The relevance of emergent models in application-driven research

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Application-driven models of cognition

Typically, models of cognition serve the study of cognition itself. McClelland (2009) put it rather succinctly when he argued that we should think of models as "tools for exploring the implications of ideas" (p 12), even though they are necessarily simplifications of the real thing. Thill (2012) discussed the additional challenges posed for embodied paradigms of cognition in this respect: sensorimotor aspects are both thought to fundamentally shape higher cognition, yet are also often the first to be severely simplified in simulated or robotic models, affecting the degree to which these models can still be explanatory of *human* cognition. However, Thill (2012) also notes that explanation of human cognitive phenomena is not the only reason for existence for these models of (possibly human or human-like) cognition instantiated in artificial agents and that another reason is chiefly *application-driven*: with the increasing prevalence of physical artificial agents in all aspects of everyday life, they may simply be necessary for these agents to fulfil their purpose. In contrast with McClelland's take on the utility of models, these models do not need to possess any explanatory power; appropriate behaviour according to specification, no matter how biologically implausible the underlying mechanisms, is sufficient.

It is therefore interesting to reflect on the relevance of *emergent* models of cognition in a context in which the required behaviour is defined and driven by a specific application and the primary mechanistic purpose of a model is to ensure these requirements are satisfied. We argue, using the example case of RET (Robot-Enhanced Therapy) for illustration, that there is a useful place for emergent models in an application-driven world despite the apparent contradiction in that the behaviour of the system has to be both emergent and specified a priori.

Emergent models in application-driven research

Consider the use of (partially autonomous) cognitive humanoid robots in therapeutic interventions with children who have autism spectrum disorder (see Thill et al., 2012, for a review and perspective). Such interventions exercise, for instance, joint attention, imitation, and turn taking. Although strongly scripted, successful therapy depends on the robot adapting to the child's behaviour and engaging in a behaviour of its own that fosters continued interaction. That is, the robot has to anticipate the child's behaviour and act effectively in the ensuing interaction to fulfil the application-driven requirement of promoting robot-child engagement in the face of uncertainty in interaction. It must therefore be able to successfully predict outcomes of actions (thereby managing or reducing uncertainty) while maintaining interaction with the child. This is the essence of cognition and herein lies the key reason for the use of emergent cognitive systems in application-driven scenarios: even though the fact that all required behaviours are pre-defined by the application may suggest a pre-defined axiomatic model of cognition, it is not possible to specify the use-case scenarios to the extent such an approach would require. Emergent models however, allow behaviour to arise *without having to define it functionally in axiomatic terms*.

The catch is the following: An agent's emergent behaviour is not controlled directly but modulated by the value systems shaped by objective functions, creating a challenge for the deployment of emergent systems in pre-defined applications. The research problem is therefore to (a) identify a value system that satisfies the conditions of emergence and facilitates application-compatible agent-environment interaction, and (b) cast the corresponding objective function in *quantitative* form so that it can be used to modulate the robot behaviour. This problem has received relatively little attention so far due to the somewhat recent resurgence of application-driven research.

To address it, we propose that artificial agents with emergent cognitive abilities should be considered as forming an eco-system with the environment in which they are deployed, much in line with situated views of human cognition. Consequently, the objective function should be cast in terms of the interaction with this environment. That the application constrains the emergent behaviour is then helpful since it requires the researcher to be very explicit about the desired interactions (again, without having to define them functionally), thus reducing the space in which the appropriate objective function can be found. Returning to the example of RET, a value system reflecting the need to maintain appropriate interactions with the child (allowing the system to increase its predictive capacity and tolerance to uncertainty) facilitates the emergence of interactive behaviours that also satisfy the application requirements, i.e. keeping the child engaged.

In sum, this illustrates a symbiotic benefit between emergent systems and given application niches: the former are necessary to deal with the inherent uncertainty in deploying artificial systems to, for instance, interact with humans while the latter facilitate the clear specification of an objective function that in turn facilitates the emergence of desired behaviour.

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References

McClelland, J.L. (2009) The Place of Modeling in Cognitive Science. *Topics in Cognitive Science,* 1, pp.11 - 38.

Thill, S. (2012) Why model cognitive mechanisms in embodied cognitive science? *Workshop on models and mechanisms: special focus on cognitive science*, Tilburg, NL, Dec 6—7

Thill S., Pop C.A., Belpaeme T., Ziemke T. and Vanderborght B. (2012) Robot-assisted therapy for autism spectrum disorders with (partially) autonomous control: challenges and outlook. *Paladyn J. Behav. Robot.,* 3(4), pp.209 – 217