Remote Paper Prototype Testing

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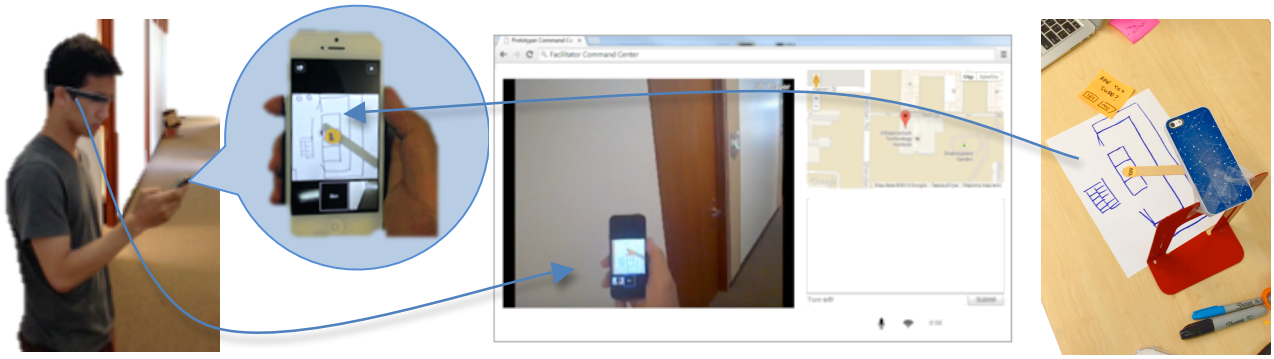

Figure 1. A tester interacts with a paper prototype of a mobile application out of the lab (Left). The designer observes the tester's interactions, first-person perspective, and location data (Center) and remotely wizards the paper prototype (Right).

ABSTRACT
To test paper prototypes of mobile applications, we have been experimenting with *remote paper prototype testing* as an approach and tool for enabling a designer to wizard a paper prototype from afar while a user tests the prototype out of the lab. This paper presents a system for remote paper prototype testing that consists of (1) a video camera placed over a paper prototype, which streams a live audio-visual feed via Google Hangouts to a tester, and (2) Google Glass on the tester, which streams a live audio-visual-data feed to the facilitator and wizard. Results from a pilot study found that remote paper prototype testing helped designers gain valuable insights through use in realistic scenarios.

Author Keywords
Paper prototyping; Lo-fi prototyping; Mobile apps; Design.

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

INTRODUCTION
Lo-fi prototyping, or paper prototyping, is a powerful tool for designers to test designs with users early in the design process [11]. Paper prototypes are fast and cheap to make, focus on core interactions instead of look and feel, and enable designers to test multiple designs and iterate quickly. Despite these benefits, HCI researchers and design practitioners have argued that paper prototyping is poorly suited for evaluating mobile applications [5]. In particular, they express the need and difficulty in evaluating mobile application designs in environments that surface realistic experiences [1,8,9]. Testing in the lab lacks situational context; for evaluating the *mobile use* of an application, scenarios often feel contrived and the users' experiences fail to reveal major issues in the design [7,8]. Testing out of the lab faces practical challenges. In order to observe the user in context, a facilitator and wizard may need to follow a user around, which may be undesirable. But even if they do, it may be hard to see a user's interactions with a paper prototype and wizard effectively in a mobile setting.

We are experimenting with *remote paper prototype testing* as an approach for lo-fi prototype testing that enables user testing a paper prototype out of the lab while a designer wizards from afar (Figure 1). To explore its use, we developed a tool by building on existing technologies that consists of (1) a smartphone camera pointed at the paper prototype, which streams a video feed through Google Hangouts to the tester's mobile device, (2) Google Glass on the user, which streams a first-person perspective audio-visual-data feed to designer, and (3) a *command center interface*, from which the designers observe and facilitate the session from the lab, and wizard interactions in response to tester actions and changing context.

