ShareTable Application for HP Sprout

Baris Unver
University of Minnesota
Minneapolis, MN 55455, USA
verxx003@umn.edu

Sarah A. McRoberts
University of Minnesota
Minneapolis, MN 55455, USA
mcrob021@umn.edu

Sabirat Rubya
University of Minnesota
Minneapolis, MN 55455, USA
rubya001@umn.edu

Haiwei Ma
University of Minnesota
Minneapolis, MN 55455, USA
maxxx979@umn.edu

Zuoyi Zhang
University of Minnesota
Minneapolis, MN 55455, USA
zhan4773@umn.edu

Svetlana Yarosh
University of Minnesota
Minneapolis, MN 55455, USA
lana@umn.edu

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Abstract
Projector-camera (pro-cam) systems create virtual environments for remote interaction with audio and video support. However, previous pro-cam systems require custom hardware and thus have not been used at-scale in the field. In this work, we present a pro-cam application to reinforce social relationships for an off-the-shelf pro-cam system. The ShareTable application users can use video chat in conjunction with sharing tabletop video, allowing them to connect while playing and interacting together.

Author Keywords
Mediated Social Touch; Remote Touch; Video Chat; HP Sprout; Social Ties; Social Computing; Computer-Mediated Communication; Pro-Cam System.

ACM Classification Keywords
H.4.3 Communications Applications.

Introduction
HCI community has spent years exploring and developing pro-cam tabletop systems for workplace collaboration [6, 2] and social communication [8, 3]. Previously, these systems have rarely been used or tested in real-world settings due to the specialized hardware involved. However, the recent release of the HP Sprout system provides commercially available

HP Sprout

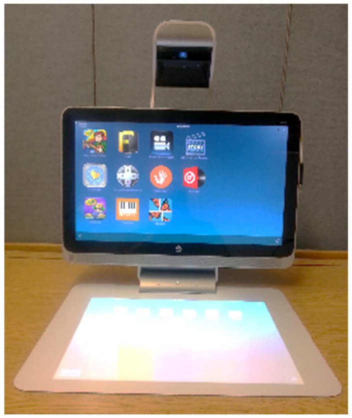

Figure 1: HP Sprout Immersive Computer.

Specifications:

- 23" touch-enabled, full HD LCD display
- 20" touch-enabled mat
- DLP projector
- HD 14.6 MP downward-facing camera
- Intel® RealSense™ 3D Camera
- LED desk lamp
- HD 1MP front-facing camera

  For more details: http://www8.hp.com/us/en/sprout/home.html

hardware to allow ideas from these research projects to reach a significantly larger audience. Figure 1 shows a view of HP Sprout and its specifications. In our ShareTable application, we leverage HP Sprout's hardware, SDK, and application distribution marketplace to create a communication medium that will be available outside of the academic setting to a more diverse group of users.

Related Work

There are very few investigations of pro-cam systems in the field as most prototypes are not robust enough for unattended use. Many applications in this space such as Collaborative Slate (or C-Slate) by Microsoft Research Cambridge [2], IllumiShare by Microsoft Research [3] and Videodraw by Xerox PARC [6] have been tested in laboratory settings with single or multiple prototypes. Similarly, the custom-hardware version of the original ShareTable system has been tested in real world settings, but with only two divorced families [9]. We seek to expand the impact of pro-cam systems by replicating the success of these custom-hardware research projects using off-the-shelf, readily available hardware.

System Description

Development Platform

For our development platform, we have used C# WPF because of the HP Sprout API dependency [5].

Communication Technology

To support greater privacy and speed, we implement a peer-to-peer (P2P) connection solution instead of using a central media server to transfer audio and video between users. We are using WebRTC to implement this connection. WebRTC also has native support for STUN/ICE mechanisms, which are crucial for establishing a connection across different networks [7].

Problems

Before starting to use WebRTC in our application, we also tried some solutions listed below.

