirteen judged the usage of flipsides as good approach.

Additionally, they ranked four different concepts for the flipsides we implemented, after a description and a demonstration of our prototype: a parallel menu, an overview of the menu with shortcuts, options related to the front side, and favorites. Ten of the participants voted for the options approach, which fits to the related category of detailed information. Therefore we decided to display options, which are related to the front side, like providing sound settings on the reverse of the music menu.

3.3 Implementation

We have implemented our approach with Java 3D. In our implementation the swinging and turning animation needed about 300 ms, but this is configurable.

The content and construction of the menu logic was based on a simulation of a conventional list-based 2D menu. We mapped the control of a multifunctional controller, which allows shifting in four directions, rotating and pressing.

4. USER STUDY

The purpose of our user study was to compare our approach with a traditional list-based 2D menu and to find out if it satisfies IVIS requirements. Furthermore, we have investigated whether animations are annoying or a helpful feature to build a mental model of the menu structure. Third we have examined whether the preview of the current state of a submenu gives orientation cues.

4.1 Evaluation Set-up

Participants had to accomplish a lane change task [11], while interacting with both systems. The Lane Change Test is a simulated driving task, which judges ease of use and distraction potential. It is designed as a so-called table set-up and consists of a PC monitor, pedals and a game steering wheel. The participant drives on a three-lane road and has to follow signs, which are attached beside the road and advise which lane should be driven in (see figure 2).

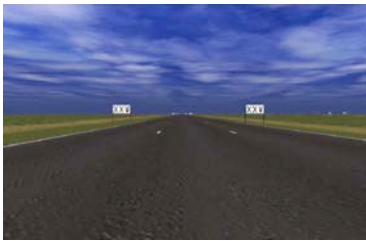


Figure 2: A Screenshot of the Lane Change Driving Task.

As result the total task completion time and the lane deviation from the ideal line can be computed by an analysing software tool. (see figure 3).

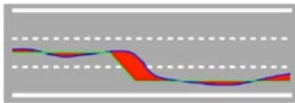


Figure 3: Lane Deviation from the ideal line.

We combined the Lane Change Test with the Dikablis Eyetracker [10], which recorded the gaze directions and focused objects while driving and interacting.

4.2 Tasks

The tasks were mainly option setting tasks such as adjusting basses in the sound system and changing menu tasks such as first selecting a radio station and afterwards activating the speech output of the navigation system.

4.3 Participants and Procedure

Fifteen participants (four women), who had no technologic background and were novices in IVIS, attended. They were between 22 and 66 years old (average of 45 years).

4.4 Procedure

The participants had to accomplish for each task one ride while using our 3D approach and one ride while using the list-based 2D menu. After each ride they had to answer four short questions about their subjective impression solving the task while driving. Finishing, they were interviewed with a questionnaire about ease of use, joy of use, acceptance, learnability and distraction.

4.5 Hypotheses

Our main hypothesis was that the metaphor would provide a faster access to the desired functionality and that memorability and

learnability would be highly supported by the natural arrangement.

Second, the animation was expected to help the users to build a mental model and to use their cognitive capabilities especially spatial remembering as well as image recognition. Third, the vertically rotated submenus were expected to give orientation cues and to help drivers find the desired functionality. Last, we expected a higher joy of use, because of the usage of 3D and animation effects.

4.6 Results

The study produced different data to measure different properties of the IVIS. Heading control values from the lane change task [11] and viewing behaviour data from the Dikablis Eyetracker [10] judge the distraction potential. Task completion time measures the efficiency. We have evaluated differences between the interfaces and tasks using a repeated-measures ANOVA on the participants values for the objective data. We could increase several usability criteria with iFlip.

