ISWC 2010: The Latest in Wearable Computing Research

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At the 14th IEEE International Symposium on Wearable Computers (ISWC 2010), researchers and practitioners from all corners of the world met in Seoul's impressive Coex Center to review recent advances in e-textiles, on-body sensors, and wearable activity-recognition and mobile technologies. The rich program followed the conference's tradition of a technical program consisting of long and short papers, posters, and demonstrations, flanked by three tutorials, a design contest, and a PhD forum.

The technical program reflected aspects of wearable computing ranging from fabric-based integrated-circuit design to novel microvibration activity sensors.

TEXTILE-BASED SYSTEMS

The first session focused on textile advances. Seulki Lee and her colleagues in the Semiconductor System Lab at the Korea Advanced Institute of Science and Technology (KAIST) presented results from a novel technique, called Planar Fashionable Circuit Board (P-FCB), to integrate chips into textiles. They demonstrated the technique on an MP3-playing textile armband (see Figure 1) and made the case for its suitability in a multilayered layout. Their evaluation of the technique included repeatedly washing and stress-testing the fabric.

Scott Gilliland and his colleagues from the Georgia Institute of Technology demonstrated several GUI widget-like fabric implementations using conductive embroidery. They collected the interfaces in an augmented swatchbook that connected to a computer for evaluating the interfaces. For example, a novel hybrid resistive-capacitive touch sensor showed high tolerance for the fabric's flexing.

Daniel Kohlsdorf and Thad Starner presented an evaluation of a passive haptic learning application, in which users learn to play a piano piece by wearing a glove with a built-in vibrator for every finger. The glove repeated the piano melody's key presses while the users actively performed another task, which varied from playing a memory game to walking through a building. Measured results showed the type of task didn't greatly hamper the learning effect.

A technology for weaving electronic components into fabrics at the yarn level won the best paper award.

Christoph Zysset and his colleagues in the Wearable Computing Group, ETH Zurich, won the best paper award. They demonstrated a technology for weaving electronic components into fabrics at the yarn level (see Figure 2). The process uses thin-film strips populated with integrated circuits and contact pads that are cut into fibers, dubbed *e-fibers*, which are in turn woven among normal and conductive fibers that form bus systems for the entire fabric. They used commercial weaving processes to evaluate the process for drapability, mechanical stability, and washability in the construction of a shirt containing embedded temperature sensors.

WEARABLE APPLICATIONS

Several papers investigated methods that enable new wearable applications. I-Chun Liu and her colleagues from the National University of Taiwan developed a wearable system that combines Chinese character recognition and blog mining to obtain menu recommendations at restaurants by simply taking a picture of the restaurant's sign board. System performance shows that the character recognition can reach about 90 percent accuracy, while the entire system's accuracy in extracting recommendations from food blogs averages 70 percent.

Donald Patterson and Mohan Singh reported on a lightweight, wearable accelerometer-based system that moni-