This paper makes three contributions: (1) an approach for remote paper prototype testing; (2) a tool that implements the approach, built with Google Hangout and Google Glass; and (3) the results of a pilot study, in which three designer-facilitator-wizards prototyped and facilitated the testing of

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two location-based mobile applications that were evaluated by five testers. Results indicate that the tool allowed designers to remotely facilitate testing, presented testers with realistic scenarios, and helped reveal critical incidents.

RELATED WORK

To facilitate testing mobile app prototypes under realistic scenarios, previous work focused on tools for creating interactive, higher-fidelity prototypes. For example, Raento et al. [10] introduced ContextPhone, which supports prototyping context-aware mobile applications. Sá et al. [6] introduced tools for mixed-fidelity prototyping that support adding interactivity to low-fidelity prototypes. Numerous commercial tools support wireframing and generating interactive prototypes of mobile applications; Balsamiq, Invision, Framer, Indigo, and Mockingbird are some examples. But while these tools enable higher-fidelity prototypes to be generated more quickly, paper prototypes are easier to make still and may focus testers' attention more on core interactions than on look-and-feel [11].

To address the shortcomings of in-lab testing, *remote usability testing* allows an application developer to view and record a tester's interactions and reactions to an interactive, mobile application prototype. MailChimp, for example, created an early prototype for remote usability testing in which a user holds up their mobile device up to their laptop's webcam while video chatting on Skype. While remote usability testing allows designers to gather feedback on computer prototypes, with remote paper prototype testing we face the added challenge of having to wizard a paper prototype from afar to realize both the benefits of paper prototyping and out-of-the lab testing.

As testers in a remote paper prototyping session interact with a video of the interface and not the paper itself, aspects of the experience are akin to *paper-in-screen* prototyping [4]. For mobile apps, a paper-in-screen prototype digitizes a paper prototype and adds navigational elements by linking drawn interface elements to different views within a mobile interface. One benefit of paper-in-screen prototypes shared by remote paper prototype testing is that users can interact with the interface on their own mobile device, adding to the authenticity of the experience. But while a paper-in-screen consists of a set of pre-determined interactions, remote paper prototype testing supports dynamic updates to an interface with a human wizard.

REMOTE PAPER PROTOTYPE TESTING

We developed a remote paper prototype testing tool to enable designers to observe, facilitate, and wizard a paper prototype testing session in the lab while a tester interacts with the prototype out of the lab. Our prototype tool is built with a combination of existing technologies.

We place a paper prototype on a desk under a smartphone that is attached to a bookstand (Figure 1, Right). The smartphone serves as a makeshift document camera, transmitting a video of the prototype through Google Hangouts (Figure 1, Left). A tester connects to the hangout and interacts with the feed as if it were an actual interface (Figure 1, Left). The tester wears Google Glass running our remote prototype testing software, which streams a video of the tester's first-person perspective, audio, and location data to the facilitator's command center (Figure 2). Based on this live feed, the wizard provides instructions and updates the paper prototype in response to the tester's actions. For example, the wizard might update the interface based on the tester's movement by manipulating a stick that points at the tester's location (Figure 1, Right). At any time, the facilitator can speak to the tester directly or via a message box. Messages are displayed on Glass and also voiced with text-to-speech.

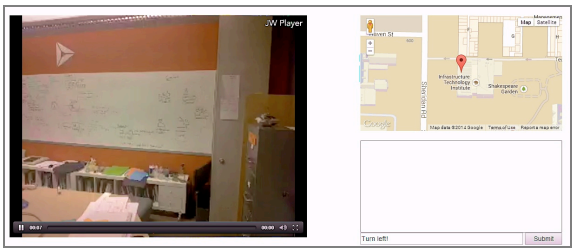

Figure 2. The facilitator's command center interface displays a video stream, location data, and a chat box.

Design Goals

Test mobile apps in realistic environments: Our remote paper prototype testing setup allows a tester to experience an app in the places and situations where they are likely to use it. For example, this setup helps support the testing of location-based mobile applications for social networking (e.g., Foursquare) for which the locational aspects of the interaction may be difficult to replicate in the lab.

