MobiSys 2014

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The 12th International Conference on Mobile Systems, Applications, and Services (MobiSys) was held in June 2014 in the historic Mount Washington Hotel in Bretton Woods, New Hampshire. MobiSys 2014 was a single track conference spanning over three days that attracted almost 200 attendees. The conference was co-located with four workshops of related fields, including augmented reality, physical analytics, cloud computing and services, and a PhD forum.

KEYNOTE: GRAND CHALLENGES REQUIRE BALANCE

This year's MobiSys conference opened with a keynote address by James Landay, a professor of information science at Cornell Tech. Landay discussed the importance of understanding the need for balance—"balance between design and technology, balance between human-centered and technology-centered approaches, and a balance between different world cultures and ways of thinking."

Landay's talk addressed some of his past research in HCI spanning domains such as the environment, culture, and education. Throughout his talk, Landay challenged audience members to think about what kinds of "audacious goals" we, as researchers, should set in response to various problems that affect people in these spaces.

In presenting his research, Landay sought to answer lofty questions such as "How do we use information to affect people's behavior?" and "What kind of feedback do people respond to?" He presented a few observations that might motivate developers and designers to move in the right direction as we seek to find that perfect balance between technology and design:

- people respond better to positive feedback from applications;
- qualitative interfaces that tell a story or engage people through a game seem to be more inviting than interfaces that merely collect/present quantitative information; and
- feedback associated with wellness (mental, physical, environmental) was generally considered to be more inclusive and accepting than feedback that could be associated with social status—the latter might deter people from using an application.

To conclude his talk, Landay shared concept videos illustrating less familiar but intriguing alternatives to user interfaces, including the Autonomous Wandering Interface, which is a personal quadcopter that follows you around, projects a user interface onto surrounding surfaces, and monitors your movements and gestures to determine interactions with the interface. Although Landay said that this wasn't necessarily his vision of the future of HCI, it served the purpose of demonstrating the sorts of ideas that can arise from gathering the right people together. This set the stage nicely for what he called his "radical" proposal: the World Lab—an interdisciplinary institute that aims to bring passionate designers and technology experts together to "invent the future today" by uniting various cultures and ways of thinking, exploring creativity, and taking risks.

MOBISYS SESSIONS

Nearly 200 papers were submitted to this year's MobiSys, and only 25 were accepted and presented at the conference. Here, we highlight selected papers from the various conference sessions (for the full proceedings, see http://dl.acm.org/citation.cfm?id=2594368).

Applications

The first session of the conference opened with Tauhidur Rahman of Cornell University and his presentation of "BodyBeat: A Mobile System for Sensing Non-Speech Body Sounds." Rahman and his coauthors set out to create a neck-worn device that could capture subtle and low-frequency body sounds and have low susceptibility to external sounds. BodyBeat, Rahman conveyed, works better than existing solutions that capture and recognize non-speech body sounds. Using a Linear Discriminant Classifier (LDC), BodyBeat boasts a classification average recall of 71.2 percent when classifying actions of the wearer, such as eating, laughing, or throat clearing. Accurate recognition of these sounds could offer significant improvements to applications like automatic food journaling or safety monitoring.

The second paper in this session tried to solve problems related to inefficient and error-prone touchscreen keyboards

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on smartphones. The typical keyboard of a current-generation smartphone is limited by the screen size. In "Ubiquitous Keyboard for Small Mobile Devices: Harnessing Multipath Fading for Fine-Grained Keystroke Localization," Junjue Wang, Kaichen Zhao, Xinyu Zhang, and Chunyi Peng describe the proposed system, UbiK, which uses dual microphones on a mobile device to accurately localize keystrokes. UbiK extracts and optimizes the location-dependent multipath fading features from the audio signals generated from fingernail contact on a hard surface, combined with gyroscope sensor data from the mobile device, to achieve 95 percent localization accuracy.

