The Virtual Chocolate Factory:
Mixed Reality Industrial Collaboration and Control

Maribeth Back, Don Kimber, Eleanor Rieffel, Anthony Dunnigan,

Bee Liew, Sagar Gattepally, Jonathan Foote, Jun Shingu, James Vaughan

FX Palo Alto Laboratory

Palo Alto, CA

Tel: 1 650 842-4800

[back, kimber, rieffel, tonyd, bee, sagar, vaughan]@fxpal.com; jtfoote@ieee.org; jun.shingu@fujixerox.co.jp

ABSTRACT

We show several aspects of a complex mixed reality system that we have built and deployed in a real-world factory setting. In our system, virtual worlds, augmented realities, and social and mobile applications are all fed from the same infrastructure. In collaboration with TCHO[1], a chocolate maker in San Francisco, we built a virtual "mirror" world of a real-world chocolate factory and its processes. Sensor data is imported into the multi-user 3D environment from hundreds of sensors on the factory floor. The resulting virtual factory is used for simulation, visualization, and collaboration, using a set of interlinked, real-time layers of information. Another part of our infrastructure is designed to support appropriate industrial uses for mobile devices such as cell phones and tablet computers. We deployed this system at the real-world factory in 2009, and it is now is daily use there. By simultaneously developing mobile, virtual, and web-based display and collaboration environments, we aimed to create an infrastructure that did not skew toward one type of application but that could serve many at once, interchangeably. Through this mixture of mobile, social, mixed and virtual technologies, we hope to create systems for enhanced collaboration in industrial settings between physically remote people and places, such as factories in China with managers in the US.

Categories and Subject Descriptors

H.5.1. [**Information Systems**]: Artificial, augmented, and virtual realities.

General Terms

Management, Documentation, Design, Human Factors.

Keywords

Mixed reality, cross-reality, 3D applications, data visualization, remote collaboration, virtual worlds, pervasive computing, simulation, mobile applications, collaborative tools.

1. INTRODUCTION

The Virtual Factory project is a case study in designing and using mixed reality systems in a working factory along with its existing control software.(See [2, 3, 4, 5] for discussions of mixed reality

or cross-reality systems.) Rather than simply build a virtual world replicating the factory, our aim was to create an electronic infrastructure that captured data from many of the company's processes and environments, and then find useful ways of using and displaying that information for different sets of people in the company, in support of their current tasks. In addition, new channels of communication between people accompany the data, adding a layer of collaboration possibilities that previously did not exist. We currently work with four input data streams:

- data from the machines on the factory floor
- data from machines in the smaller laboratory
- video data from a multi-camera video capture network we installed around the factory, and
- environmental data, tracking temperature and humidity in the factory and its associated laboratory.

Figure 1. An avatar in the Multiverse Virtual Factory.

Figure 2. The TCHO factory floor under construction.

For display and interaction devices, we are currently using mobile phones for remote control, tablets for augmented realities, web-based access for lab and camera viewing, and large displays for virtual environments.

As a first deployment of the virtual factory, a large display (a 56" LCD screen) and a client/server computer running the Multiverse virtual world platform[6] were installed on the real factory floor. To simplify matters for factory personnel giving live tours, we created an automatic animated tour in the virtual world that moves an avatar from one machine to the next, showing high definition video on the function of each machine. This system is currently in daily use by TCHO personnel for tours for B2B clients and the general public.
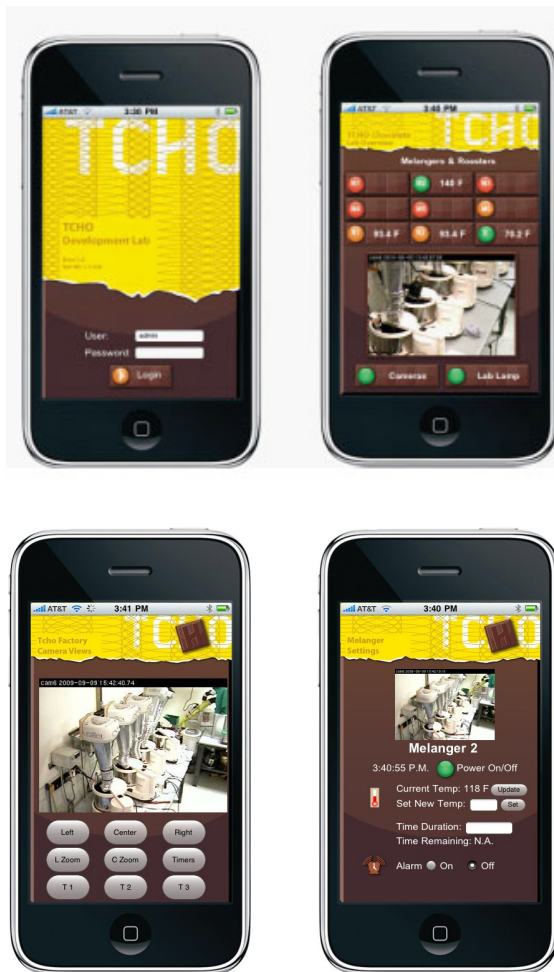

