Designing the Car iWindow: Exploring Interaction through Vehicle Side Windows

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Abstract
Interactive vehicle windows can enrich the commuting experience by being informative and engaging, strengthening the connection between passengers and the outside world. We propose a preliminary interaction paradigm to allow rich and un-distracting interaction experience on vehicle side windows. Following this paradigm we present a prototype, the Car iWindow, and discuss our preliminary design critique of the interaction, based on the installation of the iWindow in a car and interaction with it while commuting around our campus.

Author Keywords
Vehicle; side window; transparent display

ACM Classification Keywords
H.5.2 [Information interfaces and presentation]: User Interfaces

Introduction
Automobiles have served humans for more than a century and are continuing to be important in modern transportation. Drivers and passengers are holding expectations for richer in-vehicle experiences as they spend significant amount of their daily time commuting

in vehicles. Over the years, various improvements have been made to turn automobiles from merely transportation tools to a livable and comfortable space. Examples include high fidelity radios and media players, video consoles, and even refrigerators. However, most cars still lack interactivity and information richness. This void has been filled somewhat by passengers using smart phones or tablets.

Yet the car provides a specific context that could be leveraged as part of the interactive experience. Commuting continuously provides passengers with new stimulus and visual scenes as their travel unfolds, as viewed through the car windows. These scenes often provoke interest and perhaps a desire for related information. Thus it is common to see passengers seeking information about a landmark they have seen via the car window, e.g. a community, a waterfall, a restaurant. This is usually done through their smart phone. But what if the car itself could become the information appliance, where it could show that information in context? Like others, we see vehicle windows as a natural medium to provide such contextual information to passengers, where these windows provide location-aware interactive display capabilities.

In practice, front windows of aircrafts have been used to show information to pilots, which assists aviation and target-aiming. These are commonly known as head-up displays (HUDs). There are attempts to transplant this technology to automobiles. However, due to the risk of driver distraction, many HUDs in automobiles are basically passive digital representations of existing dashboards and GPS navigators, where they offer little in the way of interactivity [1]. Thus it is the passenger – rather than the driver – that has been considered as the end user. Several commercial visions have been produced that simulate an interactive side windows [2][3], through which the passenger views and interacts with the world while commuting in a vehicle, a car, taxi, tour bus, a mass public transportation such as a train, or an airliner. This paper describes our efforts of trying to bring these visions closer to reality.

We believe that an interactive vehicle window should be informative but not distracting. We propose a simple 3-phase interaction paradigm to realize rich and un-distractive interaction on side windows. We then present our prototype, the Car iWindow (Figure 1), whose design follows our side window interaction paradigm and is implemented using a transparent LCD display installed in a car. Using the iWindow prototype we ran a Wizard of Oz (Woz)-operated design critique, where we reflected on a child's interaction experience during a drive around our university campus. We hope that our work-in-progress effort can highlight some of the challenges and promises of this interaction design problem, and serve future explorations of interactive side windows.

Figure 1. The setup of the Car iWindow.

Related Work

There are two impressive future-envisioning videos that imagine enriched in-vehicle spaces equipped with interactive side windows.

In 2011 Microsoft released a video envisioning a future in which a travelling businesswoman can see the current time and the highlighted hotel where her meeting is going to be held via her taxi side-window [2]. The video briefly illustrates possible opportunities enabled by interactive vehicle windows in a combination of location-based applications.

In 2012 General Motors introduced their Window of Opportunity concept [3] in cooperation with Israel's Bezalel Academy of Art and Design. The video illustrates four creative applications for interactive side windows constituting a spectrum of novel riding experiences. In addition, a static car-like prototype is built to demonstrate the concept, using two external projectors. One simulates the outdoor scene, and the other projects the content on the window-screen.

These envisionments [2,3] conceptualize the interactive side window but stop short of actually implementing, installing and evaluating the user experience in-situ, i.e., a passenger in a car driving in the physical world.

In a related effort, Olwal [4] evaluated various interaction techniques for transparent displays, including touch, mobile device control, hand gestures and eye-tracking with a prototype named ASTRO (not necessarily in a car setting). The results indicate that hand gestures and eye-tracking are overall less preferable than touch, a conclusion that informed our design of the iWindow prototype.