Wearable Computing

Cory Cornelius of Intel Labs opened this session by presenting, "A Wearable System that Knows Who Wears It," in which the authors set out to determine if a sensor could identify its wearer. By using a wrist worn device with eight contact-point sensors, a small electrical current could be sent through the wrist to measure properties of the wearer's underlying tissue "including the specific tissue types (blood, adipose, muscle, bone, and so on), the anatomic configuration (bone or muscle orientation and quantity), and the state of the tissue (normal or osteoporotic bone, edematous versus normally hydrated tissue, and so forth)," which could then be used to distinguish between different wearers of the device. A user study with eight members showed that the correct wearer could be identified with almost 98 percent accuracy. While an intriguing finding of this work was the potential for the wrist as a biometric, further research into whether the wrist is a reliable source for long-term biometric data is needed.

The session's last presentation was "iShadow: Design of a Wearable, Real-Time Mobile Gaze Tracker," which brings real-time tracking of eye gaze to customized hardware similar to Google Glass. Eye-gaze tracking is useful in various scenarios, including hands-free interaction with the physical world and detection of unsafe behaviors; unfortunately, it's currently limited to clinical trials and user studies. The authors, Addison Mayberry, Pan Hu, Benjamin Marlin, Christopher Salthouse, and Deepak Ganesan, use a sparse pixel-based gaze-estimation algorithm on a multilayer neural network to combat a variety of challenges related to real-time tracking, computation and power requirements, and image processing. Their results show that iShadow can operate at roughly 70mW of power while continuously estimating eye gaze at the rate of 30 Hz, with errors of roughly 3 degrees. A possible direction for future work is to explore how iShadow might work with contact lenses to monitor the micro-movements of pupils inside contact lenses.

Security

To open the session on security, Amit Pande of UC Davis presented "Sensor-Assisted Facial Recognition: An Enhanced Biometric Authentication System for Smartphones." Pande and his coauthors set out to implement a system that can authenticate a user by simply having the user hold a phone in front of his or her face and move the phone from side to side. By analyzing changes in nose orientation and correlating the video captured with accelerometer data, they can defend against both 2D media attacks and virtual camera attacks, respectively, without any penalties to the authentication time. Comments at the close of this session criticized an overhyped citation that face recognition performs very close to 100 percent, which is an underlying assumption of this work.

Paarijaat Aditya of Max Planck Institute for Software Systems presented "EnCore: Private, Context-Based Communication for Mobile Social Apps." Aditya identified three main services provided in mobile social apps: discovery, sharing, and tagging, and discussed various social app paradigms. EnCore's approach makes strong security and privacy guarantees as a platform for social applications without requiring a trusted provider. Although social tagging was beyond the paper's scope, EnCore did propose *secure encounters*. Such encounters rely on device-to-device radio communications with an efficient periodic MAC-address change protocol. This allows device discovery but prevents users from being tracked by the MAC address of their device. EnCore also uses a variant of the Secure Device Discovery and Recognition protocol as a mechanism for secure social sharing via Bluetooth. EnCore was evaluated using a live testbed deployment with 35 users. The deployment included integration with Facebook and DropBox and received positive feedback overall.

Gestures

With the proliferation of wearable devices, a variety of applications in healthcare are emerging. The first paper of this session attempted to recognize smoking gestures using a wristband after training a model with inertial measurement units (IMUs) placed on the wrist and upper arm. The paper, "RisQ: Recognizing Smoking Gestures with Inertial Sensors on a Wristband," by Abhinav Parate, Meng-Chieh Chiu, Chaniel Chadowitz, Deepak Ganesan, and Evangelos Kalogerakis, shows a high recognition accuracy of 95.7 percent, with precision of 91 percent and recall of 81 percent. RisQ leverages a nine-axis IMU to capture changes in the orientation of a person's arm. A user study showed that RisQ can detect the number of smoking sessions with very few false positives over the period of a day. It can also identify the start and end of each session.

The second paper, "An Energy Harvesting Wearable Ring Platform for Gesture Input on Surfaces," by Jeremy Gummeson, Bodhi Priyantha, and Jie Liu, illustrates a prototype design of a wearable ring that can interact with other user devices. The ring detects and interprets various gestures performed on any available surface, and it wirelessly transmits the gestures to the remote device. The ring also opportunistically harvests energy from an NFC-enabled

phone for operation without explicit charging. The ring-based solution can recognize 23 unique gestures, including swipes and strokes for handwritten text entry. The evaluation of the prototype demonstrates an average accuracy of 73 percent with no explicit user training.

