Towards the Perfect Infrastructure for Usability Testing on Mobile Devices

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Abstract
In this paper, we describe various setups that allow usability professionals to conduct effective user studies on mobile devices. We describe the factors relevant when building a solution for mobile device observation and the various designs we worked with in the Google user experience research environment as we iterated to meet changing study needs. We highlight several systems that can successfully be used in an industry environment, including a novel setup that is fully portable, can be used in a usability lab as well as in the field, accommodates a large variety of different mobile devices, and allows for live observation by product teams around the world.

Keywords
User experience research, mobile device usability testing, mobile device usability observation infrastructure, iterative usability lab design

ACM Classification Keywords
H5.2 User Interfaces – *Evaluation/methodology, Prototyping*

Introduction
There are more than 2.5 billion active cellular connections in the world [1]. In many countries, the

Generic Infrastructure Issues

- Cost
- Time available for setup
- Number of observers
- Compatibility with existing infrastructure
- Available AV support

Mobile Device-Specific Issues

- Weight of the monitoring device
- Consequences of damage to mobile device being studied
- Form factor of mobile device
- Variety of mobile devices to be studied
- Naturalism of interaction with mobile device

Usability Study Context Issues

- System portability
- Frequency and duration of study sessions
- Audio and video recordings
- Live broadcast of study

Figure 1: Criteria for a mobile observation setup

number of mobile phone lines far surpasses the number of PCs and fixed telephone lines [2], revolutionizing how people access information and communicate. Designing effective and usable interfaces in the mobile space is arguably more important than ever, and studying real user behavior with mobile interfaces during the design process is critical.

In practice, however, it can be difficult for researchers, designers, or other stakeholders to observe usability studies conducted on mobile devices. Many traditional usability labs are optimized for studying PC-based interfaces, and the available equipment is often inapplicable to studies of mobile phones and other devices with small screens and form factors. In most cases, a more specialized setup is required to enable successful observation of usability studies conducted on mobile devices.

Criteria for a Mobile Observation Setup

A number of factors should be considered when setting up an observation system for mobile devices. Different mobile usability projects will have varying requirements and constraints, and they may change as the project evolves over time. In order to make good tradeoffs, it helps to consider the variables outlined in Figure 1. Some are issues one would encounter in any usability lab infrastructure project, such as cost, ability to customize the setup, or the number of observers that need to be accommodated. Others are more specific to mobile device observation systems.

For most mobile usability studies, enabling natural interaction with the device can be more challenging than in a desktop-based environment because mobile phones come in a diverse range of shapes and run a variety of operating systems. Depending on study goals, an observation system can be customized to a specific phone model or it may need to be flexible to accommodate a variety of phones. Radically different input systems such as scroll wheels, custom menu buttons, and styluses may have to be supported, and in many situations, the ability for users to hold the mobile device naturally can be critical to capture unbiased interaction patterns. Some researchers may need an observation system that will not scratch or otherwise damage the phones being observed—essential if testing on the user's own devices.

Another important consideration is the context in which the usability work is being conducted. If naturalistic field studies are required, then the system needs to be portable. High-quality recordings may be necessary to communicate study findings to product teams. Finally, the observation system may need to support live broadcasting of video and audio if team members cannot attend study sessions in person.

Different Observation Approaches in Practice

At Google, our range of mobile products and usability test plans have expanded fairly dramatically, prompting iterative changes to our mobile observation infrastructure. All of the resulting approaches we describe below were used for multiple usability studies for mobile Google products, allowing us to learn what worked well in practice in an industry environment.

All of our approaches needed to support a single researcher moderating a study without support from others, and they accommodate tests on a variety of different devices. These specific requirements meant

Figure 2: Document camera observation setup

Figure 3: Document camera system with small monitor for moderator to observe the user's screen

that we did not consider observation systems that work well under different conditions. For example, ceiling-mounted cameras, although versatile and already present in many usability labs, require an AV assistant to track participants as they move the mobile device during the study. Testing on Nokia S60 phones gives the option of a Bluetooth screen-sharing program [3], but it restricts user researchers to a phone UI with a user experience that is substantially different from that found on other major phone models. In addition, any keypad interactions cannot easily be observed.

We now describe observation systems that we have implemented and their advantages and disadvantages.

Direct Observation

For the very first study conducted on mobile devices at Google, we directly observed participants interacting with the mobile phone interface. This allowed us to quickly gather general feedback on the system. Looking over a user's shoulder, we were able to follow along as they interacted with the system we were studying. However, given the difficulties of observing a mobile phone screen from an angle and at a distance of several feet, small details were likely missed during this study. Furthermore, extended observation was extremely tiring for the moderator, especially if multiple users were scheduled on the same day.

