A Usability Evaluation of a Home Monitoring System

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ABSTRACT

In this paper, we describe results from a laboratory-based study of user interactions with the Home Heartbeat system, which allows customers to monitor sensor data about their residence. Our study focused on usability, privacy, and security.

1. INTRODUCTION

The Home Heartbeat is a shipping commercial product developed by Eaton[1] with assistance from MAYA design[2]. Home Heartbeat uses wireless sensors to determine if windows or doors are open, which appliances are on, if there is water in the basement, and so forth. We studied their forthcoming web interface in a lab-based protocol designed to determine user interface issues and any privacy or security concerns.

2. RELATED WORK

There are several usability and privacy challenges involved in designing automated home systems. Users have shown significant privacy concerns if their activities are continuously monitored and used for data mining or personalization [3, 4]. Although the Home Heartbeat system is not intended for data mining, it may raise similar concerns because it records the sensor activities and settings on a remote file server.

One high-level usability issue is that a device may be viewed by different people. The Home Heartbeat system avoids several problems by allowing just a single user account per household, but this approach significantly reduces the ability to customize settings for different people, such as parents vs. children. Another issue is that user activities related to smart home systems are not so task-centric while the majority of usability techniques are [5].

3. REASEARCH QUESTIONS

We examined three related areas:

1. Identify and measure any usability weaknesses in the Home Heartbeat website
2. Understand participants' privacy concerns for the Home Heartbeat website
3. Identify usability and privacy concerns for home monitoring products in general

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4. METHODOLOGY

We used a lab-based study to learn about participants interactions with the Home Heartbeat website. Nielsen et. al. list seven "basic techniques employed by the HCI [Human Computer Interaction] community and suggests using several in combination [6]. We used five of them: a think aloud protocol, observations, audio recordings, automatic logging of cursor movements and keystrokes, and questionnaires.

As with many software systems, "While valued, privacy is not the users' primary task" [7]. Consequently, we designed our study to involve privacy and security issues without forcing users to focus on privacy or security as a primary goal. Yet we also did not want participants to just look at the user interface without considering how they would use the system in real life. We created five different scenarios and asked participants to role play different personas. After each scenario we asked broad questions that did not explicitly mention privacy or security. We asked specific questions about privacy and security beliefs only at the very end of the experiment, when we could no longer prime participants to think about privacy or security.

Our laboratory study had several limitations. First, real Home Heartbeat customers are familiar both with the product and their own homes. We mitigated this by showing introductory videos and providing materials such as floor plans and printed online help. Second, we did not have sensors to test, which limited the tasks we could ask participants to do. Third, although MAYA software engineers graciously set up the database backend to our specifications, the data remained unchanged over time. We addressed this with calendars indicated valid dates. Finally, we ran on a MAYA development server and not in the production environment. Participants experienced slower response times.

5. RESULTS

Our ten participants were well-educated: 40% have or are pursuing undergraduate degrees; 50% have or are seeking graduate degrees. 80% have a degree in Computer Science with the remaining degrees in other Science or Engineering fields.

Participants were able to complete most of the tasks in the protocol though sometimes it took a while. For example, participants were able to read sensor settings 90% of the time, and were always able to reliably read sensor settings by the end of the full protocol. Participants were able to work through early confusion about days of the month v. times of the day (both are presented as unlabeled integers on a timeline.) In contrast, 30% of participants could not finish the last task. We asked them to change the settings for when they would receive phone calls, which uses a pseudo-sensor called "Global CallMe." We believe this is the most complicated feature in the Home Heartbeat

system, and not one that will see heavy use. However, that some of our very technical participants were forced to give up in frustration suggests room for improvement.

Most (55%) participants agreed that the Home Heartbeat system would be useful for them, but about a third (30%) expressed doubts and the rest were neutral. Concerns centered around getting notification of problems with no way to fix them. Participants rated the system most highly for simple cases where there were few ways to interpret the data. For example, Home Heartbeat was deemed most useful (80%) for a task to monitor power consumption than the less straight-forward case of checking motion sensors to see if cleaning staff did a good job (45% found it useful.)

Note that the Home Heartbeat system is faster in production, than the development servers we tested, and we do not know how well the system performs in practice. The top three most common issues with the **user interface** were:

- Trouble interpreting the activity bars for sensors
- Slow response time coupled with lack of visual feedback when waiting
- Icons were confusing. In particular, the open/close sensor is denoted as a door yet often placed on windows

These issues reflect a problem with "web 2.0" interfaces in general. In contrast to standard icons on the Macintosh or standard presentation of an hour glass to show system activity under Windows, web developers do not have a common interface of reusable components or even style guidelines. Consequently, users must learn each interface anew, which is a struggle for even the most sophisticated users.

Based on exit questionnaires, the top three **privacy** concerns were

- I am concerned about being falsely accused of a crime based on faulty sensor data (4.8 on a 6 point Likert scale)
- I am concerned about police subpoenaing Home Heartbeat records(4.4)
- My employer does not have the right to monitor me while I am on premises (3.8)

Most privacy concerns centered on the potential for legal implications created by a database of household activity. Home monitoring systems could reduce these concerns with careful thought about data retention policies.

Again based on exit questionnaires, the top three **security** concerns were:

- Using an internet application to interface with Home Heartbeat makes it less secure (4.9 on a 6 point Likert scale)
- I would not trust Home Heartbeat in a life or death situation (4.7)
- Having my home's sensors accessible over the internet is a security risk (4.5)

Participants saw a web interface to their home system as a security threat. However, they liked the convenience of being able to access data from anywhere without needing to install client software. Many software developers face this tradeoff, but customers see security as more vital in a home environment.

6. RECOMMENDATIONS

Overall, participants like the appearance of the Home Heartbeat website. However, they struggled with some specific areas, and voiced security concerns. Our recommendations follow.

6.1 Usability Issues

- Give visual indicators when the system is retrieving data.
- Provide a set of icons (including windows as well as doors) so users can change the defaults to match their environment
- Change the GUI for sensor history to make it easier to understand, particularly the bars that show activity and the unlabeled timeline
- Rethink the user interface for managing alerts and calls

6.2 Privacy Concerns

1. Post a clear privacy policy on the Home Heartbeat website
2. Support multiple logins with access control lists to protect private data and sensor settings
3. Give users more control over the sensor data that is stored on the website, e.g. allow users to delete historical data

6.3 Security Concerns

Home Heartbeat uses SSL, but our lab study did not. Consequently, the top security concern is not an issue.

1. Use SSL (Secure Sockets Layer) encryption
2. Expire sessions on the server side after a timeout period
3. Explain to users how the system works and how their data is protected

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