Maarten Keijzer
Una-May O'Reilly
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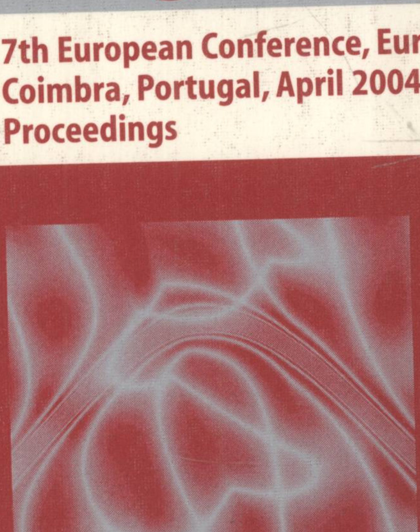
Terence Soule (Eds.)

LNCS 3003

Genetic Programming

7th European Conference, EuroGP 2004
Coimbra, Portugal, April 2004
Proceedings



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Lecture Notes in Computer Science 3003

Preface

In this volume we present the accepted contributions for the 7th European Conference on Genetic Programming (EuroGP 2004). The conference took place on 5–7 April 2004 in Portugal at the University of Coimbra, in the Department of Mathematics in Praça Dom Dinis, located on the hill above the old town.

EuroGP is a well-established conference and the sole one exclusively devoted to Genetic Programming. Previous proceedings have all been published by Springer-Verlag in the LNCS series. EuroGP began as an international workshop in Paris, France in 1998 (14–15 April, LNCS 1391). Subsequently the workshop was held in Göteborg, Sweden in 1999 (26–27 May, LNCS 1598) and then EuroGP became an annual conference: in 2000 in Edinburgh, UK (15–16 April, LNCS 1802), in 2001 at Lake Como, Italy (18–19 April, LNCS 2038), in 2002 in Kinsale, Ireland (3–5 April, LNCS 2278), and in 2003 in Colchester, UK (14–16 April, LNCS 2610). From the outset, there have always been specialized workshops, co-located with EuroGP, focusing on applications of evolutionary algorithms (LNCS 1468, 1596, 1803, 2037, 2279, and 2611). This year the EvoCOP workshop on combinatorial optimization transformed itself into a conference in its own right, and the two conferences, together with the EvoWorkshops, EvoBIO, EvoIASP, EvoMUSART, EvoSTOC, EvoHOT, and EvoCOMNET, now form one of the largest events dedicated to Evolutionary Computation in Europe.

Genetic Programming (GP) is evolutionary computation that solves specific complex problems or tasks by evolving and adapting a population of computer programs, using Darwinian evolution and Mendelian genetics as its sources of inspiration. Some of the 38 papers included in these proceedings address foundational and theoretical issues, and there is also a wide variety of papers dealing with different application areas, such as computer science, engineering, language understanding, biology and design, demonstrating that GP is a powerful and practical problem-solving paradigm.

A total of 61 papers were received. A rigorous, double-blind, peer-review selection mechanism was applied to 58 of them. This resulted in 19 plenary talks (31% of those submitted) and 19 research posters. Every paper was reviewed by at least two of the 46 members of the program committee who were carefully selected internationally for their knowledge and competence. As far as possible, papers were matched with the reviewer's particular interests and special expertise. The result of this careful process can be seen here in the high quality of the contributions published within this volume.

Of the 38 accepted papers, 32 have authors who came from European countries (about 85%), confirming the strong European character of the conference. The other 6 came from the USA, Korea, China, New Zealand, and Australia, emphasizing the global nature of our field.

We would like to express our sincere thanks especially to the two internationally renowned speakers who gave keynote talks at the joint conference and workshops plenary sessions: Prof. Stephanie Forrest of the University of New Mexico, and Prof. Zbigniew Michalewicz of the University of North Carolina.

