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Preface

Why is the question of the difference between living and non-living matter intellectually so attractive to the man of the West? Where are our dreams about our own ability to understand this difference and to overcome it using the firmly established technologies rooted? Where are, for instance, the cultural roots of the enterprises covered nowadays by the discipline of Artificial Life? Contemplating such questions, one of us has recognized [6] the existence of the eternal dream of the man of the West expressed, for example, in the Old Testament as follows: ... the Lord God formed the man from the dust of the ground and breathed into his nostrils the breath of life, and the man became a living being (Genesis, 2.7). This is the dream about the workmanlike act of the creation of Adam from clay, about the creation of life from something non-living, and the confidence in the magic power of technologies. How has this dream developed and been converted into a reality, and how does it determine our present-day activities in science and technology? What is this confidence rooted in? Then God said: "Let us make man in our image... " (Genesis, 1.26). Man believes in his own ability to repeat the Creator's acts, to change ideas into real things, because he believes he is godlike. This confidence is – using the trendy Dawkins' term – perhaps the most important cultural meme of the West.

In Prague there is a myth from the Middle Ages about this dream and confidence. According to it [8,10,11], a famous Prague Rabbi, Judah Loew ben Bezalel, who lived at the end of the 15th and at the beginning of the 16th century (a real person buried in Prague's Old Town Jewish cemetery), once constructed a creature of human shape – the Prague Golem. The construction of Golem had two main phases. First, the rabbi and his collaborators formed an earthen sculpture of a man-like figure. Second, he found the appropriate text, wrote it down on a slip of paper and put it into Golem's mouth. So long as this seal remained in Golem's mouth, the Golem could work and do his master's bidding, and perform all kinds of chores for him, helping him and the Jews of Prague in many ways. The Golem was alive (if we can call such a state alive).

The development of the old idea of Golem has two basic sources: well-developed practical skills in pottery, perhaps the highest technology of the age of the origination of the Old Testament, and the magical exegesis of the Sefer Yezirah (Book of Creation) with the idea of the creative power of the letters (symbols) [3]. Our highest technology of today is the information technology based on computers. Observing the cognitive robotics projects of the end of the 20th and the beginning of the 21st century, we may see some similarities with the work of the rabbi from five centuries ago. The power of the right interplay of silicon-based computer hardware with the software in the form of strings of well-combined symbols breathes life into our artificial agents in many surprising ways. The construction of hardware, the writing and implementing of software in order to have autonomous systems accomplishing specific tasks are, in a certain sense, the same activities as those related with the construction of the Golem.

From the perspective of computer science, Golem is nothing more than a finite-state automaton (or maybe an instance of a Turing Machine). Its abilities are limited to the performance of tasks according to the instructions from their programmer similarly to those of the present-day non-autonomous machines. Golem's ability to interact with its environment is considerably limited (according to the tradition, Golem could not speak). It has nothing like beliefs, intentions, culture, internal imaginary worlds, etc. These insufficiencies limit Golem's cognitive abilities as well as the cognitive abilities of our robots today.

In 1915, centuries after Rabbi Loew's entrance into the depository of the stories about Golems, an extremely sensitive Prague writer, Franz Kafka, published a short story entitled Die Verwandlung (The Metamorphosis) in the journal Die weißen Blätter [7]. From our point of view, this is a typical Kafka-style story about the importance of the environment for body and mind. One morning the hero of the story, Gregor Samsa, woke up as an insect and as a result of this metamorphosis, his whole life changed dramatically. His new body perceived the unchanged environment in ways that were completely different from those of his original human body. Moreover, Samsa is, because of the change of his body, perceived in completely different ways by his relatives, friends, and colleagues. His unchanged mind – full of unchanged knowledge, reasoning, and emotions – found the new ways of existence and social functioning of the new body only very laboriously and under very dramatic circumstances. Kafka's artistic feeling and reflection of the problems inside the triangle of mind, body, and environment, described in The Metamorphosis, convert nowadays into fundamental scientific problems related to the construction of intelligent alive agents. However, there is also another perspective from which we can observe Samsa in his changed form but unchanged environment. It is the perspective of Samsa's original environment (i.e. his family, his colleagues, etc.). From this perspective, we can see the importance of social interactions for the formation of the individuality of a subject. We realize that the individuality of the subject emerges, at least to a certain extent, from its interactions with other individuals. This experience is another important motivation for the present-day efforts in creating and studying collective intelligence and societies of robots.

Here are a few notes on the early history of robots. Approximately in the same period in which Franz Kafka wrote the Metamorphosis another recognized Prague writer Karel Čapek wrote his play Rossum's Universal Robots [2]. It is well known that the word robot is of Slavonic origin and that it was used for the first time in this play. However, it was invented during the summer of 1919 in the Slovak spa Trenčianské Teplice by Karel's brother Josef, who chose the word instead of Karel's original idea to use a word of Latin origin – the word labor. Čapek's play was performed for the first time at the Prague National Theater in 1921. At he beginning of the story, Čapek's robots are devoid of any emotions. Then, step by step, as the level of their mutual interaction develops, they turn into beings with a complex system of motivations for doing things, they turn more and more into emotional beings engaged in intensive communication with other robots as well as with humans, beings capable of complex feelings such as compassion, love, faith, enmity, and anxiety. In this famous play, artificially fabricated bodies have their own beliefs, intentions, culture, internal imaginary worlds, in other words, their own emerged minds.

