Towards a Computational Theory of Everything
(Position Statement)

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Abstract. Is there any common algorithmic principle behind the evolution of the universe, of life, of the mind? Should the currently prevailing computational paradigms which are limited by the Church–Turing thesis be revised in favor of more powerful ones? Can real systems exist whose computational power is provably greater than that of Turing machines? Is there a computational theory of everything? These are provocative questions that should be on the agenda of computer science for the next decade.

The universe gave birth to life, life developed the intelligence, and man constructed computers. Can this sequence be reversed? Can it be closed into an endless circle? Can a computer be intelligent? Can life emerge and exist within computers? Can man create a universe?

By the beginning of the 20th century it was not even possible to formulate questions as those above. Nowadays these questions, and similar ones, are becoming central topics in artificial intelligence and fundamental sciences such as physics, biology, mathematics, psychology, etc. In the intersection of the respective efforts there is the youngest of all fundamental sciences — computer science. At the present time, theoretical computer science is about to attack the respective problems by making use of its own tools and methods. Already now does it seem to possess the necessary knowledge and results that indicate at least partial answers to the questions at hand. The key to all answers lies in the very notion of computing.

What is computing? What entities can compute? How do we recognize that something computes, that something is 'computationally driven'? Where are the limits of computing?

Of course, computers can compute. Can people compute? Can the brain compute? There seems to be a tremendous difference between what brains and computers compute. Is this a principal difference caused by some so-far-unknown-to-us computational mechanism? Or is it merely a matter of efficiency? Or perhaps a matter of a different computational scenario? Or one of a different computational task that we cannot specify? Can the brain compute in a sense 'more'

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than computers? The brain can be conscious; it can think. Can a computer be conscious as well? Can it have emotions? Can it think? Is there a continuum of minds? What does the respective hierarchy look like? Is thinking an algorithmic process? Can we explain the emergence of mind, of the consciousness, of thinking, of language acquisition and generation in algorithmic terms? Can we understand understanding?

To the best of our current knowledge, the answer seems to be positive. The necessary ingredient in algorithmic modeling of the previously mentioned cognitive tasks includes learning via endless, and in a sense purposeful, interaction with the environment. What kind of mysterious self-organizing, self-checking learning algorithm lies behind the mind evolution? What is the corresponding computational model? Is it a mere neural net? A robotic body equipped with senses and driven by a neural net? Should we go to quantum phenomena when looking for an answer? What about biocomputers? Will they replicate themselves? Will they be alive then, in some sense? Will they be conscious? To what extent?

On a larger scale, one can ask: can nature compute? Does nature compute? Is evolution of life also a computational process? Where is its origin? What are the underlying algorithmic principles? Where are its computational limitations? Does the unpredictable, non-algorithmic nature of interaction among the evolutionary systems lead to surpassing the Church-Turing barrier? Again: what are the right computational models to capture the essence of the evolution? Are genetic algorithms the answer? Is there a single computational paradigm behind all that? Is the Internet an evolutionary system? Can we 'program' it in a way that will give rise to some artificial intelligence in it? Can an autonomous (software) agent emerge in the respective virtual environment and exist in it? Will such or similar form of virtual life keep developing ad infinitum? Will also the intelligence of such an agent grow above any limits?

Finally, on a still larger scale: the case of the Universe. Can we computationally model the genesis of the Universe? Out of what initial information? Are all these wonderful machines such as cellular automata, genetic algorithms, quantum computers, neural networks, biocomputers, internets, etc., indeed the right means to model what we are after? Are the known computational resources such as randomness, non-uniformity, fuzziness, quantum choice, interaction, really needed and/or sufficient to explain all phenomena of information exchange, forming and transformation? How faithful should our modeling be in order to capture all the necessary details? Where will the border be between the simulating system and the system to be simulated? Will then life emerge in our virtual universe? Will there eventually be some intelligence? And will it ask the same questions as we did at the beginning of our essay? Would its principal philosophical question be like this: "What was sooner: information, or the Universe?", or: "Is there a computational theory of everything?"

Today, at the doorstep to the third millennium, the issues mentioned above may sound to us as fantastically as would the questions from the beginning of this paper to men of science some 50 years ago. Or perhaps not?