Remotely facilitate a testing session and wizard a prototype from the lab: One advantage of facilitating and wizarding from the lab over following a tester out of the lab is that it is easier to manipulate a paper prototype in lab than on-the-move or at remote locations, where holding and updating a prototype can be physically difficult or awkward. The lab also provides easy access to prototype components (e.g., Post-Its, notecards) and resources (e.g., desktop computers).

Provide location-based and situational context: Remote testing can make it difficult for designers to understand user interactions in the context of their surroundings. By streaming the user's first-person viewpoint, our remote paper prototype testing tool shows designers sequences of interactions live and in-situ. For example, being able to see how a user shifts their attention between the app and their environment can provide insights about how interface elements are helping users navigate or complete tasks.

Preserve the affordances of paper prototyping: Despite their seeming simplicity, paper prototypes can be highly expressive and capture the essence of complex interactions.

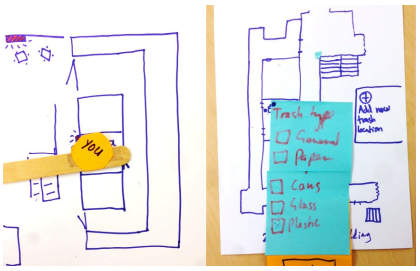

Figure 3. Left: Sugar Rush. Right: Recycle Hunt

Our tool seeks to maintain paper's flexibility while simultaneously enabling remote testing. In contrast to paper-in-screen prototyping [4], we are not limited to a set of predetermined interactions: a wizard can flexibly update the mobile interface based on situations and events.

Implementation

The remote paper prototype testing tool's native Glass component is written in Java and built using Google's Glass Development Kit Preview (API 19). Glass streams its camera video using the libstreaming library to a Wowza media server that handles viewing clients. Native Android functions implement broadcasting location information and viewing text updates from the facilitator and playing them aloud. Parse stores and transmits text updates and location data. The command center is built in HTML, CSS, Javascript, JWPlayer, and Google Maps' Javascript API.

PILOT STUDY

We conducted a pilot study over two days to explore opportunities for using remote paper prototype testing. We recruited a purposive sample of designers and testers. Three designers created and iterated on paper prototypes of two location-based, mobile applications. Five testers evaluated these two prototypes. During testing sessions, designers acted as facilitators, wizards, and observers.

Designers were given 20 minutes to create the prototype. During subsequent testing sessions, they instructed testers on tasks and scenarios, observed their interactions, and wizarded the system. Testers participate through 30-minute sessions. They were instructed to talk aloud while using the application out of the lab. After evaluating both prototypes, testers provided feedback to designers. We interviewed everyone about their testing experience at the end.

Results

Designers prototyped two applications: Sugar Rush and Recycle Hunt. Sugar Rush is a treasure hunt style app for candy (Figure 3, Left). Testers are shown a hand-drawn map with candy cane boxes marking the approximate locations of candy and a "You" pin indicating their current location. The designer moves a popsicle stick to match the tester's location. Recycle Hunt crowdsources the locations of recycle and trash bins (Figure 3, Right). Through a map view, testers can find locations to dispose of trash and add the locations of unmarked trashcans or recycling bins.

Results from the testing sessions demonstrate some of the potential benefits of remote testing and show that the remote paper prototype testing tool supported our four stated design goals:

Test mobile apps in realistic environments

Testers found themselves engaged in the presented tasks as they walked around the building looking for candy or trash bins. Testing revealed a number of critical incidents; for example, a few Sugar Rush testers could not find candy even when they were very close. One designer noted that this was "something we couldn't have found out [in a lab]."

Remotely facilitate a testing session and wizard a prototype from the lab

Designers noted that the first-person perspective streamed from Glass "[allowed them] to be reactive". Despite interacting remotely, designers observed testers interacting with the prototype application like they were trying to actually use their personal phones to complete the task. A tester commented that "seeing the paper and being able to press it seemed real," especially because they were "actually using it in the actual environment."

