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The potential of smart glasses for smart homes

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Summary

The intended contribution of this paper is to discuss the suitability of smart glasses for smart homes. Four different solutions currently used in smart homes were redesigned for the usage of smart glasses as the primary interaction device. An evaluation of the prototypes according to five design principles proposed by Norman (2002) suggests that smart glasses can be a valuable addition to existing smart home concepts.

1 Introduction

The idea of a home that intelligently supports its inhabitants through autonomic control of heating and lighting has been captivating people's minds since decades (Aldrich 2003). Though, mostly due to the lack of corresponding technology, smart homes in the past could not live up to the expectations (Trevennor 2012). With the ongoing advances in technology and the further miniaturization, the centralized access to smart home functionalities has been placed into the hands of the user in the form of smartphones and tablets. Although the concept of augmented reality has already been depicted long ago (Mann 2013) and multiple types of smart glasses are available on the market, only the comparatively recent development of Google Glass has been able to shift broad media attention on this category of smart devices. The aim of this research project has been to consider these fields of research jointly and evaluate the suitability of smart glasses as a controlling device for smart homes. To obtain a first impression of the relevance of this research area, a broad methodological approach was chosen to generate a widespread feedback within a limited period of time.

2 Methods & Material

In order to determine the state of art in smart homes, four prototypical solutions from different smart home areas were selected. The main intention of each solution was then extracted and reengineered for being used with Google Glass, resulting in four mockups that are briefly introduced below.

Figure 1: Prototypes of a fall detection (a) and a security (b) application for smart glasses

The example in the area *Healthcare* is a fall detection app (Figure 1(a)) that relies on the built-in acceleration sensor of the smart glass. As soon as a fall is detected, a predefined emergency routine that calls nearby relatives, nursing staff or the ambulance can be started.

The *Security* solution aims to ensure that when nobody is at home all security relevant settings are enforced, e.g. the windows are closed, lights are turned off and alarm system and presence detectors are turned on. The smart glass is able to detect when the wearer is about to leave the house and shows a Security-Card that gives a summary of all security relevant devices of the smart home (Figure 1(b)). Systems that have an actuator built-in can be controlled directly through the smart glasses using voice commands.

The overall goal of the *Energy* solution is to reduce energy consumption by detecting and switching-off unused electronic systems such as lights, TVs or hobs and display this information on the smart glasses. Through the subtle reminder the user is made aware of these systems and can directly turn them off.

The *Comfort* example allows the inhabitant to control e.g. window blinds through gestures. Using indoor navigation by intelligently combining the build in sensors and e.g. (off-board) pattern recognition of the video stream, the smart glasses are able to automatically detect the specific blinds the user is looking at. By moving the finger up or down the blinds can be operated.

All prototypes were evaluated against five design principles for human-computer interaction proposed by Norman (2002), namely *affordances, constraints, mappings, visibility,* and *feedback*. *Affordance* describes to what degree an object offers the user how she or he can interact with it. The term c*onstraints* refers to the intended limitation of the set of available actions. Whereas *visibility* indicates if a user is able to detect and understand the current status of the system, *mapping* is the relationship between control elements and the internal status of the system. *Feedback* describes the way the system reacts towards user interactions. These principles were initially derived by analyzing the interaction with everyday things and are now widely used to evaluate the usability of systems that offer user interaction.

The prototypes were evaluated by the authors in cooperation with a group of twelve students. All of them were experienced in the development of interactive systems and familiar with Norman's design principles. Prior to the evaluation, all students were introduced to the concepts of smart homes and smart glasses. After presenting each prototype, the findings were discussed in groups of two and submitted as group rating on a 5-point Likert scale (sample size $n = 7$ groups for *Comfort* & *Energy*, sample size $n = 1$ groups for *Healthcare* & *Security*). The sample size for the evaluation of the prototypes for *Healthcare* & *Security* was reduced in favor of inducing a broader and more qualitative feedback through a group discussion process instead of mere Likert scale ratings.

A combined quantitative and qualitative approach was chosen to deliver both a first rough estimate on the suitability of our concrete solutions as well as new and complementary solutions by fostering a more general discussion among the evaluators. We regarded Norman's design principles as suitable for analyzing smart homes because they were originally inspired by successful/failed interaction with everyday things (e.g. at home) and last not least because our evaluation experts were familiar with them.

3 Results

Figure 2 presents the results obtained from the quantitative evaluation of the four prototypes. It can be seen, that *mapping* received by far the best rating with results averaging at 4.5 points (prototypes weighted equally) and ranging only between 4 and 5 points. On the contrary, *affordance* was rated with an average score of 2.11 points (range: 1 to 4). Whereas the assessment of v*isibility* tended to be positive (4.23 points), *constraints* and f*eedback* were conceived rather poorly (3.67 and 3.33 points).

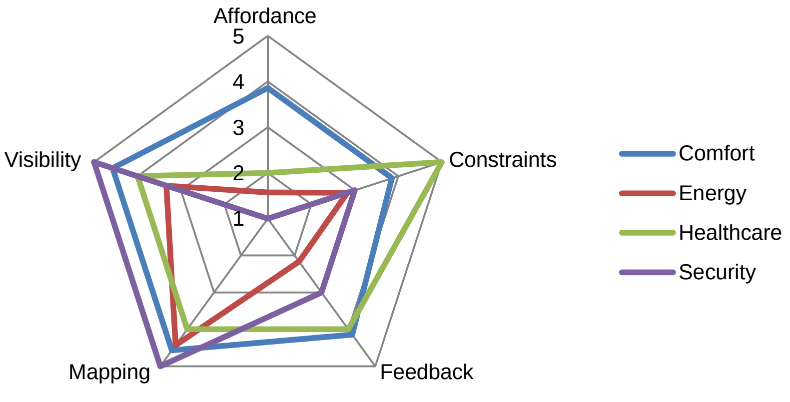

Figure 2: Results of the evaluation (verbal labels: (5) very good, (4) good, (3) medium, (2) poor, (1) very poor)

Whilst few themes that emerged throughout the qualitative feedback were specific to individual prototypes, a number of issues were identified that are of a more general nature. Whereas most evaluators perceived subtle notifications as helpful, some worried about constant interruptions. A common concern amongst the evaluators was that smart glasses might not be carried throughout the entire day, which is particularly crucial in the case of fall detection. Another recurrent theme in the discussion was the potential loss of privacy and the risks induced by poor data security.

4 Interpretation and Conclusion

The results of the evaluation were predominantly positive and revealed the general feasibility of smart glasses as a control unit for different elements in a smart home. Especially the *mapping* between the operated action and the status of the system, as well as the *visibility* of the status of the smart home system proved to be sufficient. However, the developed prototypes did not provide an adequate *affordance*, as most types of interactions were not obvious to the user but had to be trained (e.g. the specific voice commands). Likewise, the *feedback* seemed poor in the evaluation. This criterion however is not as important, as additional feedback is given directly through the addressed smart home component (e.g. the curtain closes).

The findings from this study indicate that smart glasses have the potential to be a valuable contribution for existing smart home environments. Through intelligent use and integration of the various components of smart glasses, a useful and powerful control element can be created. Further research with a larger and more representative sample size needs to be done though, to ensure the generalizability of these results.

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