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Artificial Life from Talos to Qubit

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Abstract

In this work, we try to cast some light on mankind's aim to develop artificial life and make it a commercially viable product. We start from ancient Jewish and Greek methodologies, then sample handmade instruments. We present different Middle Ages' activities in this respect to mimic real life. Viewpoints and various human efforts to create life during the nineteenth and twentieth centuries, as well as Conway's digital game of life, will be discussed. Furthermore, we give an explanation as to why classical instruments cannot produce actual artificial life.

Finally, we consider qubits and quantum computers and the latest achievements in creating life in these computers. This can highlight and link to some important aspects of life, such as Darwinian evolution.

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Introduction

The history of mankind's activities to mimic life goes back to the ancient Greeks. They had a dream to create instruments to emulate living creatures or behave in a similar manner. In this lengthy endeavour, numerous instruments were invented that could make movements automatically and repeat them. The industrial machines at the time of the industrial revolution were the result of this type of thinking. Gradually, the instruments became more and more complex and smarter, and they could solve some problems without the intervention of the operators. Artificial intelligence has made huge progress as a result of the electronic revolution in the 20th century. It is not enough to simply create a smart, self-repairing, and self-replicating machine that can mimic the movements of a living being. Such a machine must also be able to evolve like a living being.

During the 20th century, and using classical computers, a specialised field, robotics, was created as a direct result of focused efforts from scientists and engineers. These robots can automate and perform many human tasks. A collaboration of different disciplines like computer science, mechanics, electronics, and information technology managed to successfully create more and more automata, but all were incapable of evolving.

We can carry on building complicated automata with the above deficiency, or alternatively, concentrate on finding a proper solution to the artificial life puzzle.

Quantum mechanics, going down the second route, has long been regarded by scientists as a strong candidate in tackling this problem. But because of the nature of quantum mechanics, using quantum technology in making smart devices is fraught with difficulties. These difficulties are mainly related to measurement, decoherence, and interaction with the environment [1]. New research in this area shows that quality progress is slow and hard to come by. The following sections address the progress made in artificial life throughout history.

Artificial Life

According to Greek myth, the bronze warrior Talos participated in wars.[2]. In Jewish legends, there was an artificial golden calf that was able to imitate the sound of a natural bull [3]. Religious legends are filled with numerous miraculous stories about creatures that appeared suddenly. In addition to these mythic stories, which were surely figments of imagination, there was some evidence of simple instruments invented by ancient people that they were capable of executing to a certain degree some autonomous motion. During Islamic civilization, ancient India, and China, instruments were invented, such as dolls, which were capable of playing some simple music [4]. Probably the strangest of them all was the clock [5]. The automatic motion of mechanical instruments inspired some medieval philosophers like Descartes to assume that animal body movements obeyed mechanical laws. This was the beginning of steam engine invention [6]. During the nineteenth century, electromagnetic theory made huge progress, and the electromagnetic wave was applied to control and direct mechanical instruments [7]. This in itself encouraged more work to be done on automation.

Early computers were huge electromagnetic-mechanical instruments that could execute basic calculations faster and more accurately. Different activities in the field of artificial intelligence are governed by the laws of physics. Progress in this field is very fast, and nowadays robotic instruments perform most of the repetitive work in laboratories, manufacturing companies, in space, and in medicine, etc. In universities and research centres, there is a fierce competition to make smarter and smarter robots [8].

Another path emerged in the nineteenth century to understand living autonomous creatures based on chemistry and biology. The idea was based on Darwin's theory and developed by Haldane and Oparin. They assumed that life appeared from a primordial soup [9]. During the 1950s, two American scientists by the names of Miller and Urey managed to establish a simple primordial experiment in which amino acids were produced in the laboratory [10]. Today, scientists believe that the hypothesis of the primordial soup is wrong and that initial life should have appeared at the bottom of the ancient ocean by the interaction of H_2, CO_2, and H_2S under the influence of the energy of harnessing geochemical gradients [11].

Despite many intense attempts by scientists to create artificial creatures in the laboratories, but to no avail, the nearest achievement was the creation of alien DNA in the laboratory with six bases instead of the four of A, C, T, and G [12].

