

# HEURISTIKA

## Implementing a multi-purpose optimization code

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**Abstract.** **HEURISTIKA** is a Java-based system aimed to solve highly complex, non-linear problems of any sort, sustained in evolutionary algorithms assumptions. It introduces different aspects and functionalities caught in the specialized literature. It is intended to integrate heuristic methods to solve complex numerical and ODE problems, optimization, classification and control processes and all problems which involve impractical exhausting solutions. In the course of its development, the author made use of analogies and metaphors found in ordinary life concepts.

**Resumo.** **HEURISTIKA** é um sistema baseado no Java objetivada na solução de problemas altamente complexos e não lineares, com base nas premissas dos algoritmos evolutivos. Ele introduz os mais diferentes aspectos e funcionalidades recolhidos na literatura especializada. Pretende-se integrar métodos heurísticos para resolver problemas numéricos e problemas como Equações Diferenciais Ordinárias, otimização, classificação e processos de controle, além de problemas que envolvem soluções exaustivas intratáveis. No curso de seu desenvolvimento, o autor fez uso de analogias e metáforas encontradas na vida comum.

**Keywords.** Methods: numerical

### 1. Introduction

Heuristic methods have multi-purpose applications. They may be numerical, differential, logical, neural, multi branches (classifying algorithms) and so on. They may even be algorithms. **HEURISTIKA** is intended to cover all the existing heuristic methods (or ready to be extended to) such that package's mere instantiation could implement specific applications.

The author considers some analogy with processes occurring in nature — and society —, especially the processes governing the Darwin observations and theory exposed in his framework "On the Origin of Species by Means of Natural Selection" (Darwin 1859). As pointed out by uncounted texts about genetic and evolutionary algorithms (see, i.e., Goldberg (1989) for details) the primary goal of this kind of algorithms application is to find solutions for puzzling numerical, differential or integral equations, process optimizations, filtering, learning algorithms and so on, all being considered under an optimization process.

To accomplish these goals the author has developed algorithms considering aspects found in common-life concepts. In the next Section some of these aspects are introduced.

### 2. Concepts Running in **HEURISTIKA**

**Random walk:** a process that generates "beings" having the concerned characteristics of the problem in study whose parameters cover as much as possible the domain of its the function(s). The parameters values are randomly distributed.

**Selection:** environment, or evolutive pressure. In nature, selection is done by simply mate extinction. It can occur by starvation, hunt, exhaustion, or illness. The sum of all these causes is called evolutive pressure. In algorithmic development, we can define a kind of evolutive pressure inspired in nature and according to the particular application.

**World:** where the kind of payoff is defined; a set of conditions that defines on what the "organisms" should adapt. An example of world is a differential equation to be solved.

"Organisms" should adapt in the sense that the neighbourhood of the roots of the equation means the best adaptation.

**Population:** environment or **tribe**, or even **clan**. Organisms, depending on their nature, may have different ways of replication, in the sense of Dawkins (2006) description. It can be numeric, bit exchange, string compositions etc. As in real life, after replication or crossing-over, the news being may be submitted to a **mutation**. Depending on the genotype codification a mutation may be a bit inversion, or, in the case of numeric 'world', an addition of, or multiplication by a number, under the numeric domain conditions.

**Clock:** or time machine. Every life environment takes a certain number of generations, otherwise evolution won't take effect. In algorithm context each generation is linked to the concept of iteration. Then, clock, reflecting a certain number of generations is built on the same basis as the iteration context.

**Genesis:** The natural process of life is very long and yet not completely understood and described. If we want to start a process of some evolutive process, establishing the beginning of the course with beings already evolved to its operational stage from scratch needs some bridge (or a metaphor, or myth) to step over all the long and unfinished back evolution process. 'Genesis,' the chapter of the Bible may be a good metaphor.

**Armageddon:** or stopping criteria. The main aim of numerical calculations is to reach to some final results, the solution. In natural conditions, there is no ending in the environment evolution, unless the given species reaches to a deadlock in the environment it lives and gets extinct, or a hecatomb comes over. I called this process "HarMeggido" the Hebrew word for the Gospel's "Armageddon", the biblical ending of human race, and the collecting of the "elected" ones by God to go with Him to paradise. By analogy, when the process reach some condition to stop, the "elected" organisms are collected to serve as a solution to the problem.

**Migration / Colonization:** In nature and human social environment migration happens all the time. We may simulate it in a multicore CPU computer calculations using **HEURISTIKA**. It may be by transferring the best-qualified beings from a process running in a machine to another "society," running in the neighborhood. It may be the worst individuals, too. In the former case I use to call it "invasion" and in the latter one, "immigration". In human societies it may happens that the immigration process ends by being very efficient and gives beings that will dominate the "new" society, which, in real world, uses to be the case for the so-called "New World".