From the position of computer science, robots, at least in R. U. R., strictly overcome the traditional computational barrier given by the well-known Church-Turing Thesis, as well as the famous undecidability theorem by Gödel. Perhaps just because they interact very intensively with other robots, they understand the goals of the humans, the history of mankind, and they share and modify human culture.

In any case, our present-day research tries to show that massive parallel interactions of a suitable computational agent with not only its actual environment but also with the "cultural history" of this environment could exceed the computational power of the Turing Machine. Contemporary research contributes significantly to our ability to construct artificial agents which will be much more alive than our clever machines today. At the end of Čapek's story, robots become the origin of a new race, thus replacing the human race on the planet. The only living man on Earth, an old scholar called Alquist, recognizes two of the robots as Primus and Helena, the first couple of robots falling in love – Adam and Eve of the generation of beings that may once replace the humans. Years later, Prague's underground philosophy will deal with this idea.

Sometime in the late 1970s of the 20th century, a Prague philosopher and writer Zbyněk Fišer, alias Egon Bondy, wrote (and published first as a "samizdat" in 1983) an essay entitled Juliiny otázky (Julia's Questions) [1]. From the philosophical positions, the essay deals with the question of the evolution of mankind, with its future forms. More precisely, Bondy looks for an answer to the provoking questions like: Is man the final stage (something like a goal) of the (biological) evolution? And if not – this view seems to be quite acceptable for him – what will come in the future? What will replace the homo sapiens species in the line of development? Bondy states that the emancipation from the biological background, its disposal or defeat does not and cannot mean, of course, some immaterial existence of intelligence. A more acceptable opinion for him is that it means the achievement of a state in the development of ontological reality which will be able to produce a more adequate organization of matter. Bondy is not able to call this level of development any other way than some artificial form of existence. Artificial in the sense that this existence is not biogenous, but created by human intellect. Now, we can pose another provoking question: Is the enterprise of the Artificial Life a kind of prologue for creating such organization of matter?

Čapek's and Kafka's visions reflected the turbulent social situation of capitalism in the starting decades of the 20th century. The most general idea of computation we have at hand at the beginning of the 21st century was initiated in the same period. It is the idea of computing machine, the idea of different kinds of computationally equivalent formal models of computation, inspired, for example, by a mechanical activity of a worker (a human being performing computation) considered by Emil Post, and by a mechanical typing machine, the original inspiration of Alan Turing (for more about the stories see [5]). I am sure that this concept is – at least to some extent and in a certain sense – also a reflection of some of the specifics of the very basic thinking paradigm dictated by the actual historical state of the development of human society which produced it.

Fišer's alias Bondy's contemplation about the future of mankind is the result of another thinking paradigm – that of dialectic materialism. However, this Weltanschauung has been formed by the experiences of a philosopher living in the conditions of the so-called real socialism in Czechoslovakia in the 1960s and 1970s of the 20th century. While the social structure based on production and profit was, at the beginning of the 20th century, oriented mainly towards the mechanization and automation of work (in factories as well as in abstract computing devices), and, at least in a certain specific meaning, towards dealing with inorganic matter, the social structure based on dialectic materialism was oriented mainly towards changing the life-style of human beings ("Create a new man for the new future!" was a favored slogan of those times, at least in Czechoslovakia). There is an interesting parallel between the paradigm of mastering inorganic matter and the paradigm of mastering information and organic matter, isn't there?

Seen from the perspective of the science and technology of the late 20th and early 21st centuries, Artificial Life is maybe a contemporary reflection of the above mentioned ancient dream and confidence. It is a field whose fundamental starting point – the concept of life as such – arises from our actual level of knowledge and culture. It seems that this concept necessarily contains an ingredient of something secret. Understanding the principles of the functioning of some entity, we tend to view it as a kind of mechanism rather than a living body. As Rodney Brooks claims in one of his provoking considerations, he sees beetles as machines. Many more examples of this paradigmatic movement could be found, but probably the most apparent one is the starting technological explosion in the field of genetic engineering. On the other hand, as our machines become gradually very complex systems with sometimes hardly predictable behavior, they seem to exhibit some attributes of living matter. And maybe our recent artificial animal-like toys, such as Tamagotchi or cybernetic dogs, are only vanguards of the future invasion of artificial creatures adopting more and more life-like features.

Hence it is no surprise that Artificial Life is now a field – as has been written by Dario Floreano and his co-editors in the preface to the proceedings of the last European Conference on Artificial Life of the 20th century [4] – where biological and artificial sciences meet and blend together, where the dynamics of biological life are reproduced in the memory of computers, where machines evolve, behave, and communicate like living organisms, where complex lifelike entities are synthesized from electronic chromosomes and artificial chemistries.

The adventure of Artificial Life reflects this important paradigmatic change from the inorganic into the organic in the study of computation. It reflects it as a shift from the basic inspiration by mechanical events, like the movement of a reading/typing head one step to the left or to the right, towards phenomena such as massive parallelism, situatedness, embodiment, communication, gene recombination, DNA replication, mutation, evolution, etc. All of these phenomena – and many more – are dealt with in the contributions to the present volume which includes the texts of 5 invited lectures, 54 short communications, and 25 poster presentations selected by the program committee of 6th European Conference on Artificial Life held in Prague, September 10–14, 2001. For better orientation, the submitted contributions and poster texts are divided – more or less accurately according their subjects – into sections: Sec. 2 contains contributions on agents in environments, Sec. 3 on artificial chemistry, Sec. 4 on cellular and neuronal systems, Sec. 5 on collaborative systems, Sec. 6 on evolution, Sec. 7 on robotics, Sec. 8 on vision, visualization, and communication, and Sec. 9 on miscellaneous topics.

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