From the Editor in Chief

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IoT: From Sports to Fashion and Everything In-Between

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Pervasive computing and the Internet of Things have widespread impact across fields as seemingly diverse as sports and fashion.

IOT IN SPORTS

It's easy to find IoT in sports, whether you're interested in wearables or objects. I'm sure the vast majority of *Pervasive Computing* readers own—or at least have seen—fitness bracelets such as the FitBit. Less common wearables include clothing such as the Hexoskin smart shirt, which measures your heart rate, heart-rate variability, breathing rate, and breathing volume in addition to your steps and pace (www.hexoskin.com). It can also track your sleep, measuring your heart rate, breathing, and sleep positions throughout the night.

This type of technology extends beyond sports to monitor people working in extreme and high-risk environments, such as firefighters and military personnel. Smart garments can send an alarm, including a location, if a firefighter or soldier is hurt in the line of duty.

Beyond wearables, Adidas now makes a smart soccer ball, called the miCoach smart ball, which has sensors embedded within the ball and retails for US $200. The sensors can detect the speed, spin, strike, and flight path and can send the data back to your smartphone via the miCoach app. The ball is a regulation size 5, and, amazingly, the battery life lasts for approximately 2,000 kicks over the course of a week (www.adidas.com/us/micoach-smart-ball/G83963.html).

IoT is also influencing golf. GolfTEC and K-VEST use sensors and display technology to provide feedback to golfers. The sensors in GolfTEC measure launch angles, spin rates, club speed, and the like (www.golftec.com/about-golftec/technology). Video allows the golfer to observe his or her swing from multiple angles. The K-VEST measures the golfer's hip, shoulder, and hands to provide feedback on body position (www.kandicomergolf.com/technology/k-vest).

We're seeing more and more IoT technology influencing sports. Right now, the focus is on data collection, but I anticipate such data will eventually be used to teach us how to play a new sport and optimize our performance and fitness levels.

IOT IN FASHION

Perhaps more surprising are the inroads that IoT is making into the fashion industry. In the coming years, we can expect our clothing and accessories to come with RFID tags that retailers can use to manage their supply chain and reduce both theft and counterfeiting—examples include Avery Dennison (http://rfid.averydennison.com/en/home/solutions/apparel-and-retail.html) and Evrythng (https://evrythng.com/activate-digital-identities-for-products). In addition, consumers can also use these tags to find lost items and perform other functions, such as

- ensure we don't accidentally throw a hand-wash item into the washing machine or a line-dry item into the dryer,
- search for a duplicate or a new version of the same product, and
- learn fashion tips for how to wear the item or pair it with other clothes and accessories that we already own or could purchase.

I can even envision manufacturers and retailers someday using the tags to learn about the product's "end of life" in my closet, discovering why I'm donating the item or throwing it out. Is it because the item has simply been worn so many times that it has reached its end of life, or has my fashion sense matured? Or did the item shrink even though I followed the laundering instructions? Such data might help companies make manufacturing decisions to improve the quality and durability of their clothing, and retailers could note my modified fashion preferences.

Another application of pervasive technologies in the fashion industry is

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Cisco's StyleMe Virtual Fashion Mirror.[1] This display technology lets consumers virtually try on clothing, create outfits, and view different colors, all without entering a dressing room. The display overlaps the customer's reflection with pictures of clothing so that consumers can see what the outfit might look like on their body. Similarly, Panasonic's makeup mirror lets consumers virtually try on different types of makeup, from false eyelashes to eyeshadow and blush (www.youtube.com/watch?v=JtwVVhvEwU8). Beyond the ability to see how you'd look with various beauty products, the mirror can also teach an inexperienced consumer how and where to apply the various products.

The use of IoT in the fashion industry is in the early days, but I foresee some fascinating applications in the years to come—much beyond the LED-enhanced outfits that we occasionally see stars wearing to gala events.[2]

IN THIS ISSUE

One area that will be important for moving IoT and pervasive computing technology forward is the theme of this issue. Energy harvesting is critically important for certain types of IoT applications in both the sports and fashion domains. Without it, we risk forcing users to recharge the technology too often for usability, reducing long-term adoption.

In addition to our theme articles on energy harvesting, we also have several feature articles. As I mentioned earlier, IoT technology might eventually be used to optimize fitness levels, and along those lines, our first feature article is "Fitness Applications for Home-Based Training," by Iman Khaghani-Far, Svetlana Nikitina, Marcos Báez, Ekaterina A. Taran, and Fabio Casati. In this article, the authors survey fitness applications across a variety of platforms, including smartphone platforms (Android and iOS), desktop platforms (Windows and Mac), and console platforms (Nintendo and Xbox), looking explicitly at support for older adults who are frequently more isolated and less active and for whom exercising at home is an appealing option compared to traveling to a gym. The authors look at four design dimensions: interaction mechanisms, monitoring and sensing capabilities, coaching and tailoring features, and persuasion and motivation strategies.