Task completion time: As the task completion time data is showing, the 3D presentation enabled significant time savings: 45.1% average time saving for the adjusting options task and 26.5% for the changing menu context task. (see Figure 4)

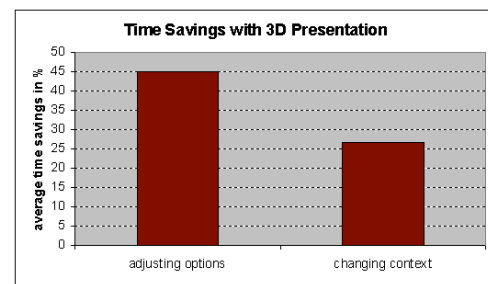


Figure 4: Average Savings for the Task Completion Time.

Heading control: As we did not use any steering moment and did not advise the participants to do the lane change in a unified manner, we got a high standard deviation for the average lane deviation. For this reason we got no significant differences for the average lane deviation. In both tasks mean deviation savings compared to the conventional list-based 2D approach has been observed: 29.9% for the options adjusting task and 12.2% for the changing context task. (see Figure 5)

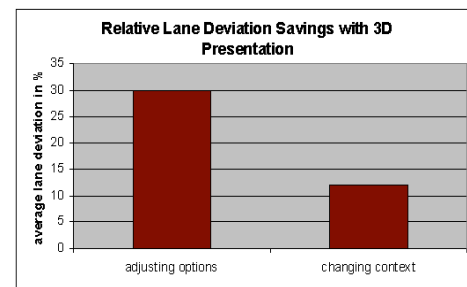


Figure 5: Average Savings for the Lane Deviation.

Glance behaviour: In comparison with the traditional list-based 2D Menu savings regarding the average single glance time and number of glances have been reached: 10.3% (31.5%) for the adjusting options task and 16.7% (14,7%) for the changing context task for the average single glance times (number of

views). These results were significant except the average single glance time in the adjusting options task. (see Figure 5)

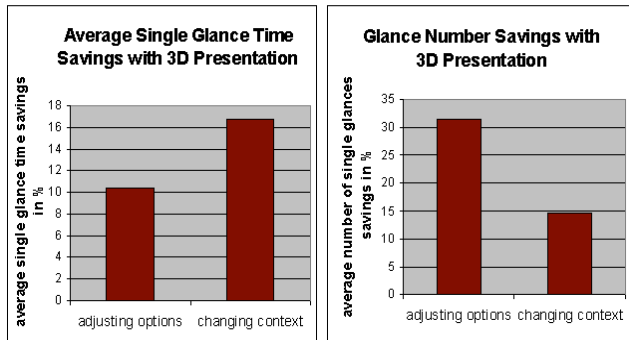


Figure 6: Average Savings for gazing behavior.

Subjective Preferences: To get a subjective impression of the difficulty and feelings of tasks, we asked after every task four short questions. The evaluation of these questions showed that users think it is easier to solve tasks, to hold the lane, to keep the street in vision and to concentrate on driving while interacting with the 3D Presentation.

The majority (thirteen) of the participants preferred the 3D Menu, because it was considered as easier to learn and to remember. They also preferred it because of its clarity of structure and its higher joy of use. Fourteen agreed that clearness is enhanced by the perspective arrangement. Ten could orient themselves better because of the previewing concept and the rotation of submenus. Four felt distracted by animation.

Finally, we requested test persons to judge both approaches by answering the AttrakDiff [3]. Outcomes are statements about the joy of use in form of pragmatic quality, hedonic quality for identification, hedonic quality for stimulation and attractiveness. We could raise the joy of use with the 3D Presentation in every part.

5. Conclusion

Our study showed that a metaphorical 3D approach has high potential for IVIS. We proved that efficiency and learnability could be improved in a competitive user study by shorter task completion times, lower deviation from the ideal lane, shorter and fewer views as well as a better subjective feeling.

6. Future Work

This work is a first step to integrate 3D metaphors as visual interaction techniques for IVIS. Next work packages will be the integration of further metaphors to support future scenarios. Additionally, there are many successful concepts and features of the computer domain, such as favourite menus, overview mechanisms or contextual help, which should be evaluated with respect to their suitability to automotive requirements. Questions about the evaluation of animations during driving have arisen and

lead to further user studies examining the influence of the length, initiation and the process of animations.

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