The success of any conference results from the efforts of many people, to whom we would like to express our gratitude. First, we would like to thank the members of the program committee for their attentiveness, perseverance, and willingness to provide high-quality reviews. We would especially like to thank Jennifer Willies who ensured the conference's continued existence and has been greatly influential in sustaining the high quality of the conference organization. Without Jennifer, we would have been lost. Last but not least, we thank the University of Coimbra for hosting the conference.

April 2004

Maarten Keijzer
Una-May O'Reilly
Simon Lucas
Ernesto Costa
Terence Soule

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EuroGP 2004 was organized by EvoGP, the EvoNet Working Group on Genetic Programming.

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Evaluation of Chess Position by Modular Neural Network Generated by Genetic Algorithm

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Abstract. In this article we present our chess engine Tempo. One of the major difficulties for this type of program lies in the function for evaluating game positions. This function is composed of a large number of parameters which have to be determined and then adjusted. We propose an alternative which consists in replacing this function by an artificial neuron network (ANN). Without topological knowledge of this complex network, we use the evolutionist methods for its inception, thus enabling us to obtain, among other things, a modular network. Finally, we present our results:

- reproduction of the XOR function which validates the method used
- generation of an evaluation function

1 Introduction

The game position evaluation function is a key part in a chess engine. It is composed of a long list of parameters [1], and using a genetic algorithm (GA) [8] to optimise them is relatively efficient, these parameters being obtained from extensive game experience. Another method, which consists of substituting an ANN for this list seems more interesting, because of the generalising capabilities of this model. In practice it is more difficult to implement. Network topology determination is the biggest problem. Evolutionist methods may help us, by evolving a network population which codes this function. We could code the matrix just as it is, in the chromosome [9], connections evolving through successive generations. This coding turns out to be unsatisfactory: the matrix size has to be prefixed and it is hard to predict it a priori. Network encoding then becomes the main problem of our study.

Boers and Kuiper's work [2] allows us, by using L-Systems, to generate modular neural networks whose size is independent of that of the chromosome, and crossover tolerant. We generate a population of L-System construction rules and then mark the resulting networks according to their capabilities to learn game position evaluations from real games. These positions are evaluated more and more deeply in the game tree, along with the increased complexity of the network.

M. Keijzer et al. (Eds.): EuroGP 2004, LNCS 3003, pp. 1–10, 2004.

2 Chess Engine

A chess engine contains three distinct parts: the management of the rules, investigation of the different variant pathways using a search algorithm, and the evaluation function.

2.1 Chess Rules

All chess engines need to know the rules to generate the legal moves or referee a game between two people. All legal moves are pre-calculated in the tables: the engine just needs to confirm that this move is one of them.

2.2 Search Algorithm

The search algorithm explores all the moves from a position and tries to find the best move. In our programme, we use the alphabeta algorithm with various heuristics [10], which are not mentioned here. The values of tree leaves are computed using an evaluation function, which is an ANN in this case.

2.3 Evaluation Function

The evaluation function is very important in all chess engines. It is very complex because it gives the final mark which it uses to select the move to play. The main operation of this function is to count the values of the pieces. After that, it is possible to refine the function, using a series of parameters to define:

- the king's safety
- maintenance of the bishop pair
- domination of the centre
- occupation of the open columns by the rooks.
- ...

We then calculate the sum of all the parameters to obtain the final mark. One of the main limitations of this technique is that we have to define the list of parameters and to set them up correctly, knowing that certain of these values will change during the game and are not self-compensating.

3 Neural Network

3.1 Presentation

Introduction. The human brain is certainly a most amazing organ. It is not a surprise if people try to pierce the secrets of its functioning, to recreate certain of its mechanisms artificially. Neural networks are directly inspired by this vision. The ANN are inspired directly by the structure of the human brain, which is schematically a field of neurons linked together. A Neuron is composed of three parts: dendrites, body and axon. The dendrites get the information (electrical impulses) from the other neurons. The body makes the sum of all this electrical information and if it goes beyond a certain level , the axon is activated, that is to say the neuron sends an electrical impulse to its successors.