**Taboo:** Some characteristics of primitive (and actual) societies may be models to the conditions that a heuristic method will run. It is well acknowledged that primitive societies ran under the set of rules of Totem-and-taboo (Freud 1913). The most conspicuous of the Totem-and-taboo rules is the incest prohibition. This rule most likely origin, according to Freud, is derived from the very primitive human groups, at initial stages, when they were similar to apes actual group formation, where, in most of them, only the dominant male (father) has rights of reproduction.

**Infanticide & Œdipus:** Here we have a mix of conditions whose metaphors may be extracted from Mother Nature or human mythology. We know that the male of some animal species uses to kill cubs no matter they are or are not its own offsprings. This is the case of the polar white bear. To avoid it, the mother-bear flees with her cub away from the father view. Furthermore, from human mythology there are countless clues that infanticide was a common practise in old societies. The biblical myth of Abraham in the sacrifice of his first-born is one of them. Even the most sacred moment of Christianity, the Jesus Christ crucifixion (sacrifice of God's Son), may be seen as a clue of this practice (Freud 1913, p. 153). On the other hand, we have Œdipus Rex: the Sophocles Greek tragedy where he, the son, ends by killing his father Laius and marrying his mother Jocasta, giving birth to Antigone, Eteocles, and Polyneices. Apart from the nefarious consequences (including the childhood phase of the feeling of castration), from the system point of view, one could say that Œdipus represents the infanticide's revenge. Anyway, in **HEURISTIKA**, if the flag of infanticide is set, the child's genotype is faced to the father's. If it happens to be less adapted, infanticide takes place, otherwise, is Œdipus that is going to run.

**Xenophobia (anti-entropy):** Rejection of "ill-formed" beings or foreigners is seen in many animal groups in nature and human societies. But, only with diversity we have at least an expectation to find the very best solution in optimization processes. One of the best diversity estimators is the Shannon entropy (Shannon 1948). Following our metaphoric attempts, we state that in **HEURISTIKA** all is done to follow the Second Law of Thermodynamics: entropy must to increase. Entropy of a population is evaluated in the following way. One makes a histogram  $H(F)$ , where  $F$  is the fitness for every being in population. The bin of this histogram is chosen such that  $b = 1/m$ , for  $m \leq N$ , the number of beings in the population. The histogram is normalized, such that  $p_i = H_i/N$ ,  $\sum_i p_i = 1$ , and  $p_i \leq 1$ . Then

$$S = \frac{\sum_{i=1}^m p_i \ln p_i}{\ln m}.$$

From the above expression,  $0 \leq S \leq 1$ .

**Epidemy and Pandemy:** Nowadays epidemy is a process almost exclusive to humankind or in environments where human handles. There is a condition on which an epidemy happens. It suffices the epidemical agent find a free way to circulate. Its chances increase every time a particular imbalance in the environment comes over. If the environment is massively populated by just one species, diversity is severely compromised. Here one finds ideal conditions for epidemy to happens. There are they who sustain the thesis on which the humanity itself is an epidemic on earth. A way to measure this imbalance is to determine the entropy of the environment.

**Cockfight:** Inspired in the infamous practice of cockfight, for roosters instinctively attack competitors to death, in **HEURISTIKA**, if the hennery-flag is set, the population is considered as a hennery and all 'beings' with similar genotypes are taken as 'roosters' that go to a cockfight, and only the best one survives. The criterium for 'similarity' is done by the custom.

**Leucocytes** It is well known that the immunologic system of superior beings on earth has got a mechanism that destroys all aberrant new cell that has just been created in the process of renewing of dead ones. This task is made by the leucocytes, the "white globules", which are present in the blood. The concept of leucocytes in **HEURISTIKA** is useful for some conditions, e.g. highly non-linear equations where different function values take to huge ranges, compromising the evaluation of the fitness.

**Late genesis** The final aim of the processes of extermination and declining number in population is to let conditions for the population to renew itself. In **HEURISTIKA**, any time the population can renew itself, the process of a random walk is retaken, and new beings appear by a 'self-generation' process. One may reason that this is an artificial process, not having a parallel in nature. Nevertheless, given the vast complexity of nature, one can conceive this process of 'late-generation' as being immigration coming from randomly distributed populations in the neighborhood.

## References

- Darwin, C. 1859, On the Origin of Species: By Means of Natural Selection (P.F. Collier & Son)  
 Dawkins, R. 2006, The selfish Gene (Oxford University Press)  
 Freud, S. 1913, Totem and Taboo (Routledge & Kegan Paul)  
 Goldberg, D. E. 1989, Genetics Algorithms in Search, Optimization, and Machine Learning (Addison-Wesley Publishing Company)  
 Shannon, C. 1948, Bell System Technical Journal, 27, 379