Smart Spaces

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With the advent of the Internet of Things (IoT) as a major force of change in industry and the rise of wearable computing for consumers, the time is right for revisiting the notion of a smart space.

Physical spaces are packed with opportunities, complexities, and of course, people. Many business and social opportunities are missed, and complexities can highly degrade people's experiences in these spaces. Pervasive computing has yet to be widely exploited in physical spaces in the same way that the ubiquitous Web and smartphones have been exploited—effectively revolutionizing the way we interact with others, work, and conduct our daily lives.

The Challenges

There are many challenges and open research questions facing smart spaces today. How can the design and construction of smart spaces overcome the fragmented devices and sensors markets? How can we use architectures, middleware, and programming models to program smart spaces dynamically, effectively, opportunistically, and safely? How can a smart space coexist seamlessly with the ubiquitous Web by offering a Web of its own to users and visitors within its boundaries? How can we enable a service view of smart spaces, turning today's spaces, which mainly provide Wi-Fi services, into providers of a much richer portfolio of space-specific impromptu services? How can users interact with smart spaces intuitively, effectively, and ubiquitously (through wearables, smartphones, public displays, or multiple devices)?

Several research projects have addressed specific physical spaces and their relevant applications, each focusing on achieving specific goals (for instance, physical or cognitive assistance to different population groups, including children,[1] the elderly,[2,3] or individuals with special needs[4]). However, despite such efforts, smart spaces still aren't common today. We don't yet have smart malls, schools, homes, or cities.

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Several enablers and ecosystem elements seem to be missing, preventing or slowing proliferation.

In This Issue

The first article in this special issue, "Edge Analytics in the Internet of Things," by Mahadev Satyanarayanan and his colleagues, considers a powerful technique, called *edge analytics*, for enhancing the IoT and enabling localized data processing with cloudlets. Cloudlets that combine mobile and cloud computing are new abstractions that offer a flexible building block for the creation of IoT and smart-space services. The presented example connects various Internet cameras through the system and runs computer vision analytics in personal and localized virtual machines for privacy-aware feature detection. Thus cloudlets alleviate scalability and privacy concerns by providing computational capability at the edge of the network close to the IoT devices.

The second article, "A Tabletop-Centric Smart Space for Emergency Response," by Jie Liu, Yongqiang Qin, Qiang Yang, Chun Yu, and Yuanchun Shi, considers a very important application domain for smart spaces—namely, enabling seamless user interaction in emergency response scenarios. They present findings based on a simulated forest fire emergency in which the system provides a real-time and interactive situational awareness of the event. They report encouraging results regarding team performance using the smart space compared to a control group.

The next article is "A Smart Environment for Children with Autism," by Monica Tentori, Lizbeth Escobedo, and Gabriela Balderas. They design and pilot-test smart-space technology for supporting the therapy of children with autism. This work considers augmented reality for supporting cognition, displays for encouraging positive behaviors, and exercise games for improving motor development. The article describes a gradual deployment of the smart-space technology in a school clinic, providing valuable insight into the possibilities of smart-space technology for supporting therapy. They observe that a smart space can provide sustained empirical measurement and iterative development, and they highlight the benefits of the technology for therapeutic and educational use.

A final article is "A Smart Fiber Floor for Indoor Target Localization," by Guodong Feng, Yuebin Yang, Xuemei Guo, and Guoli Wang. They use a carpet-embedded fiber sensor to sense pressure and construct a floor-pressure-distribution map for user localization. They describe a prototype whose design goals are to minimize the number of fiber sensors and achieve accurate and precise localization performance.

In addition to these articles, we also have two related departments. This issue's Spotlight department, "The Mirror World: Preparing for Mixed-Reality Living," by Alessandro Ricci, Michele Piunti, Luca Tummolini, and Cristiano Castelfranchi, presents a vision of smart spaces enriched by conjoining the physical world with a mirror world. The latter is a virtual, augmented world consisting of software agents representing objects and users in the physical world, in addition to its own virtual objects that can have an "augmented reality" presence in the physical world.

The final contribution is the Education and Training department, "Studying Smart Spaces Using an 'Embiquitous' Computing Analogy," by Corey A. Grave, Timothy P. Negrón, Michael Chestnut II, and Gabriel Popoola. The column reports on a four-year experience in teaching pervasive computing systems by drawing an analogy from established methods and tools used in teaching embedded computing.

We thank the authors for their contributions and hope that you enjoy reading this special issue.

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