Chapter X
Computing vs. Genetics

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ABSTRACT

This chapter first presents the interrelations between computing and genetics, which both are based on information and, particularly, self-reproducing artificial systems. It goes on to examine genetic code from a computational viewpoint. This raises a number of important questions about genetic code. These questions are stated in the form of an as yet unpublished working hypothesis. This hypothesis suggests that many genetic alterations are caused by the last base of certain codons. If this conclusive hypothesis were to be confirmed through experiementation if would be a significant advance for treating many genetic diseases.

INTRODUCTION

The mutual, two-way relationships between genetics and computing (see Table 1) go back a long way and are more wide-ranging, closer and deeper than what they might appear to be at first sight. The best-known contribution of genetics to computing is perhaps evolutionary computation. Evolutionary computation's most noteworthy representatives are genetic algorithms and genetic programs as search strategies. The most outstanding inputs from computing to genetics are reproductive automata and genetic code deciphering. Therefore, section 2 will deal with von Neumann reproductive automata. Section 3 will discuss genetic code. Section 4 will introduce the well-know χ^2 test because of this importance in establishing the working hypothesis. Later, section, will address genome deciphering. And finally section 6 will establish the conjecture or working hypothesis, which is the central conclusion of the paper, and define the future research lines.

SELF-REPRODUCING AUTOMATA

The most spectacular contribution of computing to genetics was unquestionably John von Neumann's premonitory theory of self-reproducing automata, i.e. the construction of formal models of automata capable of self-reproduction. Von Neumann gave a conference in 1948 titled "The General and Logical Theory of Automata" (Von Neumann, 1951, 1963) establishing the principles of how a machine could self-reproduce. The procedure von Neumann suggested was at first considered an interesting logical and mathematical speculation more than anything else. However, von Neumann's view of how living beings reproduced (abstractedly simpler than what it might appear) was acclaimed five years later, when it was confirmed, after James D. Watson and Francis Harry C. Crick (1953(a)) discovered the model of DNA.

It was as of 1950s that Information Theory (IT) exercised a remarkable influence on biology, as it did, incidentally, on many other fields removed from the strictly mathematical domain. It was precisely as of then that many of the life sciences started to adopt concepts proper to IT. All the information required for the genesis and development of the life of organisms is actually located in the sequence of the bases of long DNA chains. Their instructions are coded according to a four-letter alphabet A, T, C and G. A text composed of the words written with these four letters constitutes the genetic information of each living being. The Nobel prize-winning physicist Erwin Schrödinger (1944) conjectured the existence of genetic code, which was demonstrated nine years later by Watson and Crick (1953(a), (b)), both awarded the Nobel prize for this discovery. It was in the interim, in 1948, when von Neumann established how a machine could self-reproduce.

Table 1. Computing vs. genetics

From genetics to computing	**From computing to genetics**
Natural Computation (NC) ≡ Evolutionary Computation (EC) [Genetics Algorithms (GA) + Evolution Strategies (ES) + Evolutionary Programming (EP)] + Neural Networks (NN) + Genetic Programming 1966 Fogel, Owens and Walsh (1966) establish how finite state automata can be evolved by means of unit transformations and two genetic operators: selection and mutation. 1973 Rechemberg (1973) defined the evolutionary strategies of finite state machine populations. 1974 Holland (1975) and disciples defined genetic algorithms. 1992 Koza (1992) proposed the use of the evolutionary computation technique to find the best procedure for solving problems, which was the root of genetic programming. 1994 Michalewitz (1992) established evolutionary programs as a way of naturally representing genetic algorithms and context-sensitive genetic operators.	1940 Claude Elwood Shannon (1940) defended his PhD thesis titled "An Algebra for Theoretical Genetics". 1944 Erwin Schrödinger (1983) conjectured that genetic code existed. 1948 John Von Neumann (1966) established the principles underlying a self-reproducing machine. 1953 Crick (Watson, 1953) luckily but mistakenly named the small dictionary that shows the relationship between the four DNA bases and the 20 amino acids that are the letters of protein language genetic code. 1955 John G. Kemeny (1955) defined the characteristics of machine reproduction and how it could take place. 1975 Roger and Lionel S. Penrose (Penrose, 1974) tackled the mechanical problems of self-reproduction based on Homer Jacobson's and Kemeny's work. 1982 Tipler (1982) justified the use of self-reproducing automata.

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