Classical Artificial Digital Life

The electronic industry has seen massive progress, which led to the manufacturing of more and more advanced computers. This, in itself, led to the appearance of the idea of autonomous digital artificial life. One of the leaders in this field was the mathematician von Neumann. He formulated a general theory and logic of automata by the end of the 1940s. In Neumann's view, an automaton instrument holds a logical behaviour and will gradually obtain information from its environment, then combine them to create a program. He believed that living beings obey, at the end, some simple rules. He mentioned the idea of self-replication and defined a universal computer too. According to von Neumann, a classical computer reads its input from a tape and generates a set of cells that can then replicate [13].

One of the most interesting achievements regarding cellular automata is Conway's Game of Life. The game starts with some digital entities following a few simple laws. Then they evolve in time, and the appearance of new complicated rules (Figure 1) [14].

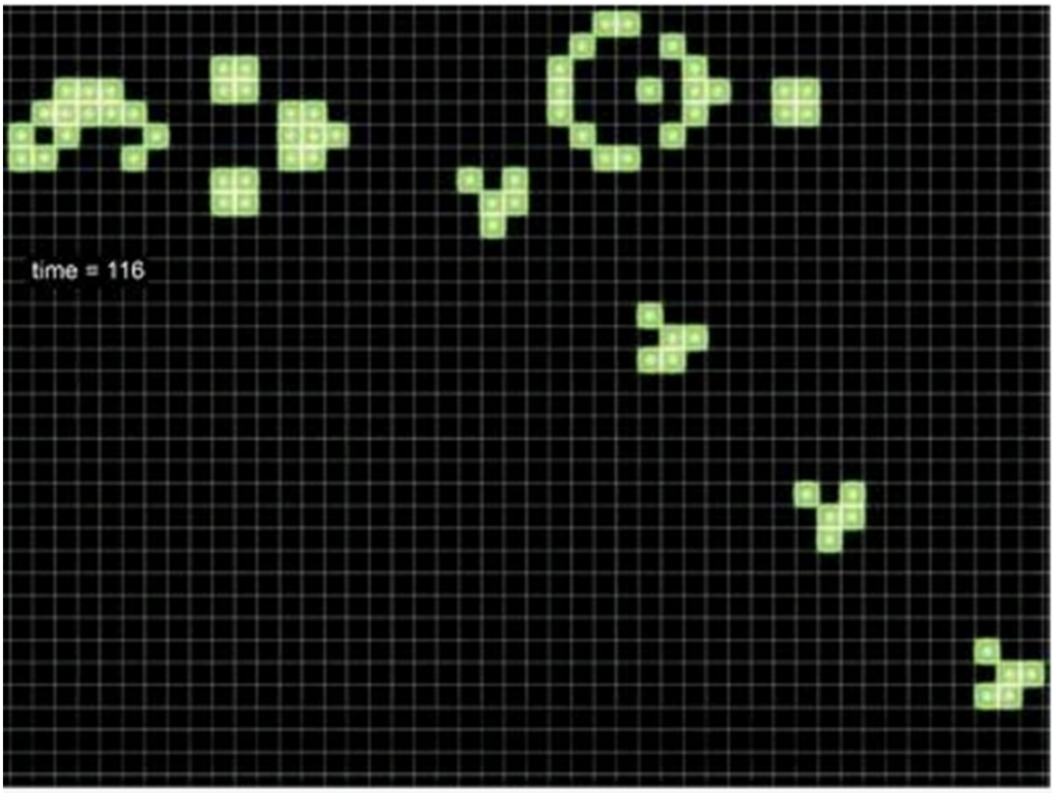

Figure 1. in Conway's Game of life. A digital cellular automaton gradually evolves in time.

Of course, the classical digital world inside the computers becomes more and more complex as time goes by. This, together with the ever more complex internet networks, may lead to the creation of an automaton within them. An example of this could be a simple virus. This hasn't happened yet.

Most scientists believe that the overwhelming factor in all of this is the speed. Current computers use classical algorithms that are not sufficiently fast enough in creating a necessary complex environment for an automaton entity to appear. This route seems to lead us nowhere. We may ask what the alternative is. The answer probably is quantum computers.

What is a Quantum Computer?