The artificial neuron. By starting from these biological considerations, we can find an artificial neural model [12]. The artificial neuron is composed of n inputs which are real numbers and one output (that can be duplicated to power different successor neurons) which is the weighted sum of all the entries. The weights correspond to each one of the connections. It is these weights which will be modified during the learning process.

Learning method: back-propagation. *Principle.* Once a network is created it possesses inputs and outputs. The goal of the learning process is to make sure that, for a given problem, the ANN selects the "correct" outputs as a function of the entries which will be presented. A level is fixed and the learner tries to obtain it.

It is important to note that this learning is supervised. This is like having an expert give a part of some solutions for the entries and the outputs. However, it is impossible to have all the solutions, and one of the properties of the ANN is to generalise. After the learning, it can find the solution for entries which it has never seen (if the structure of the ANN is well adapted). Some other techniques could also be used. Various other learning methods exist. It is also possible to process the learning of a network by a GA. This method could be used once a good topology has beenfound for the network.

Remark. This learning process does not correspond to the humain brain learning process.

3.2 An Example: XOR Function

We have tested a simple example: the learning of XOR function by back-propagation. The particularity of this simple logical function is that it which cannot be learnt by an ANN composed of only one hidden layer.

The logical XOR function is a binary function with two variables:

```
F(0,0) = 0
F(0,1) = 1
F(1,0) = 1
F(1,1) = 0
```

One of the possible topologies for the network is the following matrix (Fig. 1). If we add one connection to it (from 0 to 4), we obtain another topology (Fig. 2) which can resolve the problem.

```
Matrix:       0 1 2 3 4

            0 0 0 1 1 0
            1 0 0 1 1 0
            2 0 0 0 0 1
            3 0 0 0 0 1
            4 0 0 0 0 0
```