UI Automation

During this session, two tools were presented that would give developers more control over how to test/write tests for their apps as well as automatically identify common app errors.

Lenin Ravindranath of MIT introduced "Automatic and Scalable Fault Detection for Mobile Applications." In this paper, the authors present VanarSena, which is an automated fault finder for mobile apps. VanarSena is essentially a tool in which developers can upload their app's binary and get back a detailed report of any app crashes and failures.

Shuia Hao of the University of Southern California discussed "PUMA: Programmable UI-Automation for Large Scale Dynamic Analysis of Mobile Apps." This tool provides a generic UI automation capability that lets users define handlers for high-level events. It also offers dynamic analysis capabilities that let developers specify instrumentation for collecting dynamic state information and specific triggers to introduce dynamic changes in the runtime environment.

Both papers suggest improvements are due to the increased capabilities of the tools, which provide more control and power to the developers as well as more sophisticated approaches to interacting with UI code in an automated fashion.

Resource Usage

Managing bandwidth, energy, and computation are competing objectives of any mobile application. The first paper of this session, "Characterizing Resource Usage for Mobile Web Browsing," by Feng Qian, Subhabrata Sen, and Oliver Spatscheck, presents a comprehensive examination of the resource usage of mobile Web browsing by focusing on two important types of resources: bandwidth and energy. Specifically, the authors study various factors, such as protocol overhead, TCP connection management, webpage content, and traffic timing dynamics on 500 of the most popular websites. The report shows that all factors can affect resource utilization at different layers for Web browsing, because they often poorly interact with the underlying cellular networks.

The session concluded with a paper titled, "CoAST: Collaborative Application-Aware Scheduling of Last-Mile Cellular Traffic," by Cong Shi, Kaustubh Joshi, Rajesh K. Panta, Mostafa H. Ammar, and Ellen W. Zegura. Rather than trying to reduce the aggregate busy-hour traffic, as past solutions have done, this paper attempts to smooth the peaks that cause congestion. The key intuition of this paper, which is derived after studying traffic traces of a large cellular provider, is to delay traffic for very short periods during busy hours. The evaluation shows that CoAST can reduce traffic demand up to 50 percent, even for applications that are not thought to be delay tolerant.

Figure 1. Rio enables novel use cases by sharing I/O devices, such as a camera, audio devices, sensors, and a cellular modem, between mobile systems. This image shows one such use case: multidevice gaming by sharing an accelerometer (the tablet is using the accelerometer on the smartphone).

Performance

Ardalan Amiri Sani of Rice University presented "Rio: A System Solution for Sharing I/O between Mobile Systems," a best paper award winner this year. Sani illustrated the vision behind the work: a single system image for personal computers, making it easier for users to manage tedious tasks, such as installing the same app on multiple devices. By abstracting away details of I/O devices, such as cameras and sensors, and merely treating them as files, Rio can enforce a client/server model to let devices leverage I/O resources of other devices without modifying the apps themselves. According to the paper, Rio achieves "close to local" performance for sensors, audio devices, and cellular modem, and "usable" performance for the camera (see Figure 1). At the close of this talk, many questions were raised about various security issues, but that aspect of the system has been left to future work.

Next, Yin Yan of the University of Buffalo presented "Real-Time Android with RTDroid." Yan states that although there has been interest in trying to adopt Android for real-time systems in the healthcare and military domains, very little work has been done to explore the feasibility of doing so. Yan highlighted specific limitations of Android that currently prevent it from being a viable real-time system. The solution that Yan and his colleagues present is RTDroid—essentially a modification to the Android

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OS whereby internal components—such as the AlarmManager and SensorManager—are redesigned or modified to provide real-time guarantees. Also, the Dalvik virtual machine for Android is replaced with a real-time OS. The paper discuss the real-time fall detector they implemented to demonstrate the viability of their solution.