Figure 3. Screen shots from the iPhone web application for controlling and monitoring machines in the chocolate development lab. The UI design has a "candybar" theme.

2. MOBILE MIXED REALITY

The FlavorLab is the place where TCHO develops its proprietary methods for creating unique chocolates. Cacao beans from different growers and geographic areas are analyzed and new recipes developed for each of them. Each new harvest or type of cacao bean may require different treatment such as a longer, slower roast, a longer grind, or a higher grind temperature.

Accurate tracking and control of time and temperature are essential. Users of the lab range from expert to novice, with three experts overseeing the work of three trainees. We interviewed lab users and observed their work process over a period of several weeks. Remote status and control of the melanger (heated grinder) and roaster cycles and general awareness of the lab were the primary needs that came out of the observation and interviews.

The FlavorLab mobile mixed reality app has been in daily use at TCHO since early 2009. The current version can be seen in Figure 4. Using the remote control app, lab personnel can start the melangers and then control temperature and power-down time from wherever they are, via iPhone. Alarms can be set for push notifications to remind users when needed. The iPhone application also gives the user a real-time view into this lab (via pan-tilt-zoom camera).

3. INDUSTRIAL SOCIAL MEDIA

Both the mobile app and the virtual world are designed for lightweight social interaction as well as data and machine management. In the mobile system, for instance, users can see if someone else is already in the lab when a machine times out or otherwise needs attention. Workers can remotely check on tasks, and communicate via text message to update each other on task status. Expert chocolate makers can "look over the shoulder" of a novice without having to be physically present every moment. Though these seem like small conveniences, they create efficiencies both in employee time and in reduction of error (especially leaving the melangers or roasters heating for too long, resulting in a ruined batch).

Social aspects of the virtual factory world include using the virtual factory world for meeting clients or shared data monitoring, as well as providing a window into the chocolate factory's processes for the general public. As part of our future work for this project, we are currently building a Web-based 3D version of the virtual factory for the TCHO company website.

4. ACKNOWLEDGMENTS

5. REFERENCES

[1] TCHO Ventures, Inc. http://www.tcho.com/ (link: 4/11/2010)

[2] Paradiso, J. and Landay, J. 2009 Guest Editors' Introduction: Cross-Reality Environments", IEEE Pervasive Computing, vol. 8, no. 3, pp. 14-15, July-Sept. 2009.

[3] Ohta, Y., and Tamura, H. Mixed Reality: Merging Real and Virtual Worlds, Springer-Verlag, 1999.

[4] Milgram, P., and Kishino, F. A Taxonomy of Mixed Reality Visual Displays. IEICE Trans. Information and Systems, vol. E77-D, no. 12, 1994, pp. 1321–1329.

[5] Lifton, J., Laibowitz, M., Harry, D., Gong, N., Mittal, M., and Paradiso, J. Metaphor and Manifestation—Cross-Reality with Ubiquitous Sensor/Actuator Networks. IEEE Pervasive Computing, vol. 8, no. 3, pp. 24-33.

[6] Multiverse: http://www.multiverse.net/ (link: 4/11/2010)