Sample Articles

Research on ARM TrustZone
Wenhao Li, Yebin Xia, Haibo Chen

ARM TrustZone is a hardware-based security feature that can provide software with a high-privilege and isolated execution environment. Such isolation is ensured by hardware, which is usually considered more trustworthy than software. Thus the execution environment is also known as trusted execution environment (TEE). TrustZone technology was proposed in 2002, but did not get widely used until 2009, when Apple released iPhone 5. In iPhone 5e, Apple leveraged TrustZone to protect its Touch ID, which ensures that even if the IC is fully compromised, the user’s fingerprint data can still be safe. In 2017, Google made TEE a mandatory requirement on any Android devices with a fingerprint scanner.

Nowadays, almost all mobile phones and tablets have TEE deployed. Meanwhile, ARM integrates TrustZone in ARMv8.1 and ARMv8R-M to support a broader range of platforms including servers and IoT devices.

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HappyFeet: Challenges in Building an Automated Dance Recognition and Assessment Tool
Abu Zahir Md Faridde, Sreenivasan Ramasamy Ramamurthy, Nimalya Roy

In this paper, we discuss our experience in building an automated dance assessment tool with BU and IoT devices and highlight the major challenges of such an endeavor. In a typical dance classroom scenario, where the students frequently outnumber their instructors, such a system can add immense value to both parties by providing systematic breakdowns of the dance moves, comparing the dance moves between the students and the instructors, and pinpointing the places for improvement in an autonomous way. Along that direction, our prototypical work, HappyFeet [1], showcases our initial attempts of developing such an Intelligent Dance Activity Recognition (DAR) system. Our CNN-based Body Sensor Network proves more effective (by ~7% margin at 94.20%) at accurately recognizing the micro-steps of the dance activities than traditional feature engineering approaches. These metrics are derived by purposely evaluating the setup on a dance form known for its gentle, smooth and subtle limb movements. In this paper, we articulate how our proposed DAR framework will be generalizable for diverse dance styles involving very pronounced movements, human body kinematics and energy profiles.

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Molecular Communication: Interconnecting Tiny NanoBio Devices
Nariman Farsad

Recent advances in the field of bioengineering and nanotechnology have resulted in the emergence of tiny devices that can communicate with each other at the molecular level. This field, known as molecular communication, has the potential to revolutionize the way we think about information transfer in biological systems.

Rethinking Evaluations of mHealth Systems for Behavior Change
Predrag Klasnja, Eric B. Hekler

Much of the recent research in mobile health (mHealth) has focused on the development of apps and wearables for promoting healthy behaviors. However, there is a need to reevaluate the effectiveness of these systems in changing individual behavior. This paper discusses some of the challenges and opportunities in rethinking the evaluation of mHealth systems.
sub-millimeter and even micron or less dimensions that can perform sensing and actuation. In many cases, the main challenge in moving these devices out of the laboratory and into the real world is not production cost as they can be produced cost-effectively in large volumes, but rather a communication problem. For many applications, these tiny devices need to communicate and collaborate in swarms, or they need to transmit their measurements to other devices. Inspired by nature, chemical signaling (also known as molecular communication) is an effective solution to this problem. This article explores some of the recent advancements and challenges in molecular communication systems.

behavior changes, such as losing weight, increasing physical activity, or adhering to a medication regimen. These interactive systems help users make changes in their behavior by, for instance, tracking health-related activities and states, providing feedback, helping users set and track goals, and facilitating supportive social interactions. We refer to the features that implement such functionality as the system's "intervention components," as they are designed to actuate psychosocial mechanisms (e.g., modeling, self-efficacy, positive reinforcement, etc.) thought to mediate the behavior change process. As with any other type of behavioral intervention, mHHealth systems are only effective for some users and some of the time, but insofar as they do work, they do so mainly through the mechanisms of change that are activated via users' interactions with the system's intervention components.

Sample Articles

WHEN MIXED REALITY MEETS INTERNET OF THINGS: Toward the Realization of Ubiquitous Mixed Reality
Tahwoon Park, MI Zhang, Younghi Lee
From panoramic paintings and stereoscopic photos in the early 19th century, there has been a century-long effort to realize mixed reality, interweaving real and virtual worlds that interact with each other. Recently, over the past few years, we have witnessed the first wave of "affordable" mixed reality platforms, such as Oculus Rift and Microsoft Hololens hitting the market. In particular, 2017 was the showcase year of mixed reality technologies. The Academy awarded its first Oscar to virtual reality storytelling.1 AAA caliber virtual reality games started to hit the market with impact.2 Furthermore, major mobile operating systems, including Android and iOS, began to support augmented reality at the platform level (e.g., Android ARCore, Apple ARKit). Looking down the road, a recent forecast by Orbis Research projects over $40 billion mixed reality market worldwide by 2023.

