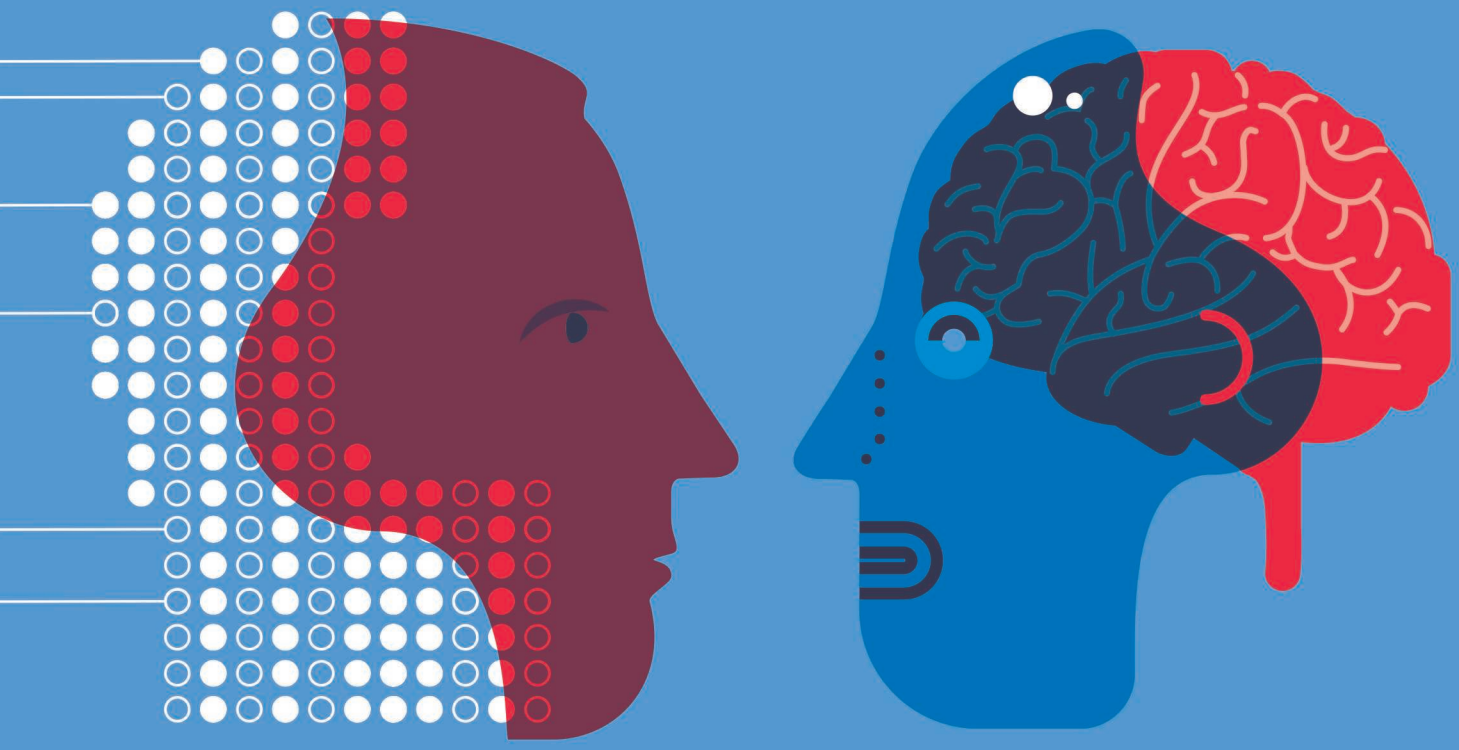

Hybrid Human-Artificial Intelligence

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Humans want machines to be intelligent, with the machines serving them as much as possible. Yet they are concerned that these machines with full autonomy may one day outperform them and become too powerful to be controlled. The blend of desire and fear has led to this emerging futuristic research area, hybrid human–artificial intelligence.

Recent advances in increased computation power enabled by cloud computing; coupled with emerging machine learning and statistical methods; in addition to the availability of big data generated by the Internet of Things, mobile devices, and social networks have led to both a significant leap in the need and progress of artificial intelligence (AI) technologies and applications. AI techniques have shown huge potential, as demonstrated in the AlphaGo competition. Some AI applications have reached industrial standards and offer real-world deployment opportunities, such as face recognition–based security checks or ticketless boarding. No doubt, AI will increasingly enable machines to respond to even more complicated situations and handle complex problems, such as precision medicine, intelligent transport, and smart cities, to name but a few. It is expected that AI will become the driving engine for the future economy and society. Nevertheless, there are two compelling issues from both technical and ethical perspectives relating to the foreseen AI-enabled industrial innovation and intelligent world that remain unsolved.

