Introduction to the special issue on computational modelling of emotion

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Celso de Melo, Dean Petters, Joel Parthemore, David Moffatt, and Christian Becker-Asano

EMOTIONS play a pervasive role in personal, social, and professional life. As artificially intelligent systems become pervasive in our lives, it is important that these systems are able to understand emotion in humans and simulate the function of emotion to be effective in their interactions with people. Computational models of emotion contribute towards this goal by, on the one hand, serving as a means to test emotion theories and help understand the function of emotion and, on the other, as the end in itself by simulating appropriate emotion and its downstream consequences – such as expressions of emotion – in computational agents. This special issue presents a critical overview of this cross-disciplinary field, with contributions from some of the leading scholars in cognitive psychology and affective computing, focusing both on theory and practice.

In the first article, Klaus Scherer summarizes the requirements for a computational model of emotion drawing on prevalent emotion theories, in particular, appraisal theories. Scherer emphasizes the necessity of modeling all components of emotion – cognitive appraisal, physiological responses, action tendencies, and expressive behavior – and the dynamic properties of emotion as it unfolds in time. Ruth Aylett and colleagues, in the second article, build on their comprehensive computational model – FAtiMA – that implements many of these requirements. In their article, they look at emotion expressions as social signals, emphasizing that expressive behavior is not a mere reflection of internal state but often is modified based on social context – e.g. suppressing emotion when an unwelcome birthday present is received. They advocate for and integrate a theory-of-mind component into their computational model.

Historically, affective computing has tended to focus on theory-driven models, such as FAtiMA, to model emotion; however, recent times have seen increasing success of data-driven deep learning models in other fields of artificial intelligence (a point Scherer also makes). Desmond Ong and colleagues, in the third article, propose a practical solution for integrating theory- and data-driven models: probabilistic programming. They begin by reviewing recent work using Bayesian modeling that capture intuitive theories relating situations, mental states (e.g., appraisals), and emotion. They note some of the limitations with the Bayesian approach (e.g., representing dynamic aspects of emotion), and propose probabilistic programming languages as a solution for these specific limitations and, more broadly, for modular computational models of emotion. Finally, they summarize a useful collection of tools and existent technology that support probabilistic programming and integration with modern machine learning frameworks.

To build the kind of general-purpose artificial intelligence that succeeds in dynamic domains, it is insufficient to have a computational model of emotion; integration with broader models of the agent's sense-think-act cycle is needed. To accomplish this, we can draw inspiration from research in cognitive psychology that seeks to build general models of the human mind. In this tradition, in the fourth article, Christopher Dancy builds on Panksepp's empathy model to propose a cognitive model integrating affect with lower-level physiology (e.g., hunger and thirst) and higher-level cognition (e.g., the effects of stress on memory). In complementary fashion, in the fifth article, Amir Moye and Marieke van Vugt propose a cognitive model for focused attention and meditation that can serve as the basis for a more general model of emotion regulation. Methodologically, both articles build on extensions of the ACT-R unified cognitive framework – ACT-R/Φ and Prims, respectively – which is well-established in cognitive psychology but may be less familiar to affective computing researchers.

The last two articles focus on one important and representative domain: human-robot interaction. The last decade has seen growing interest in robots that are able to navigate complex social environments – e.g., elderly care – which require a certain level of emotional sophistication. Lola Cañamero, in the sixth article, surveys research on models of emotion in robots, organizing this literature according to the underlying theoretical framework and the focus on general emotion principles. Finally, in the seventh article, Joost Broekens and Mohamed Chetouani address the important challenge of increasing transparency in robots. Researchers tend to agree that successful adoption of artificially intelligent systems require users to be able to understand and trust the actions performed by the system. Broekens and Chetouani propose using appropriate emotion expression to increase the transparency of a reinforcement learning robot by virtue of exposing the internal state of the algorithms through the expressions (e.g., surprise when an unexpected transition occurs).

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