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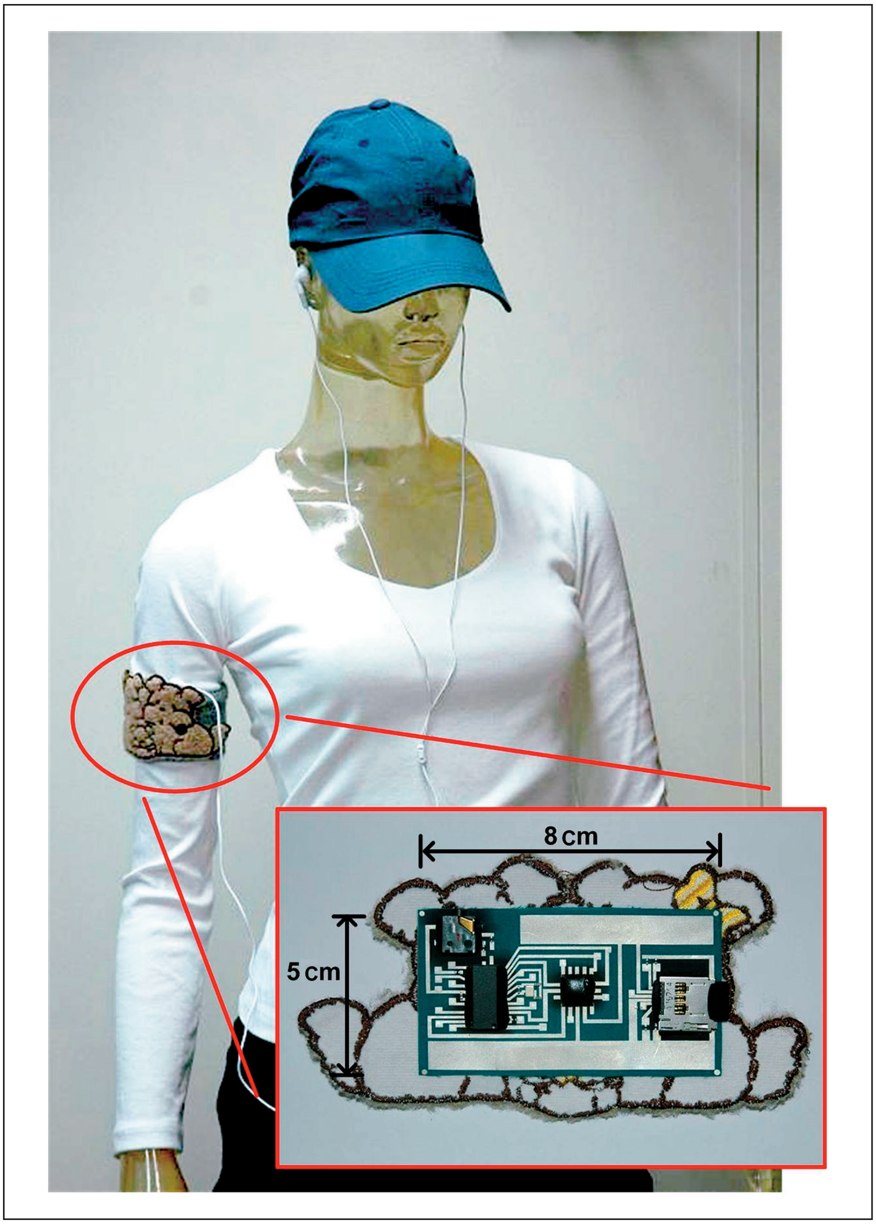

Figure 1. A demonstration of multilayered circuit printing on plain fabric. The application integrates a textile-based MP3 player in an armband.

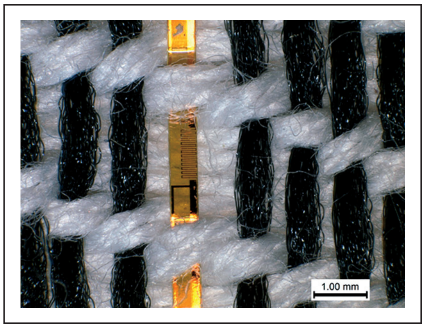

Figure 2. A close-up of a temperature sensor on an e-fiber. The sensors were woven into the fabric using a commercial fabrication process.

tors limb motions in high-risk infants to assist in predicting cerebral palsy. Inspired by the conventional method of a one-hour video observation by an expert, their system aims at spotting the involuntary movements experts use for diagnosis. They studied 10 babies in an intensive care unit wearing an accelerometer sensor on each limb (see Figure 3). Results from the proposed recognition method showed that it can usefully assist the video observer.

Thomas Holleczek and his EHZ Zurich colleagues explored the use of worn GPS and gyroscope sensors to assist snowboarders with their training. The system detects direction and turns, whether the user is riding on the board's front or back side, as well as carving and skidding. Evaluation during real-life experiments on several ski slopes showed the system to be physically robust, with output comparable in reliability to current insole-based systems.

