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: Interaction styles; User-centered design.

General Terms
Design, Human Factors

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 (generally referred to as ground vehicles in this paper). Over the years various improvements have been made in attempt to turn automobiles from merely transportation tools to more home-like space, for example, installing radios, media players and even refrigerators; however, most cars still lack interactivity and information richness compared to the common smart phones or tablets being held by their passengers.

On the other hand, the commuting experience continuously provides passengers with new stimulus and visual scenes as their travel unfolds, viewed through the car windows. These scenes often provoke interest and need for related information, and 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, using the web browser on their smart phones or a different information appliance. Like others, we see the vehicle windows as a natural medium to provide contextual information to passengers and are looking for ways to enhance the car windows with location-aware interactive display capabilities.

In practice, front windows of aircrafts have been utilized to show information assisting aviation and target-aiming, more commonly known as head-up displays (HUDs). There are attempts to transplant this technology to automobiles whereas due to a risk of distracting drivers, many HUDs in automobiles are basically digital representations of existing dashboards and GPS navigators and offer little interactivity [1]. Visionaries envisioned various possibilities of interactive side windows [2][3], thus avoiding the windshield and the driver, and focusing on a passenger viewing the world via a side-window 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.

Believing 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 and installed in a car. Using the iWindow prototype we ran a Wizard of Oz (Woz) operated design critique reflecting on the user experience while interacting with our prototype during 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 imagining enriched in-vehicle spaces equipped with interactive side windows which relate directly to our effort.

In 2011 Microsoft released a video depicting an envisioned 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 simulating the outdoor scene, and the other projecting the content on the window-screen.

These envisionment videos [2][3] conceptualize the interactive side window but stop short of actually implementing, installing and evaluating the user experience in-situ, 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 digitizing vehicle side windows? We believe that most passengers would like to remain intrigued by the rich physicality of the outside world, and by changing environments they view through the car windows. 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 create more disengagement and separation. We are aware that the information superimposed an interactive window is likely to be distractive or even to 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: *ever-present widgets*, *active notifications* and i*nformation conjuring* (Figure 2).

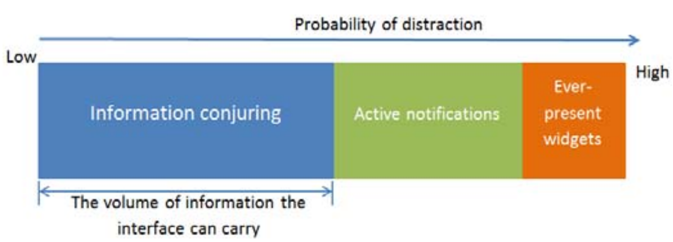

Figure 2. A schematic diagram of the 3 interaction phases. The probability of distraction increases from left to right and the phase **areas** represent *the volume of information* interfaces in this phase can carry.

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.

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, lowering the potential for distraction.

Active notifications pop up on the window to inform passengers of pre-defined types of events which they are not able to perceive. For example, if the user expresses interests in cinema tickets on sale those cinemas will be highlighted on the iWindow when passed. Although popping-up notifications are seemingly more distractive than ever-present widgets, they could be considerably powerful in aiding the perception of surrounding environments. Thus they are designed to carry more information than ever-present widgets, and meanwhile are only allowed to be activated for user-defined events.

Information conjuring refers to displaying information in response to a user's explicit request. For instance, the passenger touches the window where an old church can be seen and information related to the church is shown. Interfaces in this phase allow user to browse much richer content than the other two. In implementation, the iWindow approximates the location of the user's head and can thus estimate the line-of-sight between the approximate eye location and the finger touching on the iWindow. Combining this with map databases, the spot being pointed at can be identified and related information is then revealed.

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

Implementation and Critique

Following the design approach we outlined above a prototype we call the car iWindow was implemented. 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 young 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, with the experiment administrator sitting at the 3rd row of the SUV and operating the iWindow via Woz.

Our participant was given brief explanation about the basic functions of the iWindow, the role of the *ever present widgets*, the *active notification* 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 design critique administrator sitting behind the user generated and manipulated all the iWindow displayed

Figure 5. The process of *information conjuring*: contact – expanding – information shown - hide

information 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 of the iWindow (so, out of the user’s view) the notification was also turned off.

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

As the user 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). In a limited space like a private car, touch input might be very convenient while in the design process we were unsure about whether touching a window appeared unnatural to users. 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 with no cumber by the young participant. 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.

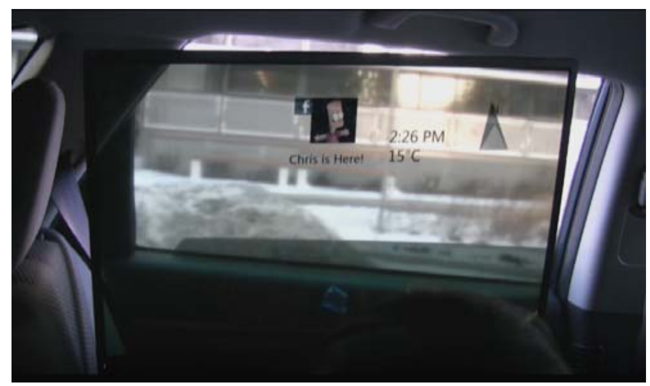

Figure 4: The *active notification* indicating that Chris is in this building.

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 *ever-present widgets, active notifications 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 is very preliminary and still requires considerable work and improvements. First, to evaluate the design in realistic non-Woz driving scenarios, location-aware sensors, such as GPS systems, and algorithms linking vehicle positions, passenger inputs and adjacent environments should be implemented. With a high-fidelity prototype and more participants, we might find answers to some important questions about the iWindow usability and user experience, for instance, 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.

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