INTERDISCIPLINARY TEACHING STRATEGIES for Designing and Building Effective Smartphone Applications
Carla Viviana Coleman Cordova, Nilanjan Banerjee
Working together, we’ve created an interdisciplinary project that teaches both designers and developers the life cycle and project management of mobile application development. Working with professional clients, visual arts and computer science students, we used teamwork to tackle real-world projects with deadlines, milestones, and budget constraints. Throughout the semester, students from the Advanced Interface Design and Mobile Programming classes collaborated to apply their design and programming experience to develop smartphone applications for clients. This paper presents the insights gathered from teaching this interdisciplinary course.

Sample Articles

IoT Platform for Sports Analytics
Mahanth Gowda, Ashutosh Dheke, Sheng Shen, Romit Roy Choudhury, Sharon Xue Yang, Lei Yang, Suresh Golwalkar, Alexander Eskin

2017 SIGMOBILE Outstanding Contributions Award: Norman Abramson
Citation: Fundamental contributions to the theory and practice of random access wireless networking.
This paper is an experience report on IoT platforms for sports analytics. In our prior work, we proposed iBall, a system that explores the possibility of bringing IoT to sports analytics, particularly in the game of Cricket. iBall develops solutions to track a ball’s 3D trajectory and spin with inexpensive sensors and radios embedded in the ball. Towards this end, iBall performs fusion of wireless and inertial sensory data and integrates them into physics-based motion models of a ball in flight. The median ball location error is at 8cm while rotational error remains below 12° even at the end of the flight. The results do not rely on training; hence we expect the core techniques to extend to other sports like baseball, with some domain-specific modifications.
farmer. Yet building such a system is very challenging due to sparse Internet connectivity and lack of reliable power sources. This is further exacerbated by weather variability that stresses the system in numerous ways. We discuss how we built and deployed Farmbeats in the face of these challenges. We hope our experiences will aid researchers who are beginning to explore deployments in farming or other weakly connected, power-starved scenarios, such as construction, oil fields, mining, and others.

Sample Articles

**Bringing Home Baby**
Iqbal Mohomed

Now that mobile phones are a ubiquitous computing medium, we are seeing a stream of connected (and sometimes intelligent) devices. It's interesting to consider whether these so-called "smart" devices can help new parents and caregivers of young children. In this article, some problem areas that might be quite simple are considered — except that the technology solution must be both childproof and accurate enough to entrust the health and safety of your precious cherub. AT CES 2017, a slew of products were introduced that attempted to do exactly that, to help measure parents in some way.

**An Elevator Pitch on Deep Learning**
Yuan-Ting Hu, Alexander G. Schwing

Machine learning improves all aspects of our life and very few days pass where we don't interact with a machine learning driven application. For example, we may use fitness trackers that monitor the quality of our sleep. Before leaving to work, we may check the weather forecast. To get to work, we use a navigation system that predicts the fastest route to our first meeting. On the road, we use voice commands to interact with our phone. Web searches and e-commerce recommendations are based on machine learning. Cameras detect faces when we take a picture and our email inboxes are protected by spam filters, which are designed using machine learning tools.

Sample Articles

**10 Years of Networking Women**
Katia Jaffres-Rusner, Sami Rollins, Tracy Camp, Wendi Heinzelman

Networking Networking Women (N²Women) celebrated its 10-year anniversary at the fifth N²Women Workshop co-located with MobiCom 2016. Founded in 2006 by Tracy Camp and Wendi Heinzelman, N²Women is a discipline-specific community for researchers in the communications and networking field. The main goal of N²Women is to foster connections among the underrepresented women in computer networking and related research fields. N²Women allows women to connect with other women who share the same research interests, who attend the same conferences, who face the same career hurdles, and who share common career objectives.

**Mobile Systems Research with Drones**
Luca Mottola, Kamin Whitehouse

Robot vehicle platforms, often called "drones," offer exciting new opportunities for mobile computing. While many systems respond to device mobility (such as smartphones), drones allow computer systems to actively control device location, allowing them to interact with the physical world in new ways and with newfound scale, efficiency, or precision.
Approximate Computing: Unlocking Efficiency with Hardware-Software Co-Design
Luis Ceze and Adrian Sampson

Generations of computer scientists and practitioners have worked under the assumption that computers will keep improving themselves; just wait a few years and Moore’s Law will solve your scaling problems. This reliable march of electrical-engineering progress has sparked revolutions in the ways humans use computers and interact with the world and each other. But growth in computing power has protected outdated abstractions and encouraged layering even more abstractions, whatever the cost.