Localization

This session opened with the other best paper award winner, "COIN-GPS: Indoor Localization from Direct GPS Receiving," by Shahriar Nirjon, Jie Liu, Gerald DeJean, Bodhi Priyantha, Yuzhe Jin, and Ted Hart. This paper contradicts the popular belief that GPS can't work indoor due to poor signal strength and on-device computation power. The authors designed a steerable high-gain directional antenna to receive signal strength. Later, by leveraging cloud computation power, they offloaded complicated calculations related to signal acquisition and decoding. On 31 randomly chosen indoor locations, COIN-GPS performed with the median accuracy of less than 10 meters.

The MobiSys 2014 sessions concluded with, "I am a Smartphone and I can Tell my User's Walking Direction" by Nirupam Roy, He Wang, and Romit Roy Choudhury. This paper doesn't propose another localization system but rather solves a common issue faced by all localization schemes present today: finding the user's true walking direction irrespective of device's orientation. Challenges arise because the compass direction and the user's walking direction coincide only when the two axes are perfectly aligned. The accelerometer doesn't solve this problem because the direction blends with various other motion patterns during the act of walking, including bouncing, swinging of arms or legs, and so on. The key contribution of WalkCompass is the authors' analysis of the anatomy of walking patterns from the perspective of smartphone sensors. The evaluation of WalkCompass across 15 different environments demonstrates a median error of less than 8 degrees, across six different users, three surfaces, and three holding positions.

NSF SUPPORT

Thyagarajan Nandagopal, program director of the National Science Foundation, invited the entire mobile community to come together with breakthrough ideas in designing mobile computing community testbeds. He promised full support from the NSF in organizing specialized study groups, meetings, workshops, and conferences in realizing that vision. The important takeaway from the lunch meeting was that there is no recipe for a successful research testbed from the NSF's point of view—a collaborative effort and long term vision from the community is the only way forward.[1]

POSTERS AND DEMOS

Accompanying the papers and talks, MobiSys 2014 also featured 16 posters, eight pre-recorded video demos, and 19 live demos.

Among the posters and demos was "Open Data Kit 2.0 Tool Suite," presented by Waylon Brunette and Samuel Sudar of the University of Washington. ODK is an open source toolkit that helps organizations around the world build data-collection solutions. The video demo session included a more focused look at "ODK Tables," a module that specifically helps users visualize and edit data as well as sync data to an ODK server.

Another poster, "M-SEven: Monitoring Smoking Event by Considering Time Sequence Information via iPhone M7 API," was presented by Bo-Jhang Ho of UCLA. Using a two-stage classification approach to first detect subbehaviors (for example, is_stationary, is_walking, or is_driving), and then combine features from this data to infer higher-level behaviors (such as smoking/not smoking), the presented system uses time sequence analysis of activities to determine whether a person is smoking.

David Mascarenas of Los Alamos National Laboratory presented "Remote Sensor Placement," which was featured in both live and video demos. The device is a means of remotely deploying sensors in a precise and rapid manner. A high-powered gas gun and laser rangefinder are used to measure distances and determine the amount of energy needed to deploy a given sensor and successfully attach it without damaging it. Attachment mechanisms are currently being developed to allow sensors to be attached to various materials.

MobiSys 2014 was a display of exemplary research work and great overall success. The conference was superbly executed by the program committee chairs, Landon Cox and Z. Morley Mao, and general chairs, Andrew Campbell and David Kotz. As we bid adieu to this edition of the conference, we're already looking forward to MobiSys 2015, which will be held 18–22 May 2015 in Florence, Italy (see www.sigmobile.org/mobisys/2015). It will be co-located for the first time with the International World Wide Web Conference (WWW 2015) to further enhance synergy between the fields of mobile computing and the Web. P

REFERENCE

1. T. Nandagopal, "Mobile Networking/Computing Testbeds for the Future?" presented at the 12th Int'l Conf. Mobile Systems (MobiSys 14), 2014; www.sigmobile.org/mobisys/2014/Mobisys-CommunityInfrastructure-Talk.pdf.

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