- Microsoft Expression Encoder and .NET Framework 4.0
- Ozeki Camera SDK
- IIS Media Services
- VLC plugins
- FFMPEG plugins

But none of these provided the intended result. We faced problems with no audio support, low audio and video quality, high time latency between source and target users, connection problems between networks, etc. One important limitation of WebRTC is that it can only work across web browsers. After we had decided on WebRTC for our implementation, we found out that native C# web browser component (an instance of Internet Explorer) has no support for WebRTC. We tried other browser engines like Awesomium, Gecko, and Chromium and finally found out that CefSharp [1] which is a .NET binding for the Chromium Embedded Framework has support for WebRTC. Thus, to support video/audio transmitting, we use two instances of CefSharp per system. One instance is for forward-facing video and audio streams and the second one is for downward-facing video from tabletop (mat). We implemented a RESTful API for user registration, authentication, and directory management tasks.

Video Echo Cancellation

The major problem when developing pro-cam systems is video echo, a kind of visual feedback loop between

Use Case Scenarios

Figure 2: Mediated Touch

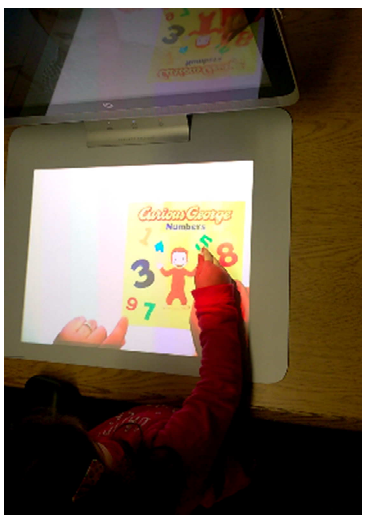

Figure 3: Reading Together

setups. Some approaches to prevent video echo in pro-cam systems are digital background removal, polarized isolation, light frequency multiplexing, and time multiplexing. The main idea behind digital background removal is to separate the projected image from the real objects by using various digital image processing techniques [4]. Multiplexing and polarization need custom hardware to suppress projected video beyond the image processing. However; we wanted to leverage the existing Sprout platform and avoid any additional hardware. We tried out different methods and found that low latency and a high frame rate help to overcome this problem. Additionally, we have discovered that the white background of the mat and an external source of light, overhead lights of the Sprout can suppress up to 90% of video echo which is sufficient for the purpose of remote play.

Use Case Scenarios

The ShareTable application is useful for any people who need efficient, immersive remote collaboration. In addition to existing video chat applications, ShareTable provides a shared space for overlapping users' tabletop video. By using this feature, interaction with everyday objects like papers, pencils, books, toys, etc. can be possible and these artifacts become natural components of the video chat, in the same way, they would be of a face–to-face conversation. Another benefit of the ShareTable app is that users can use their hand gestures for pointing and expressing themselves like in real-life. The following are some use case scenarios for the app.

- Distance learning
- Video conferencing
- Mediated touch (metaphoric/remote touch) (Fig 2)
- Reading, drawing & playing in remote (Figs 3, 4, & 5)
- Online consultation
- Online rehabilitation and recovery
- Online healthcare
- Reinforce and support social ties

Conclusion & Future Work

The ShareTable application provides many opportunities to create new knowledge in HCI. We plan to expand the laboratory studies to real-world settings and explore user interaction.

Enhancing Video Echo Cancellation

To provide a better user experience, we will implement digital video echo cancelation methods to reduce the video echo, still without using any additional hardware like IR emitters, filters, or polarized lenses.

Easy to Use

Currently, the ShareTable application uses common application standards, without much consideration for accessibility. An email address and a password are required to create an account and login to the app which is very similar to existing video chat applications. Also initiating a video call is done with a button click and navigating to the proper contact. However, we are planning to investigate ways that make app usage easier for kids and elders. For example, we intend to connect contact pictures and physical cards so users can initiate a call just putting printed out cards on the mat. The status of the call progress can also be visualized on the mat with animated colored circles surrounding around the card.

Use Case Scenarios

Figure 4: Drawing Together

Figure 5: Playing Together

Multi-User Interaction Support
The ShareTable app currently allows only two separate contacts to connect at the same time. We will solve this limitation and add the multi-user capability to our application.

Symmetric vs. Asymmetric Device Interaction
It is required that each of the users own a Sprout to use the ShareTable app. But, we will work on this issue and incorporate other devices like standard computers, tablets, and smartphones with Sprout for asymmetric device connections.

The ShareTable app will serve the HCI community by investigating pro-cam system related questions in real-world settings. We will be sharing the source code of the application and the data collected from the system, and we would like to transform it into an open platform. The ShareTable system will be able to benefit public users and HCI, alike.

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