On the Full Organism Challenge: Or, Can we Computerize an Elephant?

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Abstract

We show how techniques from computer science and software engineering can be applied beneficially to research in the life sciences. I will discuss the idea of comprehensive and realistic modeling of biological systems, where we try to understand and analyze an entire system in detail, utilizing in the modeling effort all that is known about it. I will address the motivation for such modeling and the philosophy underlying the techniques for carrying it out, as well as the crucial question of when such models are to be deemed valid, or complete. The examples will be from among the biological modeling efforts my group has been involved in: T cell development, lymph node behavior, organogenesis of the pancreas, rat whisking, cancer tumor formation, and various projects regarding the C. elegans nematode. The ultimate long-term "grand challenge" is to produce an interactive, dynamic, computerized model of an entire multi-cellular organism, such as the C. elegans, which is extremely complex despite its small size, but well-defined in terms of anatomy and genetics. The sweeping potential benefits of such a model will be discussed.

ACM Classification
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Keywords
Biological modeling; full organism challenge; *C. elegans*; Statecharts.

Short Bio

Prof. David Harel has been at the Weizmann Institute of Science in Israel since 1980. He was Department Head from 1989 to 1995, and was Dean of the Faculty of Mathematics and Computer Science between 1998 and 2004. He was also co-founder of I-Logix, Inc. He received his PhD from MIT in 1978, and has spent time at IBM Yorktown Heights, and sabbaticals at Carnegie-Mellon, Cornell, and the University of Edinburgh. In the past he worked mainly in theoretical computer science (logic, computability, automata, database theory), and he now works mainly on software and systems engineering and on modeling biological systems. He is the inventor of Statecharts and co-inventor of live sequence charts (LSCs) and behavioral programming. He co-designed Statemate, Rhapsody, the Play-Engine and PlayGo.

Among his books are "Algorithmics: The Spirit of Computing" and "Computers Ltd.: What They Really Can't Do", and his awards include the ACM Karlstrom Outstanding Educator Award (1992), the Israel Prize (2004), the ACM Software System Award (2007), the Emet Prize (2010), and five honorary degrees. He is a Fellow of ACM, IEEE and AAAS, a member of the Academia Europaea and the Israel Academy of Sciences, and a foreign member of the US National Academy of Engineering and the American Academy of Arts and Sciences.

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