The Once and Future Internet of Everything
David E. Culler

I am often asked these days, “Is IoT really as transformative as all the buzz suggests, or is it a lot of hype?” My answer is simply, “Yes.” And the road to here has been a fascinating interplay of academic research accomplishments, industry advances (often with other drivers), and standardization processes (for lack of a better term). It was predictable that today we would be poised for the “next tier” of the Internet to take off, but the endgame seems to be even messier than expected.

Sample Articles

Controlled Studies Outside of the Lab
Khai Truong

Often, evaluators study a computing system inside a laboratory setting to best gain an understanding of the effect of the system when different factors are manipulated. The laboratory setting allows evaluators to create not only the environment, but also the scenario in which a user study of system is conducted. Thus, the laboratory setting allows evaluators to control possible confounding variables and to develop insight about the cause-and-effect of the system when they manipulate specific usage factors. For example, it is clear that people often use mobile devices while walking. Thus, a laboratory study can be designed to test how well users might be able to interact with a mobile device while walking on a treadmill machine. Such a study, because it is conducted in a laboratory setting, would allow the evaluators to control the speed at which study participants would walk while using a mobile device, without fearing that participants must also pay attention to traffic or could be distracted otherwise.

Prototyping Capacitive Sensing Applications with OpenCapSense
Tobias Grosse-Puppendahl, Andreas Braun, Xavier Dellangeli

OpenCapSense is a prototyping platform to develop innovative applications that rely on perceiving humans with electric fields. Despite today’s use of capacitive sensing mostly as a method to detect touch, it offers many interesting facets that range from mid-air interaction to contactless indoor localization and identification. The platform provides active sensors to detect human interactions at distances of more than 60 cm, by generating electric fields. Passive sensors allow for measuring changes in electric fields that occur naturally in the environment, enabling detection distances up to 2 m.
MOBILE SENSING: Retrospectives and Trends
Margaret Martonosi
It is difficult to think back to a time before smartphones existed, with their ubiquitous computing and communication capabilities, and with detailed, location sensing easily available from Global Positioning Systems (GPS). In the late 1990s, when my research group began work on mobile sensing, smartphones had not yet been invented. While GPS did exist, GPS receivers were expensive, power hungry and not widely available. Our first mobile computing project started as a power efficiency study for a GPS-based interactive campus tour. GPS-based tour applications are familiar now, but were unheard of then, and the physical implementation was a challenge. We used a Palm Pilot PDA (personal digital assistant) connected to an external GPS receiver and an external Wi-Fi card. In those days, PDAs had neither GPS nor any wireless communication capability! Given the bulkiness of the various pieces of our "app," we carried them and their batteries around in a shoebox. Since both the GPS and the radio were quite high power (over 1W), they greatly impacted the system's battery life. Our power efficiency work explored methods to locally cache maps on the PDA, and to power down modules when not in use.

Battery-Free Connected Machine Vision with WISP-Cam
Saman Naderiparizi, Zerina Kapetanovic, Joshua R. Smith
Sustained exponential improvements in the energy efficiency of microelectronics has recently enabled us to build battery-free camera systems that are powered entirely by propagating radio waves. This paper describes primitive machine vision applications built using this highly constrained, battery-free camera system. After describing the WISP-Cam system and its constraints, we show how to use it to capture (relatively) high-resolution images of faces, without ever capturing a full frame at high resolution. This example application illustrates the issues that arise in partitioning a demanding vision application across mobile hardware that is highly constrained in power, storage, computation and communication.

A Great Time for Makers
Prabal Dutta and Iqbal Mohamed
The last few months have been especially exciting for the DIY and Maker scene. We have witnessed a wave of equipment that used to cost tens of thousands of dollars but has now become more affordable. In this column, we do a whirlwind tour of the categories that excite us the most.

Why and How to Use Phelonlab
Jinghao Shi, Edwin Santos, and Geoffrey Challen
While smartphone app marketplaces have enabled large-scale app-level experimentation, medium-scale experimentation with the platform code implementing the app interface and providing core device services remains difficult for academic researchers. But this is where many of the ideas currently being explored by the mobile systems community must be evaluated—including new networking protocols, security and privacy mechanisms, storage abstractions, and energy management strategies. To enable these experiments, we built and are operating PhoneLab, a 175-smartphone testbed where real users run experimental Android platform builds on their primary devices. We are eager to make PhoneLab useful to the mobile systems community. To aid in this effort, this article discusses why PhoneLab might be...
useful for your research and provides an overview of how to use the textfield, including examples drawn from our group's current projects.

