Introduction to the Special Articles in This Issue

Artificial Intelligence on Mobile Devices

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■ *This issue of AI Magazine contains several guest-edited articles devoted to some exemplary works of AI on mobile devices. It includes four works that range from mobile activity recognition and air-quality detection to machine translation and image compression*

In the film *2001: A Space Odyssey,* a bulky computer system known as HAL captivated a generation of people with the concept of artificial intelligence (AI) and intelligent machines. Today, as the world moves into one in which everyone owns at least one mobile device, be it a smartphone, a tablet, or other handheld device, applications on the devices are increasingly more intelligent as well. Estimates put the global revenue for mobile apps at $150 billion dollars,[1] and mobile speech-recognition platforms will grow 68 percent through 2017 through cloud-based solutions, according to ABI Research.[2] We will see more and more applications of AI on the mobile devices.

This special issue of *AI Magazine* is devoted to some exemplary works of AI on mobile devices. We include four works that range from mobile activity recognition and air-quality detection to machine translation and image compression. These works were chosen from a variety of sources, including the International Joint Conference on Artificial Intelligence 2011 Special Track on Integrated and Embedded AI Systems, held in Barcelona, Spain, in July 2011.

In "User-Centric Indoor Air-Quality Monitoring on Mobile Devices," written by Yifei Jiang, Kun Li, Ricardo Piedrahita, Yun Xiang, Lei Tian, Omkar Mansata, Qin Lv, Robert P. Dick, Michael Hannigan, and Li Shang, the authors develop a novel and important technique for portable indoor air quality (IAQ) detection. They present their system MAQS, which uses a mobile-phone-based indoor location tracking system to determine the whereabouts of users. MAQS uses air-quality sensing devices to report on the quality measurements for an individual or a group of people in real time. This system demonstrates an integrated ability to locate users based on Wi-Fi signals and to apply an air-exchange-rate-based IAQ method using CO_2 sensors and a zone-based proximity detection method for pulling the data from different sensors and phones together. The MAQS system in particular tackles the important issue of energy savings by allowing the different devices to share information.

In "Speaking Louder than Words with Pictures Across Languages," Andrew Finch, Wei Song, Kumiko Tanaka-Ishii, and Eiichiro Sumita explore an iPad-based system for cross-language communication using pictures. Their system allows users of one language to express their thoughts in a sequence of picture icons, based on which they generate natural language in the native languages of the users of the system for verification of the user's intention. Then, the system can translate the user's sentences to another language based on the meaning of the picture icons, completing the machine-translation process. This second channel of communication makes the machine-translation result more robust. In addition, as the authors claim, the process of pointing and tapping on icons is a natural way of inputting on mobile devices. They implemented their idea in a system known as picoTrans, which is able to predict the user's intended expression from the icon sequence most of the time. This system not only shows the possibility of machine translation on mobile devices, but also points at a new way of natural interaction between users and mobile devices.

In "Thinking Fast and Slow: An Approach to Energy-Efficient Human Activity Recognition on Mobile Devices," Yifei Jiang, Du Li, and Qin Lv propose a two-phase approach to activity recognition for trip detection using a mobile phone. The two-phase approach applies a well-known theory in psychology of human decision making, which leads to a deliberation-intuition architecture to balance accuracy and energy efficiency. Focusing on trip detection, the deliberation phase uses sensors that provide information such as GPS and Wi-Fi data in a cell-ID-based learning system, and the intuition phase relies on the cell ID patterns to predict the start and end of a trip. The system was tested on real-life mobile phone data over a long period of time, showing a large amount of energy savings and high accuracy and timeliness in intuitive trip detection.

In the final article, "Learning Compact Visual Descriptors for Low Bit Rate Mobile Landmark Search," Ling-Yu Duan, Jie Chen, Rongrong Ji, Tiejun Huang, and Wen Gao consider a very important problem of mobile-based systems: how to transmit large images using low-bit mobile-based image search. The method that they employ is clever: once a mobile user enters a region, the server transmits a downstream supervision to "teach" the mobile device by linearly projecting the original high-dimensional image into a compact code book. Then, users' queries based on a high-dimensional code-word histogram can be converted to a compact histogram, which is transmitted for search and query.

The four articles in this special issue represent a cross section of work in the increasingly popular area of AI on mobile devices. We can see that the AI systems on mobile phones must consider a number of new issues and constraints, including limited energy resources, constrained communication bandwidth, relatively small display area, and emphasis on user interaction models. In addition, it is necessary to consider a number of other issues for AI systems on mobile phones, such as geographical information, location techniques, user studies, and computer-human interaction.

Notes

1. See Strategy Analytics (www.strategyanalytics.com).

2. See ABI Research (www.abiresearch.com).

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Feng Zhao is an assistant managing director at Microsoft Research Asia, where he oversees multiple research areas including hardware computing, mobile and sensing, software analytics, systems, and wireless and networking. His own research has focused on networked embedded systems such as sensor networks, energy and resource management of distributed systems as in data centers and cloud computing, and mobile devices and mobility. He has also done work on parallel computing, fast *N*-body algorithms, machine recognition, and diagnostics. Prior to Microsoft Research Asia, Zhao was a principal researcher at Microsoft Research Redmond, where he founded and managed the Networked Embedded Computing Group. The group has developed the MSR sensor mote, tiny Web Service, SenseWeb and SensorMap, Data Center Genome, JouleMeter, and GAMPS data compression. With the help of some of these technologies, today the Microsoft data centers are among the most densely instrumented and monitored cloud computing infrastructures in the world. Zhao received his Ph.D. in electrical engineering and computer science from MIT, has taught at Stanford University and Ohio State University, and currently also serves as an affiliate faculty member at the University of Washington and an adjunct professor at Hong Kong University of Science and Technology. Zhao was a principal scientist at Xerox PARC and founded PARC's research effort in sensor networks and distributed diagnostics. He served as the founding editor-in-chief of *ACM Transactions on Sensor Networks*. An IEEE Fellow and ACM Distinguished Engineer, he received a Sloan Research Fellowship and NSF and ONR Young Investigator Awards.