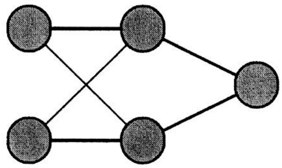

Fig. 1. Topology represented by the matrix

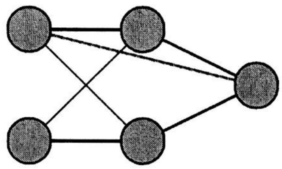

Fig. 2. Topology with one more connection

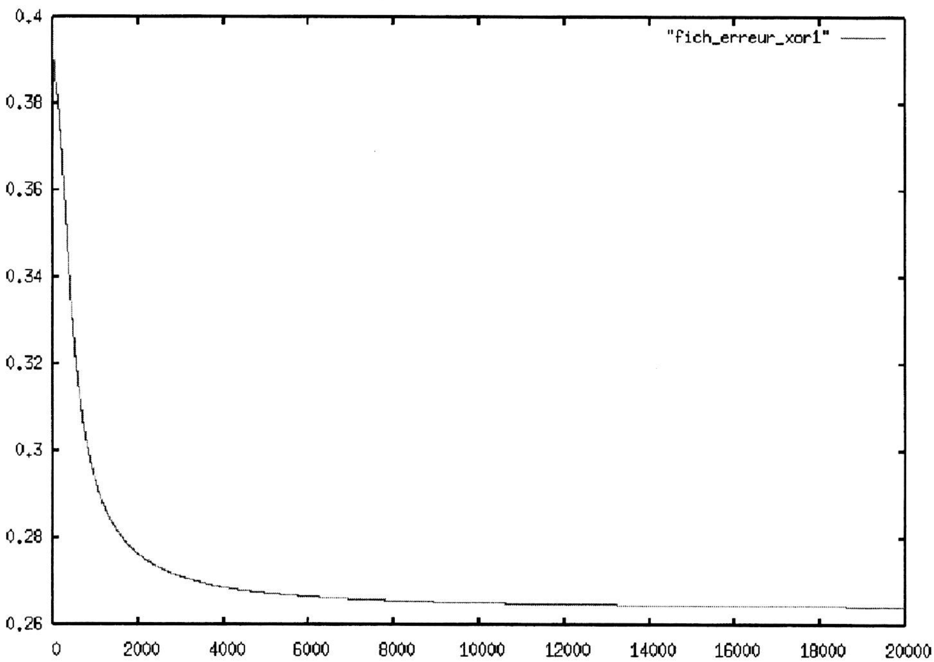

Fig. 3. Learning by the topology of Fig. 1: the graph represents the error on the function for each step of calcul

For the topology of Fig. 1, the error (Fig. 3) does not fall below the local minimum 0.26. In contrast, with the topology of Fig. 2 the learning is better (Fig. 4). This simple example shows how sensitve the learning is to the topology of the neuron.

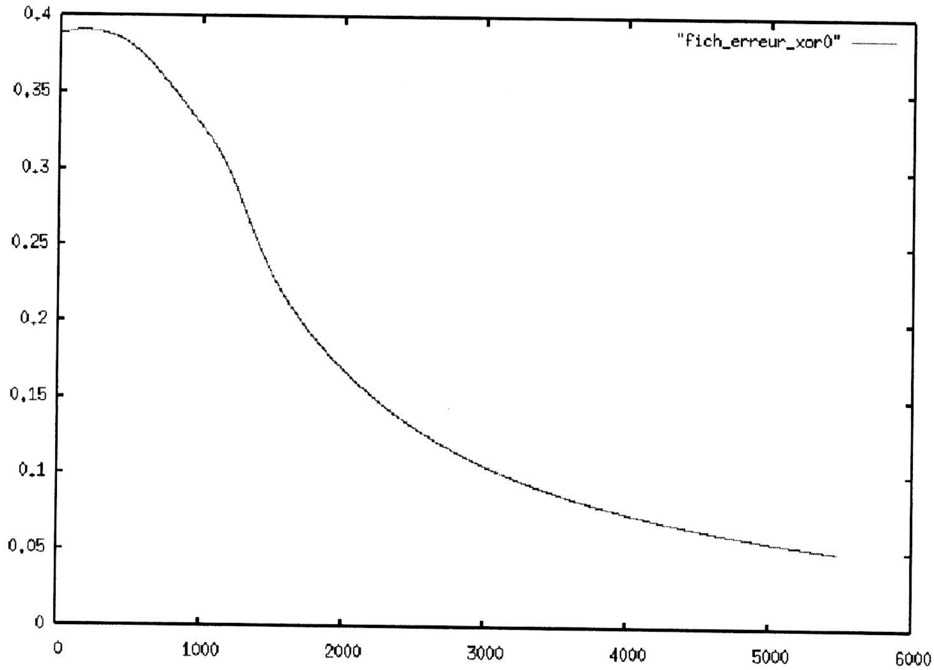

Fig. 4. Learning by the topology of Fig. 2: the graph represents the error on the function for each step of calculation

3.3 Back-Propagation: Limits and Solutions

Problems linked to back-propagation are essentially due to the structure of the network. Regarding this structure, a network will be able to learn, unable to learn, able to learn but need a long time, able to learn but unable to generalise. Another thing is that the net may potentially be able to learn but converges to a local minimum when initial weights are not correctly chosen. It is always the network structure that is responsible for the initial weights sensitivity: some nets are convergent for any set of initial weights, others do not converge every time. We noticed that nets with a modular topology were better for learning. By modularity, we mean the network is made up of many other sub-networks. A connection between two networks is a connection between each output of the first to each input of the second. The next paragraph explains how to create networks with strong modularity.

4 Neural Net Generation with L-Systems

L-Systems [11] are grammar systems generally used for generating artificial plants. They are based on cellular development. We use them to generate modular neural networks. These grammar rules are obtained from a string [4].