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Synthesis and Taxonomy of Human Computation

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Abstract This chapter seeks to characterize the conceptual space of human computation by defining key terminology within an evolving taxonomy.

Introduction

Human Computation is an emerging, multidisciplinary field spanning communities. Broadly, it refers to human participation in computational systems and the information and capabilities that arise from that. Beyond this general definition, however, there is a tendency for multiple and sometimes conflicting perspectives, as well as confusion. Therefore, this chapter seeks to characterize the conceptual space of human computation by defining key terminology within an evolving taxonomy.

Previous efforts have sought to flesh out the conceptual space of human computation (Law & Von Ahn, 2011) and related terminology (Quinn & Bederson, 2011). The present effort seeks to update this body of work in the context of new research and broader multidisciplinary context.

Key Concepts

Two key concepts are described here that provide a context for interpreting and understanding the definitions that follow.

Goals and intentionality

Human computation (HC) systems are purposeful. They are driven by outcomes that derive from individual behavior, such as enjoyment from playing a game (see Celino; Ghosh; Sanfilippo et al., all this volume) or payment for completing a task (see Chandler et al., this volume). They are also driven by outcomes that derive from collective behavior or interactions, such as the advancement of science that results from citizen science projects (see Lintott, this volume). Furthermore, the locus of intentionality in human computation systems may be individual or collective. For example, an individual may launch a crowdsourcing campaign to satisfy a personal objective. Or a system's behavior may be driven by goals that are defined collaboratively by system participants.

Two related ideas emerge from this conceptual framing: emergent HC and engineered HC. Emergent HC refers to systems in which collective behavior is a natural consequence of individual behaviors; and may help inform a deeper understanding of individual behaviors in the context of system dynamics. Engineered HC refers to the notion of overtly creating a context in which the interaction of individuals within will give rise to desired systemic behavior. Though the emergent/engineered dichotomy is being introduced in this volume, the underlying concept is relevant both to understanding the scope of human computation and the relatedness of the terms that follow. Estrada and Lawhead (this volume) introduce the related concepts of natural, stable, and disruptive human computation, which also seem to be useful concepts for further partitioning the space of HC systems.

Computation = information processing

The relationship between computation and information processing has been a subject of some controversy. These terms have been differentiated on the basis of historical usage in theoretical contexts (see Piccinini & Scarantino, 2010). However, the construal of computation as being equivalent to information processing seems to best fit the practical context of human computation.

In HC, "computation" refers not just to numerical calculations or the implementation of an algorithm. It refers more generally to *information cessing*. This definition intentionally embraces the broader spectrum of "computational" contributions that can be made by humans, including creativity, intuition, symbolic and logical reasoning, abstraction, pattern recognition, and other forms of cognitive processing. As computers themselves have become more capable over the years due to advances in AI and machine learning techniques, we have broadened the definition of computation to accommodate those capabilities. Now, as we extend the notion of computing systems to include human agents, we similarly extend the notion of computation to include a broader and more complex set of capabilities.

It is this sense of computation that is intended in the definitions that follow.

Key Terminology

This chapter seeks to define key terms, which have been selected on the basis of prevalence in the book and broad usage across sub-disciplines. These definitions derive from prior work, lively collegial discourse, and the application of basic inference to a growing set of related concepts. It goes without saying that the meaning of terms evolves through usage. For maximal relevance herein, current popular usage *as applied to the study and practice of human computation* exerts considerable bias on these definitions. For this reason, you may discover that in some cases canonical meanings have been deprecated. Given the diversity of the community, context-based usages, and dynamic nature of the conceptual space in a rapidly growing field, it is unlikely that this set of definitions will meet with unilateral agreement. However, this chapter seeks to represent the most common views and, in certain cases, multiple views when there are divergent semantic tracks. For brevity of exposition, we do not belabor etymology, but instead seek to provide the reader with an accessible point of reference.

Glossary

Term	Definition
Collective Action	Human computation in which individual behaviors contribute to a collective product that benefits all members of the collective (see Novak, this volume).
Collective Intelligence	A group's ability to solve problems and the process by which this occurs.
Crowdsourcing	The distribution of tasks to a large group of individuals via a flexible open call, in which individuals work at their own pace until the task is completed (see Chandler, this volume).
Distributed Cognition / Collective Cognition	"The use of information technologies to make distributed information processing by humans much more powerful, focused and efficient" (see Heylighen, this volume).

Distributed Intelligence	The problem-solving capacity of distributed cognitive systems (see Heylighen, this volume).
Distributed Problem Solving	The application of massively distributed cognitive systems to solving problems (see Greene & Thomas, this volume).
Distributed Thinking	The effective distribution and coordination of information processing tasks among human computational agents informed by cognitive architecture (see Blumberg, this volume).
Human Computation / Distributed Human Computation	1. The design and analysis of multi-agent information processing systems in which humans participate as computational elements. 2. The subset of systems theory in which the systems are composed of machines and humans connected by communications networks.
Organismic Computing	Augmented human collaboration characterized by shared sensing, collective reasoning, and coordinated action (see Michelucci, this volume).
Participatory Sensing	The human-use of sensor-enhanced devices for spatially distributed data collection, enabled by pervasive computing (see Lathia, this volume).
Social Computing	Information processing that occurs as a consequence of human social interaction, usually assumed to occur in an online medium. Note: there is some debate in the field about how to classify systems in which behavior relies upon social knowledge or judgment but does not involve social interaction among participants.
Social Informatics / Social Network Analysis	The use of big data to understand social behavior (see Lerman, this volume); in Social Network Analysis the "big data" is presumed to originate from behavioral data derived from technology-mediated social systems.

Superorganism	1. Individual organisms functioning together to support the objectives of the collective (see Pavlic & Pratt, this volume). 2. "A collection of agents which can act in concert to produce phenomena governed by the collective" (Kelly, 1994)

Conclusion

This synthesis of key concepts in human computation is a snapshot. It is expected that the usage of these terms and related concepts will evolve with the discipline. Thus, this glossary should be revisited and refined by the community as necessary to best support fluid communication and broad comprehension across sub-disciplines.

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