In our second feature article, Suining He, Bo Ji, and S.-H. Gary Chan from The Hong Kong University of Science and Technology present "Chameleon: Survey-Free Updating of a Fingerprint Database for Indoor Localization." He, Ji, and Chan strive to make it easy to keep fingerprint databases up-to-date in spite of updated access points (APs). They make the observation that unaltered APs cluster a user's location whereas altered APs tend to disperse the user's location. With this observation, they can use the unaltered APs to localize the user and use the location to update the fingerprint database of the altered APs. They study this approach both on their university campus and in a major airport. If their results can be replicated, this approach could have major implications for the maintenance of indoor fingerprint databases.

Our third feature article, "Emerging Trust Implications of Data-Rich Systems," by Bran Knowles, identifies the challenges in building users' perception of trust in pervasive systems. In the article, Knowles uses a hypothetical fitness application, called the Fangle-Bangle, to illustrate the concepts. The six challenges identified include how such systems let users verify the data collected, how the data chains of these systems are mapped and presented to users, and how users can be given insight into the underlying algorithms without overwhelming them with technology. Understanding and addressing these components to trust is critical to the long-term acceptance and, consequently, the ultimate success of pervasive computing technologies.

On a related note, in our Pervasive Health department, Kelly Caine discusses the many ways we inadvertently give away private health data in

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EDITORIAL BOARD CHANGES

First, I'm pleased to announce that board member Robin Kravets will be taking on the role of Associate Editor in Chief. I look forward to her contributions, especially given her expertise in the areas of mobile computing and communications.

I'd also like to introduce two new board members, Florian Michahelles and Daqing Zhang.

Florian Michahelles heads the Web of Things research group at Siemens Corporate Technology. The Web of Things team borrows methods from the Semantic Web and investigates how machines, devices, and sensors can communicate and share data based on ontologies and semantics without requiring prior defined communication standards. The research group is being formed in Berkeley by international researchers who collaborate with leading US universities in industry-funded and publicly funded projects. Michahelles received his PhD from the Swiss Federal Institute of Technology (ETH) Zurich. Contact him at florian.michahelles@siemens.com.

Daqing Zhang is a Chair Professor at the School of EECS, Peking University, China and Vice Chair of the Pervasive Computing Federation of China. His research interests include context-aware computing, mobile computing, big data analytics, and pervasive elderly care. Zhang obtained his PhD from the University of Rome "La Sapienza." He is the associate editor for *ACM Transactions on Intelligent Systems and Technology* and *IEEE Transactions on Big Data*. Contact him at dqzhang@sei.pku.edu.cn.

her article "Privacy Is Healthy." She discusses the limitations of the Health Insurance Portability and Accountability Act, especially as it relates to non-clinical data collected by fitness-tracking apps and health-monitoring systems. She gives recommendations for actions that users and developers can take to improve their own and their users' privacy. This call to action is critically important for developers: if users misunderstand the privacy implications of the applications they use and discover that the health information they thought was private has been released, our industry will face a major crisis in terms of consumer trust, and adoption of our applications will greatly suffer.

In our Smartphones department, Yu-Chih Tung and Kang G. Shin present "ForcePhone: Software Lets Smartphones Sense Touch Force." This work describes a mechanism by which smartphones that don't have the force-sensing hardware (that is, all Android phones and lower-end Apple phones) can use software-based force-sensing. The idea behind this technology is to make it easier to use your phone one-handed. As someone who has been temporarily one-handed due to a broken shoulder, the idea is very appealing. The biggest issue I had, though, was in aiming and snapping photos—a use case that was, unfortunately, not included in their user study.

In this issue's Conferences department, Mateusz Mikusz, Sarah Clinch, and Sougata Sen provide an overview of MobiSys, which was held this past June in Singapore, and ASSET, the first Asian Students Symposium on Emerging Technologies. MobiSys included 31 papers and two impressive keynotes and covered topics ranging from smart environments, to sensing, to location awareness, to security and privacy. This year's best paper award went to Endri Bregu and his colleagues for their paper, entitled "Reactive Control of Autonomous Drones," about a new way of controlling drones, such that sensor readings only trigger controlling components if the sensor values have changed. If you were unable to attend the conference this year, I encourage you to read through the summary. It will make you aware of the many papers relevant to this community and will help you identify those of most interest to you.

Finally, our Notes from the Community department covers everything from interactive light to Pokémon Go. Of particular interest was the discussion of Project Jacquard, an effort between Google and Levi's to create a jacket for urban cyclists who want to interact with their phones while cycling. Multitouch sensors woven into the cuff of the jacket let the cyclists answer or place calls and use navigation apps.

The breadth of our field is amazing. The fact that pervasive and IoT technologies can be applied in such diverse areas as fashion and sports helps illustrate that fact. Someone once accused me of thinking that fashion and sports are the same field. In fact, I might be guilty of that—at least when you consider the use of IoT technology within these fields. One could argue that the cycling jacket proves my point.

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