**Sample Articles**

**Battery Fundamentals**

*Anthony Ferrise*

The use of batteries as a portable power source has gained tremendous importance for powering mobile devices and for enabling greener and less energy-intensive transportation. Whether the demand is for a smart phone, laptop, tablet or the next wearable, the consumer demands a thinner and lighter battery while maintaining or increasing battery life at the lowest possible cost. This demand has caused many companies to increasingly consider the battery and its performance when designing their next device. While, in the past, it may have been acceptable to take an “off-the-shelf” battery that meets specifications and “plug it in”, many companies are starting to implement “smart” designs that take into account specific battery chemistries and characteristics to improve overall performance. This requires a knowledge of how a battery works. With this in mind, this article gives an explanation of battery fundamentals, why batteries degrade over their life, what limits their performance, the trade-offs between high power and high energy, and current efforts to build a better battery. While many of the overall properties are similar for many battery chemistries, here we will focus on the lithium-ion battery, specifically the cobalt oxide/graphite lithium-ion battery, one of the most popular battery chemistries for mobile devices.

**Hiding Secrets in Plain Sight**

*Landon Cox*

**Sample Articles**

**Astrobiology App for Kids:**

*Software as a Cognitive Prosthesis for Conceptualization of Astronomical Theories*

*Ana C. Calderon, Catherine Tryfonas, Cai Smith*

It is well known that children have difficulty conceptualizing astronomical concepts, such as gravity (Schoultz et al., 2001). We argue that a solution to this is to create effective and efficient prosthetics for aiding in their thinking and visualization, and exemplify this with an app that introduces astrology to children. The app was designed to be a hybrid between a game-like learning app and an

**Deployment Study Length: How Long Should a System Be Evaluated in the Wild?**

*Khai Truong, Julie Kientz, Nilanjana Banerjee, A. J. Brush, Ratul Mahajan*

There are many different ways to evaluate a novel interactive system. However, placing that system into the hands of real users and allowing them to use it as they would like in their natural environments may arguably be the best approach to understand if it "really" works. This is because findings learned from user studies conducted in the lab or a controlled setting are limited in external validity and therefore might not generalize
encyclopedic app. Similar difficulties arise in teaching mathematics to children (see for instance, Trouche, 2003). We predict that our app might have usage not only in children’s astronomical education, but could also be used by people of all ages wishing to familiarize themselves with astrology, in an introductory manner.

Lab of Things in Education
Ajoydand Samuel, Dean Mohamedally, Nilanjan Banerjee, A. J. Brush, Ratul Mahajan

Lately, much has been said about the Internet of Things and how it is going to change how we will live, work and play. Gartner forecasts that by 2020, every person on the planet will carry four connected devices. The majority of this growth will be driven by the interconnection of devices, sensors, smart objects and the like, and is expected to usher in changes to almost all aspects of our lives. This change will require, on the one hand, large-scale design, development and deployment of cloud and network systems; and on the other hand, design of hardware sensors, actuators, software middleware, and network protocols.

Scikit-learn: Machine Learning Without Learning the Machinery
G. Varoquaux, L. Buitinck, G. Louppe, O. Grisel, F. Pedregosa, A. Mueller

Machine learning is a pervasive development at the intersection of statistics and computer science. While it can benefit many data-related applications, the technical nature of the research literature and the corresponding algorithms slows down its adoption. Scikit-learn is an open-source software project that aims at making machine learning accessible to all, whether it be in academia or in industry. It benefits from the general-purpose Python language, which is both broadly adopted in the scientific world, and supported by a thriving ecosystem of contributors. Here we give a quick introduction to scikit-learn as well as to machine learning basics.

A Brief History of Cloud Offload
A Personal Journey from Odyssey Through Cyber Foraging to Cloudlets
Mahadev Sayanarayanan

Every time you use a voice command on your smartphone, you are benefiting from a technique called cloud offload. Your speech is captured by a microphone, pre-processed, then sent over a wireless network to a cloud service that converts speech to text. The result is then forwarded to another cloud service or sent back to your mobile device, depending on the application. Speech recognition and many other resource intensive mobile services require cloud offload. Otherwise, the service would be too slow and drain too much of your battery.

Democratizing Computing with App Inventor
David Wolber, Harold Abelson, Mark Friedman

MIT App Inventor is a visual blocks language that enables beginners and non-programmers to create apps for their phones and tablets. It has empowered thousands to create software with real-world usefulness, and see themselves as creators rather than only consumers in the mobile computing environment. Educationally, it offers a “gateway drug” that can help broaden and diversify participation in computing education.