Design

The key question which drives our design process is: what is the purpose of a digital vehicle side window? We believe that most passengers would like to remain intrigued by the rich physicality of the outside world, and by the changing environments they view through the vehicle's window. Our answer to the question is to use the digital side window to tighten the connection between the physically isolated passenger and the outside environments, rather than to create more disengagement and separation. We are aware that the information superimposed an interactive window is likely to be distractive, or that any presented information may obscure real scenes. Thus our interaction design approach attempts to mitigate distraction caused by the iWindow visuals, while still maintaining its informative goal. Our iWindow design approach is based on three interaction phases, each with a different distraction potential: *active notifications, ever-present widgets* and i*nformation conjuring* (Figure 2).

Our design pursues equilibrium between the information the user seeks about the scene viewed through the iWindow, and the potential for disturbances. Thus, the interaction phase containing higher risk of distraction is designed to provide less information, and vice versa. Figure 2 is a schematic diagram relating our three interaction phases, the probability of distracting in each of them, and the information volumes associated with them.

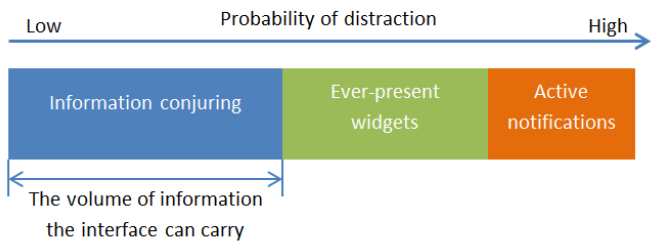

Figure 2. A schematic diagram of the 3 interaction phases. The probability of distraction increases from left to right and the phase **areas** represent *the volume of information* the interfaces in this phase can carry.

Active notifications pop up on the window to inform passengers of pre-defined types of events which they cannot easily perceive. One interesting possibility is supporting serendipitous finding. For example, if the user expresses an interest in "churches built before 1800" the churches in this category will be highlighted when passed. Pop-up notifications are the most distractive amongst the three phases, so they are only activated for passenger-defined events and are designed to convey the least amount of information. *Ever-present widgets* are information sources always visible on the window. They indicate simple and general information such as the time and temperature. An ideal widget should be presented in an unobtrusive, even ambient way, for example, hidden in the lower bottom corner of the iWindow, thus lowering the potential for distraction.

Information conjuring refers to displaying information in response to a passenger's explicit request. For instance, if the passenger touches the window where an old bridge is seen, information related to the bridge is shown. Since they are response to expressed request, interfaces in this phase allow the passenger to browse much richer content than in the other two phases. In order to determine which target the user is specifying, the iWindow approximates his/her line-of-sight with a line from the estimated head position to the touching fingertip. Combining this with map databases, the area being pointed at can be identified and related information is then revealed.

These 3 phases together form an interaction space in which passengers benefit from a comfortable balance between augmentation and reality.

Implementation and Critique

Following the above design approach, we implemented a prototype we call the car iWindow. We install a Samsung 22'' transparent LCD display panel connected to a control PC in a Kia Sorrento SUV as an interactive side window (Figure 1). We used the iWindow in a Woz design critique session, where a 6 year old participant was sitting in the 2nd row of the SUV and interacting with the iWindow as the car was driven around our campus. The experiment administrator sat in the 3rd row of the SUV, and operated the iWindow via Woz. Head position estimation and touch sensing is not realized in the current prototype.

Our participant was given brief explanation about the basic functions of the iWindow, the role of the *ever present widgets*, the *active notifications* and told that she will need to touch the iWindow when she saw a building invoking her curiosity (initiating the *conjuring* phase). After this brief explanation, the car was driven around campus with its actual side window all the way down, and the iWindow visually replacing it (although physically not covering the entire window space). The Woz administrator sitting behind the passenger

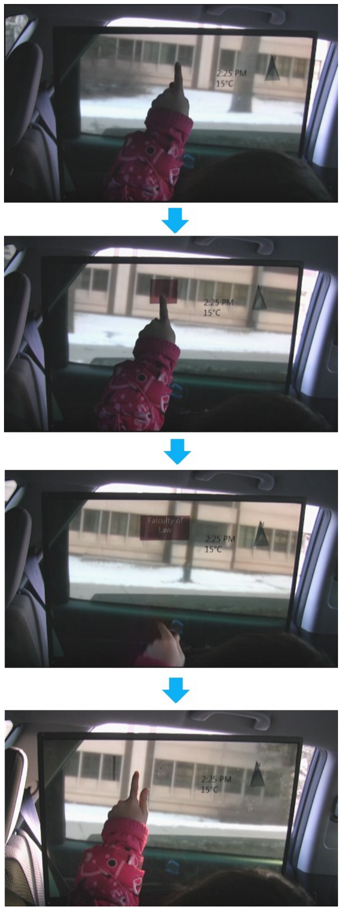

Figure 5: information conjuring

Figure 3: The *ever-present widgets* present the time, temperature and the direction

generated and manipulated all the information displayed on the iWindow using a basic Woz iWindow software tool we prototyped.

