Transformative Computing and Communication

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Transformative computing is a new paradigm that stems from the confluence of wireless networking, artificial intelligence, and sensing devices. This combination of computing and communication technologies enhances everyday computational experiences. The four case studies in this special issue explore this new model.

Remarkable advances in wireless networking, artificial intelligence (AI), and sensing devices are causing a seismic shift. We are observing the emergence of a brand-new paradigm, transformative computing. We define this paradigm as the opportunistic cross-fertilization of computing and communication technologies, leveraging existing infrastructures and natural signals to uncover novel, compelling, and sometimes unexpected ways to redefine our everyday computational experiences.

For instance, computational models can faithfully explain minute human behaviors and vital signs by analyzing ambient wireless signals. Sensory models can automatically construct an indoor map by deciphering the motion signatures of smartphones. Representative learning models with acoustics and motion signals that were obtained from a pair of earbuds can meaningfully interpret an individual's facial expressions, emotions, and mental health. Bleeding-edge signal processing can encode and transmit digital information by using natural light.

Naturally, this new paradigm is creating interminable possibilities. It is opening doors for technologies and systems to augment our awareness, cognition, and intelligence; improve our health; and help us experience physical and digital reality in radically different ways.

IN THIS ISSUE

In this special issue, we, together with the feature authors, bring forward four research case studies that offer illuminating views of this new transformative computing paradigm. Two of the articles project our readers into the future of wireless networks, explaining their metamorphosis to accommodate human sensing in its first principle. The remaining two articles take a computational stance, offering detailed insights into the role of edge and mobile computing in reimagining edge devices to analyze and augment human behavior.

In "Future Millimeter-Wave Indoor Systems: A Blueprint for Joint Communication and Sensing," Alloulah and Huang present a compelling vision of a millimeter-wave system purposefully designed for unified communication and sensing. The authors discuss and quantify a variety of system-level challenges such as resource management, processing complexities, and signal inference for this dual-function network while contextualizing these challenges in useful applications, such as building analytics.

In a complementary article, "On the Use of Stray Wireless Signals for Sensing: A Look Beyond 5G for the Next Generation of Industry," Savazzi et al. demonstrate the transformation of omnipresent radio-frequency (RF) stray radiation into a dense web of RF images to explain an environment. Their systematic and data-driven exploration

offers a detailed view of learning algorithms with stray wireless signals for modeling body-induced artifacts and associated challenges. Based on the incredible amount of attention focused on industrial Internet of Things applications, we expect this timely contribution to shape related research on wireless sensing to explain human dynamics.

In our third article, "Augmenting Cognition Through Edge Computing," Satyanarayanan and Davies take us on a journey to the future of being human in a sensory world that showcases a remarkable application of human cognition augmentation. The authors demystify the technical building blocks required to realize this class of edge-native application experience, essentially drawing a blueprint of a transformative technology with the confluence of lightweight wearables and edge AI.

Finally, in "Predicting Personality Traits From Physical Activity Intensity," Gao et al. revisit the rich body of behavior analytics work with sensory mobile and wearable devices. By borrowing and fusing principles from activity recognition and social computing literature, they reconfirm the power of mobile sensing in explaining human behavior and, in this case, human personality.

We optimistically look forward to a sensory world of the future, enabled by remarkably intelligent transformative
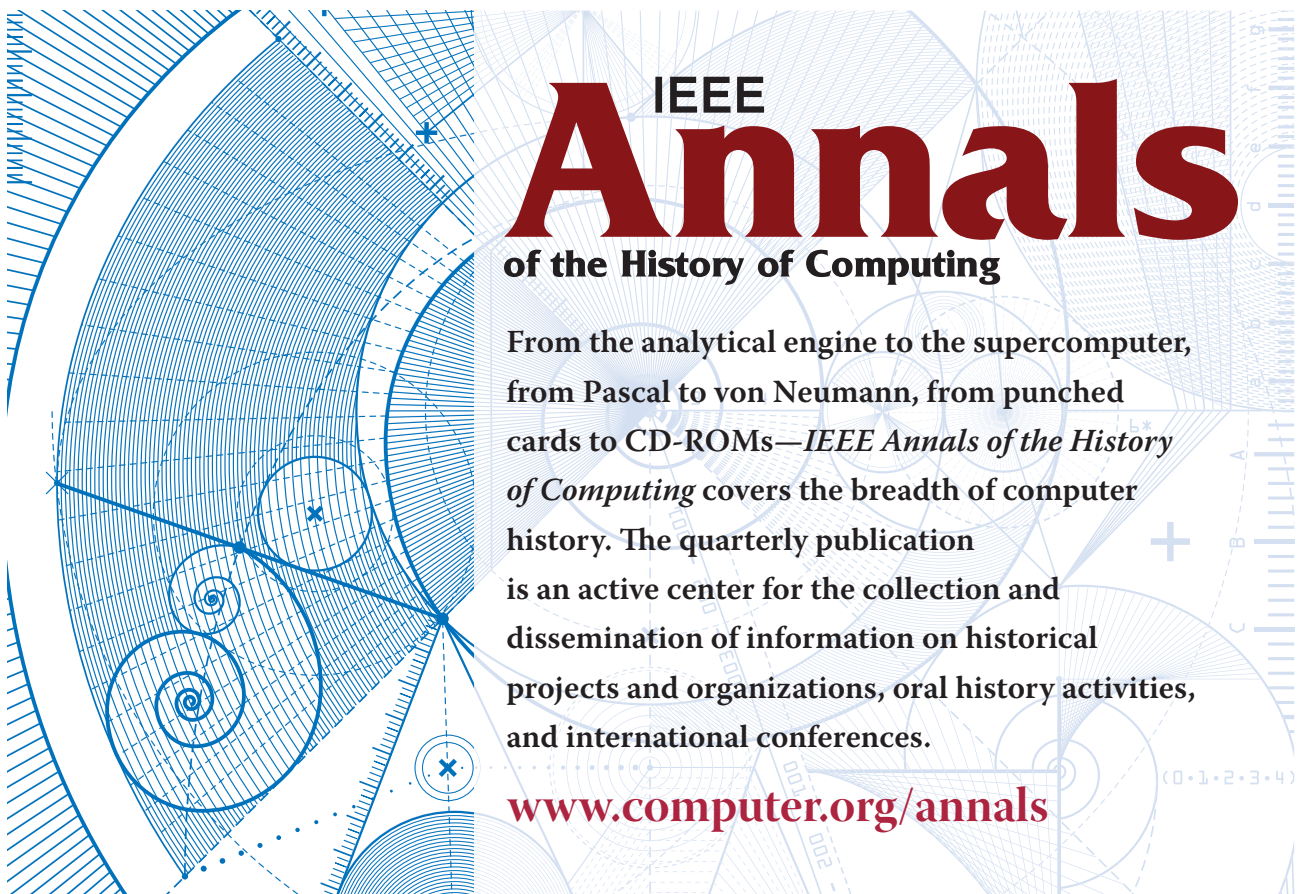
technologies that can understand us and help us to become better versions of ourselves. These four articles shed some light in that direction as well as coalescing a set agenda for transformative computing research. We hope that future research on this space will provide solutions for many, if not all, of the unresolved concerns.

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