Charting User Perceptions on Using a Window as a Mixed Reality Display at Home

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Abstract
In this paper, we describe our user research on the concept of a mixed reality display utilizing a room's window. We conducted a user study, where participants from 12 households were asked to brainstorm use cases and give their perceptions of an imaginary mixed reality window view. Users found the concept useful for both informative and decorative purposes. In particular, content that was linked to the physical world view, e.g. related messages and weather was seen as especially valuable.

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Mixed reality; augmented reality; user studies; window displays

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction
Mixed reality, where the view of the physical world is overlaid with digital information, is a technology area with a significant potential, which has already emerged in consumer products. Mobile applications such as

Layar [3] and Wikitude [9] are examples of applications that are already accessible to large audiences.

Applications that augment the physical world have used a variety of display or projection technologies for output. Typical examples include using a mobile phone as a magic lens, where the user sees digital information overlaid with a physical world view shown on a screen [4], and pico projectors that beam additional graphical elements onto an physical object, e.g. on a paper map [5]. In this paper, we focus on the concept of using a room's window as a mixed reality display.

The idea of using a see-through glass window as a display or interaction surface is not new, and e.g. Corning's concept video [1] introduces several concepts around the (yet futuristic) technology of utilizing window glass for such purposes. Earlier research has also demonstrated the use of a car windscreen as a mixed reality display for route navigation [6]. Generally, the mixed reality window concepts so far have focused on rather narrow use cases or on building proof-of-concept level demonstrators. In our research, we were interested in charting user perceptions with a wide perspective, and wished to investigate end-user aspects rather than technology potential. In the following, we describe our study exploring people's perceptions, expectations and interests related to using one of their home's glass windows as a display for mixed reality applications.

User Study

Study Set-up

In autumn 2012, we organized a field study where people developed potential use cases and provided feedback on early mixed reality application concepts for the home environment. As a whole, the study design involved using cultural probes [2] as well as explicitly defined tasks which the participants were asked to do during a one week period. One central element of the study was to chart the potential of the window as a mixed reality display. Altogether 12 households (comprising a total of 21 participating persons) took part in the study. Each household consisted of either 1 or 2 persons (children excluded). The participants were aged between 24 and 70 years, with an average age of 40 years.

Figure 1. Imaginary content placed on a real window, creating a mixed reality window display (household #2).

Case I – Annotated Window View

To start the study, a photo of one of the participants home's windows was taken (either by the participants and sent to the researchers, or the researchers took the photo during the starting session at the participants' house). The researchers added graphical annotations to the photo to demonstrate the concept, see Figure 1 and Table 1. The annotated picture was sent to the

Figure 2. Example outcome of the second probe pack task of mixed reality content on window. (Translations: Temperature outside -5C -> Heat the car! Warning of slippery traffic conditions - Child's training -> Which of us will take him there? - Waste collection today) (household #6).

participants and they were asked to give feedback on their perceptions of different content types.

Added annotation types on window	Amount of photos with annotation
Current weather and forecast	12/12
Outside and inside temperature, wind	12/12
Acquisition request for the city	12/12
Road repair request for the city; or Notification to garbage disposal company	10/12 or 2/12
Information about a car seen on the window; or Information about a house seen on the window	7/12 or 5/12
Reminder of a household task	6/12
Picture from a friend	12/12
Dinner request sent to a friend	12/12
Reminder of jogging	12/12

Table 1. Amount of each type of annotation shown on the window glass. This was defined based on the content of the physical view.

Results. In general, using a window as a mixed reality display was perceived as acceptable, with some limitations. The information placed on window had to be *important* and *useful* but not *oppressive*; the issue of information overflow was raised, and the participants stated that the information should have a *valid justification to be on the window - "The other than weather related stuff could be located on a door or anywhere else. From a window you would rather watch outside than that kind of information"* (#11).

All participants perceived the idea of showing weather forecasts, temperature and other weather related information on the window positively - *"Weather is something what you look from the window anyway and seeing when the clouds will go away and the rain stops would be nice"* (#4). Messages related to the context of the scenery seen from the window were better received than general messages. For instance, communication with local infrastructure services, for example sending messages to maintenance or waste management departments, was considered useful. However, not all type of content relating to an object seen through the window was something the participants wished to see. For instance, a reminder to take care of the hedge was thought to increase stress level than to lower it. Sending and receiving private messages to and from friends via the home window was considered rather odd and useless.

Case II – Brainstorming

The use of window glass was also investigated with brainstorming tasks, which were given to the participants. during the one week study period, in addition to the cultural probes driven free concepting tasks, on one study day the participants were explicitly instructed to innovate on the following topic: "What kind of information would you like to see on your home windows and mirrors". An example of the task's outcome is illustrated in Figure 2.

Results. In total, 12 ideas were invented based on a window, and 10 for a mirror. The window ideas were divided roughly on 2 categories: informative and decorative (mixed reality) content. Based on the preliminary analysis, informative category information related to:

1) Information about the visible object and buildings on the window.
2) Weather and sunset.
3) Dressing instructions according to the weather conditions.

Decorative category consisted of

1) Landscape screen savers.
2) Mixed reality seasonal illuminations.
3) Children's scanned drawings.
4) Different greetings for neighbors and passersby.

Discussion

As information displays and interactive surfaces are likely to become more and more frequent inhabitants in our homes, it is valid to study people's perceptions and ideas around them. User perceptions of mixed reality annotations have earlier been investigated e.g. in [7; 8], but our research differs from earlier research both in its method and for its focus (home environment; window glass as the interactive media). We believe that our research has value when mixed reality technologies are developed further, and in the next steps of intelligent home technologies.

Windows are a fundamental part of domestic buildings, and looking out from one provides both information and pleasure. When equipped with appropriate technology, they provide an interesting possibility to be used as displays. The capability to use them as (semi)transparent displays allows the development of use cases that are heavily linked to the physical content outside of the window. Our study results indicate that there are a number of potential use cases for utilizing window glass as a mixed reality display. It should also be noticed that although our study aimed to chart user perceptions of mixed reality, the participants also suggested use cases that utilized the window glass simply as a display rather than displaying information related to the view seen through the window.

The research presented in this paper is preliminary by its nature, and we plan to continue our work on domestic window glass displays by developing a prototype system to investigate the potential use cases further. In the workshop, we wish to contribute to the discussion on how to integrate displays in everyday life environments in a subtle way, and gain feedback for our research.

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