The New Computationalism – A Lesson from Embodied Agents

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Abstract. Computationalism is traditionally considered in the context of cognitive science as perhaps the dominant contemporary approach to understand cognition and cognitive phenomena. It consists in application of concepts and methods of theoretical computer science for understanding and (re)constructing phenomena appearing in much broader fields of science, including the natural sciences and also economics, and some other branches of social sciences. The contribution sketches this new situation, and provides an example of a theoretical model rooted in the traditional computationalism which reflects some new requirements.

1 Introduction

In the context of cognitive science, computationalism is traditionally considered as perhaps the dominant contemporary approach to understand cognition and cognitive phenomena. In present days computationalism plays a crucial role not only in cognitive science, but also in the field of cognitive psychology, artificial intelligence and also in an important part of advanced cognitive robotics.

According to [6] (p. 71) the central doctrine of the traditional computationalism considered as the basic paradigm for the study of cognition consists in the view that cognition is essentially a matter of the computations that a cognitive system performs in certain situations. In this context, computation is considered as the activity performable by Turing machine, so as computation in the Turing sense generally accepted in the field of theoretical computer science. Computationalists also maintain that neural computations are Turing-computable, that is, computable by Turing machines, which means that all of the connectionism present in cognitive science becomes a part of the traditional computationalism.

Having at hand the collection of notions and results formulated and discovered during the 50 years of the existence of theoretical computer science research based...
crucially on the concept of the Turing machine proposed in [18] we are trying to explain the nature of phenomena of (human) intelligence (usual esp. in artificial intelligence and in advanced robotics) at the level which provides the real base for engineering (re)production of it. The crucial hypothesis accepted almost generally as a base for such considerations is the Church-Turing hypothesis which says, roughly speaking, that a function is computable, in the intuitive sense, if and only if it is Turing-computable [2, 18].

2 A Slump in the Traditional Computationalism?

However, it is possible to treat computationalism in more general context. In this broader meaning, computationalism consists in a conceptual framework originated and formulated in theoretical computer science to understand some aspects of (re)construction (some fragments of) phenomena appearing in broader fields of science as those related to cognition and mind. As parts of these fields we recognize (some branches of) natural sciences, like biology, chemistry, physics, astronomy, also some subfield of economy, some branches of social sciences and arts (e.g. some sub-area of the field of new media, computer art, robotic art, etc.). As the present day state-of-the-art in science and engineering signalizes, both the traditional computationalism and the connectionism have some problems how to react to many new situation appearing in some fields of science and engineering.

Let us emphasize R. Brooks' appeal formulated during his plenary talk for the 8th International Conference on Artificial Life (Sydney, Australia, December 11, 2002) which focused the attention on a need of a new understanding of computing and computability, in other words to reconsider the actual form of computationalism and push our understanding of computation closer to the present-day requirements. Earlier, in Nature (p. 410), R. Brooks wrote:

We have become very good at modeling fluids, materials, planetary dynamics, nuclear explosions and all manner of physical systems. Put some parameters into the program, let it crank, and outcome accurate predictions of the physical character of modeled system. But we are not good at modeling living systems, at small or large scales. Something is wrong. What is wrong?

There are a number of possibilities: (1) we might just be getting a few parameters wrong; (2) we might be building models that are below some complexity threshold; (3) perhaps it is still a lack of computing power; and (4) we might be missing something fundamental and currently unimaginable in our models of biology.

The important and general lesson from the fields like artificial intelligence, advanced robotics, artificial life and cognitive science is, that the Turing machine universality as a mathematical concept which states that all kinds of computers are equally good devices for performing computational tasks, might be misleading in situations, when we consider machines embedded in their real physical environments.