On the technical side, although powerful learning algorithms are now able to extract and establish models and patterns from large-scale data sets, where the machines perform better than humans, there are problems relating to explainability and interpretability due to the opaque nature of some learning algorithms. In addition, there is a gap from the knowledge learned, that is, models and patterns, to problem solving, namely, the capabilities of reasoning and inference against application business logic for decision support or application-specific functions. Existing AI techniques are still struggling with reasoning and cognitive inference, an area in which humans significantly outperform machines. As such, it remains a challenge for AI to be used as daily technologies and a driver for economic development. On the ethical side, the vision that AI-enabled machines may one day replace humans, and the significant progress made in the last several years, brings growing concerns that AI may overtake human intelligence or, in the worst situation, spiral out of control to destroy human society. For example, it is difficult to imagine what would happen if autonomous drones or self-driving cars could make decisions by themselves and if they can learn and evolve by themselves. This is not just fiction or assumption; it has now become reality.

Clearly, human intelligence and AI each have their own strengths and weaknesses. Machines are effective and efficient for discovering implicit knowledge or hidden patterns from large-scale data, whereas humans are good at conducting cognitive analysis, that is, reasoning, inference, and making instinct judgments by taking into consideration dynamic and multiple factors. These machines do not have to be competitive, mutually exclusive, or one dominating/replacing another. One way to address the above concerns is to marry the strengths and mitigate the weaknesses of human intelligence and AI, making them work in collaboration and cooperation. This has led to the conception and inception of the latest research endeavor, termed *hybrid human-AI* (*H-AI*). H-AI is dedicated to investigating models, methods, technologies, and systems that enable and support the synergy, symbiosis, and augmentation of human intelligence and AI. This provides a promising approach to technical and ethical challenges; humans and machines can each focus on what they are good at, meanwhile, humans still largely control decision making.

The intent of this theme issue of *Computer* is to draw the attention of relevant communities to this emerging and promising research area and provide a forum to disseminate the latest views and research results relating to the theories and practice of H-AI. The articles in this issue are targeted to scientists, researchers, technology innovators, industrial experts, and application developers in the H-AI–related fields aiming to inspire and stimulate relevant research and technology development and help guide and forge research communities for future H-AI research.

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ABOUT THIS ISSUE

The article "A Research Agenda for Hybrid Intelligence: Augmenting Human Intellect With Collaborative, Adaptive, Responsible, and Explainable Artificial Intelligence," by Akata et al., argues that hybrid intelligence is an important new research focus for the field of AI, and it further proposes a research agenda to address the four challenges of realizing hybrid intelligence. For each of these challenges, the article surveys the state of the art, identifies research gaps, elaborates research approaches, and points out future research directions.

"Interactive Artificial Intelligence: Designing for the "Two Black Boxes" Problem," by Wenskovitch and North, presents a symmetric, collaborative H-AI model using semantic interaction as a design philosophy to connect human and machine. The model is based on the notion of a "two black boxes" problem, namely the black box learning algorithms and the black box cognitive process of a user. The article discusses challenges associated with the two-way communication between the pair of cooperatively learning entities and the benefits that emerge from combining the expertise of the human and the AI.

In "Multiple-Input, Multilayer-Perception-Based Classification of Traces From Side-Channel Attacks," Feng et al. discuss a multiple-input, multilayer perceptron-based method for the classification of power traces in which a probability is assigned to each class, indicating the likelihood that each trace corresponds with the label (that is, the S-box output) for further recovering the key. The method can handle ghost peaks and reduce the number of power traces needed in the process of analyzing the key used by cryptographic modules. Initial experiment results have shown that the proposed method outperforms other state-of-the-art side-channel techniques in terms of effectiveness and efficiency.

In the article "BeeMe: Real-Time Internet Control of Situated Human Agents," Pescetelli et al. introduce the online platform BeeMe for Internet collective action and problem solving in open-ended environments. BeeMe allows a scalable Internet crowd to collectively control the actions of a human avatar acting in physical space in quasi real time. It develops heuristic algorithms that read in users' conversations and output human actionable commands representing majority preferences. In a test case of thousands of individuals collectively solving a sci-fi

Internet mystery, BeeMe demonstrates near-human performance in interpreting the democratic consensus and is less prone to favoring nonrepresentative views.

"Exploring a Humanoid Video-Understanding Algorithm Guided by Behavior," by Hu et al., presents a multitask hybrid 2D/3D convolution network incorporating human behavior that makes the video description language consistent with people's understanding of a video. The method uses the Cauchy distribution to enhance the correlation of each frame and a human behavior classification subtask to assist in performing the video description task. The study establishes a "communication" bridge between the visual field and the language field, making use of human wisdom to facilitate video understanding.

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