Provide location-based and situational context

Designers repeatedly expressed the usefulness of being able to see the users' actions in context. A Sugar Rush designer said: "With Glass you get to see what's going on when they switch their focus from the app to the real world...If you're testing in lab, you go like 'Great, you found the candy.' But …you didn't know what to do when you got to the location." Seeing user actions in context also helped designers identify interactions that confused users. In Sugar Rush, an early prototype provided no feedback when users reached the location of the candy. The designer found that users "tried to click on [the candy icons]" and wondered what to do next. Based on this observation, the designer updated the prototype so that the wizard would shake the user location popsicle stick as feedback for when a user approached candy. This prompted users to look up from their phones and helped them find the candy.

Preserve the affordances of paper prototyping

Designers felt that the ability to prototype on paper and immediately test it in realistic scenarios helped them gather "more insights faster." Designers focused on expressing the core idea behind the application, knowing that there may be flaws but that remote testing would help to "immediately realize all of the ways [they] would fail." For Recycle Hunt, the designer "realized that [users] didn't have any incentive to use the app at the point in which [their] knowledge was useful. If [they] knew where the recycling thing was [they] wouldn't use the app, which shoots down the entire premise." He noted that the flaw he had discovered through testing would be "sort of devastating if you spent a long time on it," but that finding the flaw through remote paper prototype testing "was a very useful place to get to."

DISCUSSION

The Case for Remote Paper Prototype Testing

To facilitate testing prototypes of mobile applications in realistic scenarios, previous work focused on helping designers create higher-fidelity prototypes and provided features for logging and analyzing usage data [6,10]. In contrast, our tool allows designers to create paper prototypes, test them outside the lab, and, unlike paper-in-screen prototyping [4], flexibly update the interface in response to events and situations while testing.

With our remote testing method, designers can use paper prototypes of mobile apps to identify critical incidents and usability problems through actual mobile use cases. Paper prototypes in the pilot took only 20 minutes to create; a computer prototype with comparable functionality may have taken a full day to create. That said, paper prototyping requires continued human involvement during testing, and may not support longitudinal studies. Future work will more carefully investigate the respective benefits and shortcomings of remote paper prototype testing and higher fidelity prototyping in varied use cases.

Technology for Remote Paper Prototype Testing

Remote paper prototyping testing can integrate a variety of technologies to create a more powerful overall experience. In the pilot, we used Glass for its first-person perspective, which allowed designers to remotely observe what users were looking at, their location, and their situational context. More generally, our core approach centers on (1) streaming a live audiovisual feed of the paper prototype to a remote tester, and (2) streaming information from the tester back to the wizard.

Future work will explore the tradeoffs in complexity, cost, and functionality through alternative implementations of our approach. For example, we could create a testing app that (1) use the front facing camera to capture the user's facial expressions, and (2) display street view as testers move about an environment. These technologies offer a substitute for Glass to capture context and user reactions.

In our pilot, wizards expressed that managing multiple technologies while reacting to user actions and changing situations was difficult. To reduce this burden, we will also explore setups that reduce the need of the wizard to shift their attention and the effort required to complete wizarding actions. For example, we will overlay an event stream of user actions on top of the video of the paper prototype in the command center. We will also experiment with augmented reality displays of prototyping materials.

Testing Lo-fi Prototypes in the Wild

Our future work will study the limits while expanding the use of remote testing for lo-fi prototypes to testing in actual locations, times, and situations. For location, pilot testing took place inside an engineering building in which testers and bystanders were tech-savvy and felt little to no aversion to Glass or talk-alouds. We plan to test mobile prototypes in public venues such as parks, coffee shops, and department stores to study if wearing Glass affects testers or bystanders, examining if they feel self-conscious and exploring any social implications of using this technology. For times, pilot testing sessions lasted only half an hour and at scheduled times. Future work will seek to allow testing throughout a user's existing routine, explore methods for (a) notifying wizards of pending interactions, and (b) recruiting a real-time crowd to act as wizards on demand [2,3]. For situations, our pilot focused on mobile apps in which location plays a crucial role in the experience, but the remote testing approach may be useful for a wide range of mobile use cases and contexts. Our future work will explore the advantages and limitations of remote paper prototype testing across a large range of scenarios, such as ones that require inter-personal interactions, that are time sensitive, or that make use of other technologies, such as cameras.

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