Including designers and other product team members in the study was also challenging. Having additional observers in the test room would have made study participants feel crowded. Inviting observers into the observation room of a traditional usability lab allowed them to listen to a live audio feed of the users' comments. However, given that the users' interactions with the GUI were not transmitted, observers may have gotten incorrect impressions of the usability of the product being studied because they only knew what the users said rather than what they did.

Nevertheless, this approach had value. Since there is no cost involved in this setup (other than the mobile device being used), any user experience professional should be able to conduct usability studies with this method, especially if study sessions can be scheduled across multiple days with less than one or two hours spent moderating per day.

Document Camera on a Desk

When testing products for which team observation is more critical, a simple setup described in [4], based on [5], may be appropriate. In order to easily capture the mobile device screen, we used a standard document camera with a phone that was fixed to a desk (Figure 2). We then projected the video feed from the document camera into the observation room, which allowed the product team to watch the users interacting with the product being studied. In the case of Google SMS, this also enabled us to easily capture the specific query syntax the users entered during the study session. Initially, the moderator still used direct observation with this setup. Later we added first a small monitor (Figure 3), then a larger one in the lab room that allowed the moderator to observe the video feed from the document camera. For recording the sessions, we initially used a standard DVD recorder in a PC located in the observation room, then later added a standard TV tuner card to record the video feed directly to hard disk.

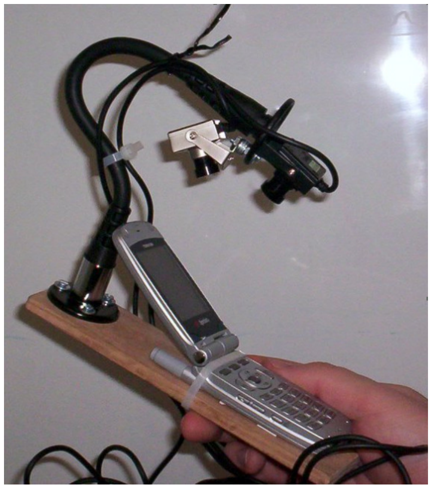

Figure 4: Sled-based observation system

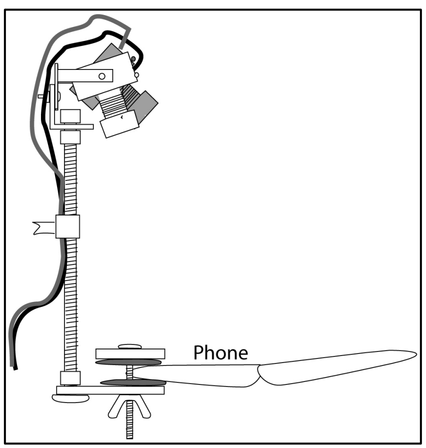

Figure 5: Schematic of observation system directly mounted to phone

Overall, this setup worked well for studies focusing on mobile UIs with comparatively simple interactions. It was relatively cheap and required little time or effort to set up. In addition to serving as an effective tool for mobile device observation, this setup could easily record paper prototype studies as well as small card sorting exercises. However, a major drawback is that the mobile device being recorded has to be fixed to the desk, preventing the participants from holding the phone and interacting with the product in a natural manner. Specifically, participants cannot use their thumbs to type or select softkeys, which slows down text and command entry and thereby affects user behavior.

Getting the Phone off the Desk – Designing the "Sled"
As we started conducting usability studies for more complex Google Mobile products, we needed to enable users to interact with the phone more naturally. We investigated options for allowing users to hold and move the phone during the study while capturing a live, high-quality video stream of their interaction with the mobile device. We decided to build our own mobile observation device because we wanted to simultaneously capture a high-resolution video of the mobile device screen and of the users' interactions with the keypad—features not available from commercially available products (e.g., [6]). We therefore built a device in which the phone was mounted on a wooden "sled" with a gooseneck that supported two cameras: one focusing on the screen, the other a wide-angle lens that captured the keypad (Figure 4).

We quickly found that this device had significant problems when used in practice. The weight of the gooseneck and other materials made the entire unit heavy and imbalanced. In early internal trials with Google employees, we quickly found that users were unable to comfortably hold the device for more than 15 or 20 minutes. Furthermore, most participants held the device with both hands, when many of them operated their own mobile phones one-handed.