The three *ever-present widgets* indicating the time, temperature and the direction to which the window is facing were located at the top-right corner of the display (Figure 3). The direction was presented by a rotating 3D compass visualization, pointing to the north.

When the car passed by a certain building, the iWindow showed a cartoon avatar along with texts saying "Chris is Here!" superimposed on the building to show the user's friend's hypothetical location as an *active notification* (Figure 4). After the building was out view of the iWindow (and thus out of the passenger's view) that notification was turned off.

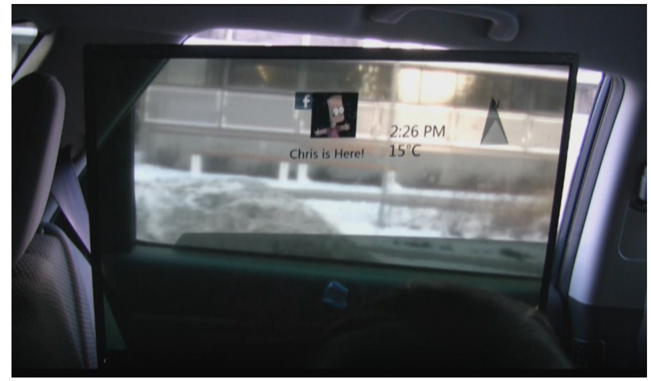

Figure 4: The *active notification* indicating that Chris is in this building

As the passenger held her fingertip on a particular building seen through the iWindow, a text block expanded from where she touched and eventually revealed its name to complete an *information conjuring* process (Figure 5). The expanding interface, as being "conjured" by the touching finger, was designed to confirm the user's intent for responses (and visual obscures at the same time) and to avoid unwanted disturbance caused by casual contacts. In addition, the user could hide the interface simply by dragging it aside. We note that, in our design process, we were unsure about whether touching a window would appear natural to passengers. However, in a limited space like a private car, touch input uses space more efficiently as compared to pointing or gesture. Olwal's evaluation [4] proves that touch is still welcomed in interactions with transparent displays and, in our tour through the campus, touch as a input method was learned and performed without issue by the young participant.

Conclusion and Future Work

Inspired by visions of more interactive and informative in-vehicle environments, the iWindow explores the interaction space of vehicle side windows. In order to allow future interactive side windows to enhance riding experiences we proposed an interaction paradigm aiming at creating a strong and balanced information connection between passengers and outside environments. This paradigm, consisting of *active notifications, ever-present widgets and information conjuring*, tries to offer considerable interactivity and information while minimizing visual disturbance. Based on this interaction model we designed the Car iWindow prototype and presented its Wizard of Oz design critique in a car.

Our current iWindow prototype and its evaluation are very preliminary and still need considerable improvements. First, to evaluate the design more thoroughly, a high-fidelity prototype should be built. These could incorporate location-aware sensors such as GPS systems, touch sensing, and algorithms linking vehicle positions and passenger inputs to the adjacent environment. Second, the information content needs to be expanded beyond the extremely simple information available in our prototype. Third, a larger study involving more participants from diverse age groups needs to be conducted to find answers to some important questions about iWindow usability and user experience. Questions include: are people comfortable with the 3-phase interaction paradigm when moving in fast-changing environments? What is the best input method for interacting with interactive car side windows? Are superimposed texts and images capable of transmitting location-based information clearly, especially in urban areas crowded by dense buildings which make an ununiformed clutter background?

We would also like to explore the possible application of our simple 3-phase interaction paradigm, although originally formulated for ensuring undisturbed viewing experiences through interactive side windows, in a broader range of displays, and whether it could be extended to serve as a model for analyzing cognitive loads of elements comprising other interactive systems.

Acknowledgements

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