Evolution of a Tabletop Telepresence System through Art and Technology

Tony Dunnigan, John Doherty, Daniel Avrahami, Jacob Biehl,
Patrick Chiu, Chelhwon Kim, Qiong Liu, Henry Tang, Lynn Wilcox
FX Palo Alto Laboratory
3174 Porter Drive
Palo Alto, CA, USA
tonyd@fxpal.com

ABSTRACT
New technologies arise in a number of ways. They may come from advances in scientific research, through new combinations of existing technologies, or by simply imagining what might be possible in the future. This video describes the evolution of Tabletop Telepresence, a system for remote collaboration through desktop videoconferencing combined with a digital desk. Tabletop Telepresence began as a collection of camera, projector, videoconferencing and user interaction technologies. Working together; artists and research scientists combined these technologies into a means of sharing paper documents between remote desktops, interacting with those documents, requesting services (such as translation), and communicating through a videoconference.

Categories and Subject Descriptors
H.4.m [**INFORMATION SYSTEMS APPLICATIONS**]: Miscellaneous.

General Terms
Design, Human Factors.

Keywords
Digital desk, tabletop systems, telepresence.

1. INTRODUCTION
Teleconferencing systems have been steadily improving, both in audio/video transmission quality and in the user interfaces to control them. These systems support screen sharing during video conferencing, but sharing paper documents, or other tangible objects, requires users to present them to videoconferencing cameras in an unnatural way. Dedicated overhead cameras are better at capturing paper documents while users interact with them on a tabletop surface. As researchers develop these technologies, concept artists depict how they can be combined and extended to create novel work environments. This video illustrates the evolution of Tabletop Telepresence, a system for desktop conferencing that combines the usual "talking heads" with a shared desktop environment.

2. INSPIRATION
The digital desk was described over 20 years ago as a means to seamlessly work with paper documents and electronic content on a desk [8]. The system involved a camera that recognized documents and user activity on the desktop and a projector that displayed digital content. A related system [6] used a low-resolution video camera to capture selected parts of paper documents.

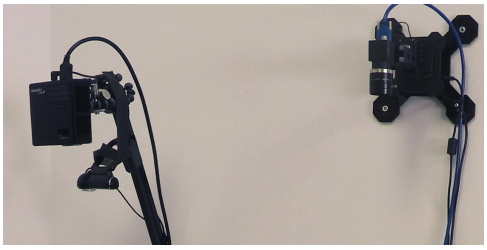
Improvements in camera/projector systems allowed the creation of vision-based gesture interfaces ([3], [7]), and rich document interactions [5]. In these, the user interacts with an interface projected on the desktop along with paper documents to control applications such as document services on a digital desk. High resolution cameras also enabled the capture of document pages on a tabletop surface with sufficient quality for OCR [4].

Concept artists working among researchers saw examples of teleconferencing technologies and digital desks, and imagined a system that combined the two in a novel manner. The first concept was a conferencing system in which a paper document on one side of a videoconference could be printed at the other end. This involved using a camera to capture the document, transferring the document image to the remote site for printing, and providing a projected interface controlled by gestures. This was later enhanced with the addition of document translation, which leveraged a web-based document service for OCR of the document image and then translation before printing at the remote location.

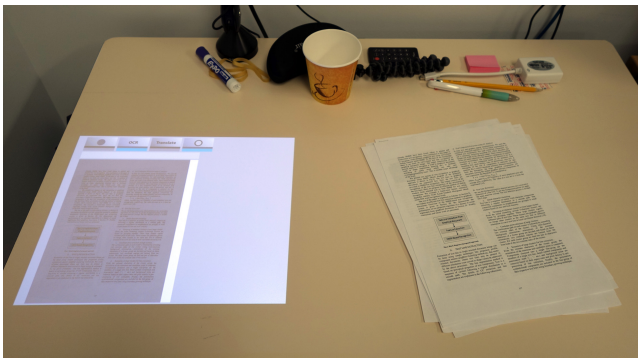
3. DEVELOPMENT
We were able to build a working prototype of the system that emerged from the concept art. We added a projector-camera module to our existing tabletop document capture system [4] to provide a vision-based user interface [7], and to support projection of a document on the tabletop. We integrated the Google Translation service to process the captured document OCR results into Japanese or other languages.

Figure 1. Concept of teleconferencing with a digital desk.