A quantum computer is a machine that uses quantum physics to carry out its operations by utilising its notion of superposition and entanglement. A quantum computer is drastically different from the classical, or better known as current, computers.

Classical computers are based on the binary system, i.e., the unit of information is a bit which can only be 0 or 1. But in quantum computers, we have quantum bits (or Qubits). A Qubit can have any of these values: 0, 1, and a superposition of those two (Figure 2).

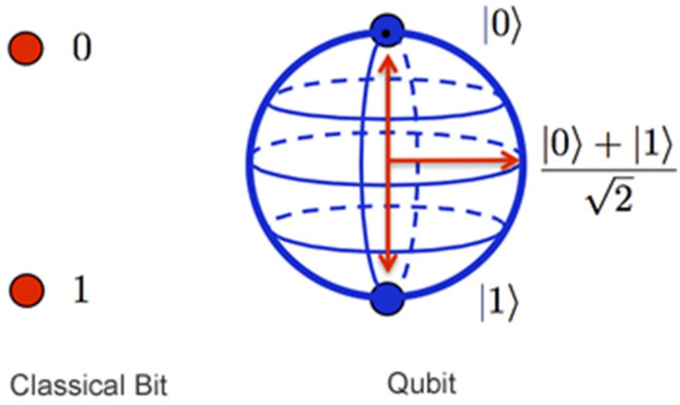

Figure 2. Difference between classical and quantum bits; in a classical system, we have just 0 and 1, but in a quantum system, in addition to 0 and 1, we have the superposition of those two.

In a classical computer, the computations are based on classical algorithms, while in a quantum computer, they are based on quantum algorithms, and the latter can outperform the former quite easily. In a classical computer, the bits depend on the direction of the current in the chip, but in a quantum computer, the Qubits depend on a quantum property like the spin of an electron or that of a photon. For example, an electron spin, in an isolated system, can take two states, up or down, and the superposition of these two, and the information can then be stored in the four states [15].

Quantum Artificial Life

The game of life of Conway needs to be run for a very long time to mimic a living being. There is no guarantee at all that something life-like will happen towards the end of this game, but we will see some emerging behaviour appearing in it.

Recent advances in artificial life have given researchers new tools for understanding and simulating biological processes in the laboratory. The aims are diverse, ranging from the comprehension of the emergence of life to the explanation of the appearance of dynamical hierarchies that give rise to complexity. Examples include consciousness at a single agent level to social organization at a group level. Self-replication and self-organization are based on direct interactions between artificial living entities, i.e., the individuals. Moreover, these techniques are applied to different research lines such as modelling the formation of biological tissues and explaining the dynamical structure of fluids. A quantum information protocol has been developed nowadays that models the biological behaviours of individuals living in a natural selection scenario. The artificially engineered evolution of the quantum living units showed the fundamental features of life in a communal environment, such as self-replication, mutation, interaction of individuals, and death [16][17].

A group of researchers from physics and chemistry at the Basque Country University in Spain has carried out a very ingenious piece of work. They used a twenty-qubit quantum computer from IBM to show the most important aspects of Darwinian life and evolution in microscopic quantum systems. They successfully coded quantum aspects, biological behaviours, and Darwinian natural selection. The main characteristics of evolution in the system were interaction between individuals, self-replication, adaptations, inherited mutation via entangled quantum information, and dying.

The self-replicator mechanism used by researchers depended on partial cloning events. This action ties each phenotype and genotype to some empty states, then copies the expected original qubits to both generated quantum bits.

At the end, the interaction between different individuals, based on certain conditions, can produce changes in phenotypes, which in itself depends on genotypes. A combination of the parts via four qubits leads to a minimum of a suitable Darwinian scenario [18].

Conclusions

It has been and still is a human being's ambition and dream to create humanoids. We are now, after the computer revolution, a step closer to realising this aim.

Nowadays, we can see robotics conquering a good percentage of human activities. Robots are used in space, medicine, and manufacturing. We may witness, in the near future, robotic cars on our roads. Robots are now used as workers, warriors, and even sex slaves! They all contribute profusely to everything we do. But still, they are in their infancy, and there is a long way to go. It seems quantum science will help us in our endeavour to be able to create artificial life in laboratories.

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