Mounting the mobile phone onto the sled was also problematic. The most secure, stable mount was achieved with stick-on Velcro; however, we could not use stick-on Velcro and risk the adhesive damaging the phone if we wanted to test on the participants' own devices. Given these major drawbacks, we abandoned this design and concentrated on building a device that would be more light-weight and flexible.

Cameras Directly Mounted onto the Phone
To reduce the weight, we designed a system that directly mounted the cameras onto the phone. Prior work in this area conducted by other researchers focused primarily on mobile field studies [7], [8]. By contrast, our system is optimized for usability studies and is at the center of our current mobile observation system at Google (Figures 5 and 6). By using a clamping mechanism to fasten a camera mount directly onto a mobile device, the weight of the observation device has been dramatically reduced and is distributed effectively. Using exchangeable clamping mechanisms, we can accommodate a very large variety of form factors, including flip and bar phones, PDAs, and even some portable gaming systems. Using two cameras to record the screen and keypad separately, we can observe phones with fairly high-resolution screens, and can optionally mount a third camera to observe the users' facial expression. The entire device can be powered with a 9V battery and can therefore be used in

Figure 6: Observation system directly mounted onto flip phone

almost any location around the world. This setup has been appropriate for almost all of our usability needs, with the one drawback of not being able to easily study voice interactions without using speaker phones or a headset, since the user cannot put the phone to her ear with the monitoring device attached.

Recording Infrastructure for In-Lab Recording
Some usability facilities may already have a good way of recording two video streams. At Google, we experimented with a combined hardware/software solution for capturing and recording multiple video streams. There are a variety of different options available, most geared towards use in surveillance applications, e.g., from [9]. We chose an option that would allow us to record up to 16 streams simultaneously at full NTSC resolution, while keeping all the video and audio in synch. However, since most available packages are optimized for capturing hundreds of hours of video at once, the encoding is often to proprietary file types or using proprietary video and audio codecs, which makes sharing the resulting digital recording difficult without conversion to a common format for playback. Since most hardware-based surveillance solutions require an available PCI expansion slot to be incorporated into a computer, this system is only somewhat portable: it can be installed in a desktop computer with a small form factor such as [10], but is not compatible with most notebook computers. While not inexpensive, the main advantage of hardware-based solutions is that many full-resolution video streams can be captured at once, which can be invaluable for conducting experiments that simultaneously record multiple image feeds.

Observing and Recording Anywhere
In practice, quickly sharing user recordings with the product teams has been invaluable. We needed a solution that would allow for live streaming of videos to remote offices for product teams not physically located in our Mountain View headquarters. We also required the system to be fully portable and battery-operated so that we could easily take it to users for tests that did not suit the usability lab. Since our newest iteration of the camera device already accommodated battery operation, we needed a recording and monitoring setup that could be installed on any Windows laptop computer. We chose a software solution that would work with standard USB input adapters for the audio and video coming from the cameras. A number of vendors offer appropriate solutions, and we chose a product from [11] that allows direct capture to a standard video file format, and allows remote sharing of the recording in real-time. Figure 7 shows a typical setup of this system in one of our usability labs. The moderator watches the study on a large monitor, which displays the video feed of the mobile device screen and of the keypad side by side (Figure 8). In order to allow for easy interaction between the moderator and the participant, the monitor can be positioned close to the mobile device but angled so as to prevent the participant from observing the live video feed directly. Observers watch a projection of both videos in the observation room, or access a live feed of the study over the internal network. In the field, the setup is adjusted so that observers can easily follow the study on the moderator’s monitor.

Given that all the encoding is software-based, many current computers (especially current laptop computers) will not be able to capture video at the full

Figure 7: Directly mounted observation system used in a usability lab

Figure 8: Monitor with live video feed used by moderator to observe the user's screen and keypad

NTSC frame rate of 30 fps. However, recordings at much lower frame rates (especially when recording the screen) are sufficient for most usability applications. For those requiring high frame rates and the ability to easily watch multiple streams in synch, a combined hardware and software solution as described above may be more appropriate.

Conclusion

By taking an iterative approach to developing our mobile device observation platform, we were able to accommodate the changing study needs we encountered at Google. We have developed a flexible infrastructure for mobile studies that allows us to observe most devices in most locations and allows product team members to easily experience their users first-hand.

With rapidly advancing technology, exciting new possibilities such as very light-weight, fully wireless setups that securely and reliably transmit video feeds with minimal battery needs are starting to become feasible. However, even with current off-the-shelf technologies, many of the approaches described above will fully meet the research needs of most practitioners and can serve as valuable tools to bring the users into the mobile UI design process.

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