INVITED TALK: AN OUTLOOK FOR SELF-AWARENESS IN COMPUTING SYSTEMS

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Talk summary

Novel computing systems are increasingly being composed of large numbers of heterogeneous components, each with potentially different goals or local perspectives, and connected in networks which change over time. Such future computing systems, from robots to personal music devices to web services, should be able to achieve advanced levels of autonomous behaviour, in order to adapt themselves at run-time and learn behaviours appropriate to changing conditions. Nevertheless, users engaging with different parts of the system still expect high performance, reliability, security and other qualities. Such systems will therefore be faced with the challenge of managing trade-offs between these conflicting goals at run-time, both at the global and at the local level, in response to changing conditions, and sometimes with humans in the loop.

In order for a system to effectively adapt itself, its ability to be self-aware becomes important. Self-awareness is concerned with the availability, collection and representation of knowledge about something, by that something. A self-aware node has knowledge of itself, permitting reasoning and intelligent decision making to support effective, autonomous adaptive behaviour. Such self-information might include its internal state, its history, its social or physical environment, its goals, or perhaps even its own way of representing or reasoning about these things.

There are several clusters of research in computer science and engineering which have used the term self-awareness explicitly. However, there is no general methodology or common framework for describing or benchmarking the self-awareness capabilities of these systems, or the benefits that self-awareness brings. In this talk, I shall survey definitions and current understanding of self-awareness in psychology, focussing on three key concepts: public and private self-awareness, different levels of self-awareness, and the emergence of self-awareness in collective systems. I will then attempt to translate these concepts from psychology to the computing domain, and show how their explicit consideration may be beneficial in the engineering of adaptive computing systems. Based on this understanding, I shall present a working definition for self-aware computing systems, with the aim of providing common ground for future discussions.

I will then describe some prospects for realising an increased capacity for self-awareness in computing systems, and what will be required in order to achieve the increased adaptivity and robustness that the vision promises. Online learning is expected to play a key role, as will techniques for decision-making in the presence of multiple objectives, representative of the conflicting goals of adaptive nodes in dynamic heterogeneous environments.

Finally, I will describe some challenges which need to be faced in both developing and applying self-aware systems. For example, how should self-aware systems learn and adapt to changing conditions at run-time, considering trade-offs both between system goals and the overheads associated with learning itself? Another critical question is that of how to formulate claims about what we can expect from self-aware systems, when deployed in uncertain and dynamic environments. As should become clear, there is still much to understand about how to incorporate self-awareness properties into computing systems.

About the speaker

Peter Lewis is a post-doctoral research fellow at the Centre of Excellence for Research in Computational Intelligence and Applications (Cercia) in the School of Computer Science at the University of Birmingham. His research is concerned with investigating algorithms and techniques for achieving self-awareness and self-expression in decentralized computational systems. Particular focuses include economics-inspired computational techniques and online learning algorithms, such as those using evolutionary computation and other nature-inspired techniques. He obtained his PhD from the University of Birmingham in 2010, on the topic of evolutionary market-based resource allocation in decentralised computational systems.