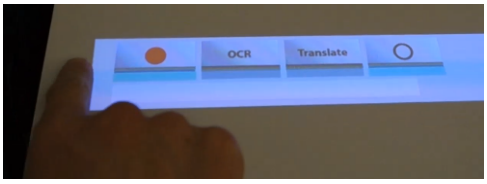
DOI: http://dx.doi.org/10.1145/2733373.2807400



(a)



(b)



(c)

Figure 2. (a) Projector-camera module and 4K camera mounted on a pan-tilt unit. (b) A user interface toolbar and a captured document are projected on the left side of the table. (c) Close-up of toolbar.

The the tabletop system hardware consists of a Point Grey Flea3 4K video camera for document capture, which is mounted on a pan-tilt robot turret that scans the entire tabletop surface. The document capture occurs in two stages: first by detecting document pages on a cluttered tabletop based on a text probability map, and then by capturing a sequence of overlapping frames of the detected page which are fused into a high quality image that can be processed by OCR [4].

The projector-camera unit is made up of a generic webcam and a lightweight Optoma pico projector. The projected user interface widgets use vision-based techniques that monitor patterns of occlusion on the widgets' hotspots to recognize swipe gestures and button press gestures [7].

Although teleconferencing functions are not integrated into the current system, researchers assumed that teleconferencing could be added with standard systems like Skype or Hangouts. Our concept artists then produced additional illustrations and videos that depict systems with teleconferencing and remote printing capabilities.

4. CONCEPT EXTENSIONS

As video conferencing has become more common, its limitations have become more obvious. Remote participants in meetings consistently report that they feel less "present" than their co-located counterparts. To mitigate this problem, a new generation of telepresence devices is being developed. These devices provide remote collaborators with an enhanced sense of embodiment in environments to which they connect. In particular, we built a prototype telepresence robot called Jarvis [1]. Jarvis consists of an articulated display with a camera, speaker and microphone that can be actively or passively controlled by a remote participant.

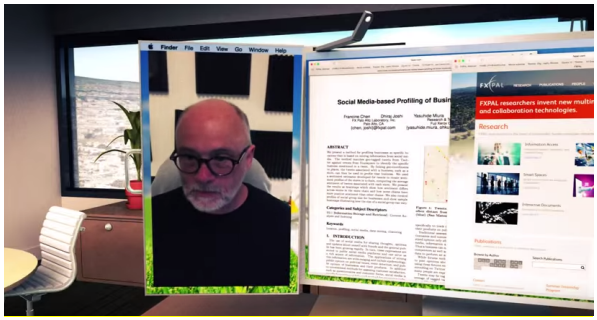


Figure 3. Concept of Tabletop Telepresence with Jarvis.

Inspired by Jarvis, concept artists added embodied telepresence to the developing Tabletop Telepresence system. This again resulted in a new round of illustrations and videos.

5. CONCONCLUSIONS

Concept art has long contributed to product and industrial design, helping manufacturers iteratively improve their product offerings. This video shows how introducing concept art into the early stages of research broadens its scope and helps us iterate into the future.

6. REFERENCES

[1] Biehl, J., Avrahami, D., & Dunnigan, A. Not really there: Understanding embodied communication affordances in team perception and participation. *Proc. CSCW '15*.

[2] Golovchinsky, G., Qvarfordt, P., van Melle, B., Carter, S. Dunnigan, T., DICE: designing conference rooms for usability. *Proc. CHI '09*, pp. 1015-1024.

[3] Kjeldsen, R., Pingali, G., Hartman, J., Levas, T., Podlaseck, M. Interacting with steerable projected displays. *Intl. Conf. on Automatic Face and Gesture Recognition (FGR '02)*, pp. 402-407.

[4] Kim, C., Chiu, P., Tang, H. High-quality capture of documents on a cluttered tabletop with a 4K video camera. *Proceedings of ACM DocEng 2015*.

[5] Liao, C., Tang, H., Liu, Q., Chiu, P., Chen, F. FACT: fine-grained cross-media interaction with documents via a portable hybrid paper-laptop interface. *Proc. ACM Multimedia '10*, pp. 361-370.

[6] Newman, W., Dance, C., Taylor, A., Taylor, S., Taylor, M., Aldhous, T. CamWorks: a video-based tool for efficient capture from paper source documents. *Proc. ICMCS '99*, pp 647–653.

[7] Tang, H., Chiu, P., Liu, Q. Gesture Viewport: Interacting with media content using finger gestures on any surface. *ICME '15 demo*.

[8] Wellner, P. The DigitalDesk Calculator: Tangible manipulation on a desk top display. *Proc. UIST '91*, pp. 27-33.