Martin Berchtold and colleagues from the Karlsruhe Institute of Technology described a service-based activity-recognition system for smart phones. The system creates an evolving classification scheme that selects classifier modules on the basis of minimal user feedback. The group has stress-tested the system in terms of feasibility in real-world environments, and an evaluation of its recognition rates reached 97 percent for 10 basic activities with up to three minutes of personalization per activity.

Michael Matscheko and his colleagues at Johannes Kepler University Linz investigated the effectiveness of different placements of vibro-tactile elements embedded in a wrist watch, both in the wristband and on the watch face. An evaluation over 1,823 trials favored embedding the tactors in the wristband.

WEARABLE SENSING

Several papers focused on recognition and sensing techniques that use wearable setups.

Giuseppe Raffa and colleagues from Intel Labs, Santa Clara, and KAIST presented a gesture-recognition study that exploits low-computation algorithms to make such systems feasible on battery-powered wearable devices. Experimental results on movement detection and an early template-matching algorithm on 5,000 gestures plus eight hours of background data showed that the proposed method achieves similar

WEARABLE COMPUTING

Figure 3. Accelerometer-based system to capture cramped-synchronized general movements (CSGMs). An infant in the intensive care unit is wearing four accelerometers to spot characteristic CSGMs for diagnosing cerebral palsy.

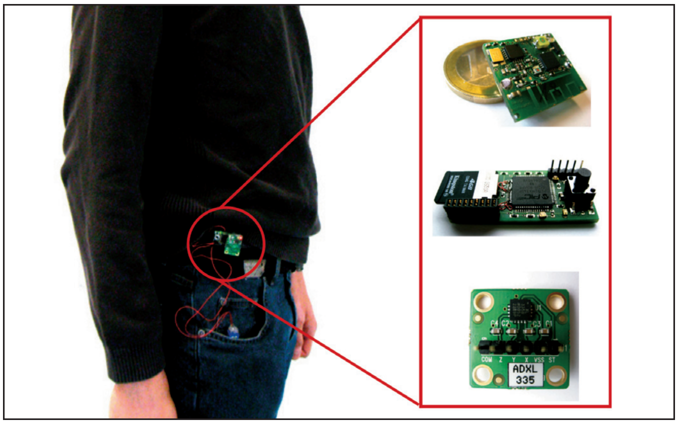

Figure 4. The evaluation setup for a novel low-power microvibration sensor. Deployed in activity-recognition scenarios, the small, inexpensive sensor performed well against a 3D accelerometer.

accuracies to state-of-the-art systems, while considerably decreasing the data transmission and computation requirements.

Ulf Blanke from the Max Planck Institute and Bernt Schiele from the Technical University Darmstadt proposed a method of transferring already-existing activity knowledge to another setting, thereby reducing the need for substantial training efforts. Their study verified that a layered approach to activity recognition, dubbed *partonomy-based*, helps in reusing trained activity events in other scenarios. The method recognized activity events such as sawing, hammering, and drilling and composite activities such as mounting shelves or related activities in two furniture-building scenarios.

Dawud Gordon and colleagues from the Karlsruhe Institute of Technology and the Technical University Braunschweig introduced a promising sensor for activity-recognition systems. They evaluated a small, inexpensive microvibration sensor against a 3D accelerometer in a typical activity-recognition scenario (see Figure 4). The new sensor showed particular sensitivity in frequency regions where accelerometers are less responsive. It improved recognition for especially high-frequency activities at little extra cost.

Stephan Bosch and colleagues from the University of Twente and Inertia Technology, the Netherlands, presented an online method to detect user interactions with objects. The method uses the correlation between motion data from a wrist-worn sensor and data from similar units attached to objects. In an implementation on lightweight wireless sensors, their algorithm showed adequate accuracy and response time in lab tests. In an interactive "hot potato" ball game, the algorithm achieved a realism scenario, confirming good accuracy and showing slight response times (2.5 seconds).

These summaries represent only a small portion of the conference technical papers. The full set, together with the posters, is available through the IEEE Xplore digital library (http://ieeexplore.ieee.org). I encourage your participation in ISWC 2011, which will be in San Francisco. More information is available at www.iswc.net/iswc11.

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