Evolutionary Interactive Genetic Algorithm: A Special breed of Interactive Genetic Algorithm

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Abstract

In this paper, a new breed of Interactive Genetic Algorithms (IGA) is proposed. It is based on the idea of outsourcing and natural evolutionary process, which is a ongoing process in the nature. In evolutionary interactive genetic algorithm (EIGA), both selection process and the organization of the genetic process are outsourced, i.e. delegated to outside human agent. In nature, not only the organisms evolve in their corresponding environment, but the environment itself also evolves during the course of evolution process, which means at the beginning of evolution process, the "satisfactory solutions" are not foreseeable. The suggested model allows IGAs dealing with problems where "satisfactory solutions" are not conceivable at the very beginning of GA process. In other words, it offers one more perspective in searching for optimal solutions. Moreover, EIGA makes IGAs a more complete algorithm in the sense of natural evolution..

Keywords: Interactive Genetic Algorithms, multi-agent organization.

1. Introduction

From fern to tree, from reptile to bird, nature seems to have unlimited solution space in the revolutionary process searching for solutions which are better adapted to the environment. Early GAs [1], [2] were inspired by nature's nearly flawless way of evolving complex living organisms and by Darwin's theory of natural selection [3]. Using the computational power of modern computers GAs haven been applied to a variety of fields such as engineering design, mathematical analysis, economical model, etc,. Have GAs simulated all essential mechanisms of natural evolution. This paper argues that it has not. Think of evolution in term of dynamic process, where fitter solutions are evolved generation after generation, and the environment itself also evolves during the course of evolution. This approch expands GAs' solution space and make it a more complete algorithm in terms of natural evolution.

Section 2 gives a brief review of GAs and shows the trend of human interaction with GAs that was the background and motivation of this research. Section 3 describes the general model of evolutionary interactive genetic algorithm as a multi-agent IGA, where both selection process and the organization of the genetic process are outsourced. The future works and conclusion are put in section 4.

2. Human Agents

Genetic algorithms were first proposed by Holland [1] as a simple and robust searching techniques in which populations of test points are evolved by random variation and selection. GA was inspired by mechanism of natural selection where fitter individuals have better chance to survive in a competing environment and hence, propagate themselves to the next generation. After the initialization, three basic operations are performed by GA systems, crossover, mutation and selection. Early GAs have these three operators centralized inside computational procedure defined by GA programs, like SGA [2]. To propagate from current generation to next generation, mechanism of crossover, the probability of mutation and the selection criteria (fitness) are all predefined by system organizer. This algorithms have become widely used in a number of applications such as engineering design, mathmetical analysis, pattern recognization, and so on.

However, for application fields such as graphic image, music composition or anythig related to creative design, systems' optimization indexes are difficult to specify. This usually means that optimal solutions exist only in the mind of users' mental psychological space. It is for this reason that IGA was introduced [4][5], where system's fitness function is replaced by users' subjective evaluation. In other words, IGA embedded uses' preferences that were influenced by their intuition, emotion, education

backgrounds and even social standings in the GA system. In this sense, IGA extend the problem domain to human aesthetics where satisfactory solutions are difficult or even impossible to come by using traditional GAs.

The concept to view GA as information flow management/organization was proposed in HBGA [6], where all genetic operators are outsourced and delegated to humans, except for organizational function that remanin the core competence of GA. This algorithm was applied in Free knowledge Exchange project (FKE) [6] where natural language was used and better answers using strings evolved to fit the constraints (problems). FKE emphasized human collaborative intelligence through network communication, performance issues that came about using computer/human interactions such as preferences balance, human fatigue, human capacity were also discussed. In short, HBGA can be viewed as an extension of IGA. The above brief review of GAs is incomplete but it shows the trend of human interaction with GAs that was the background and motivation of this research.

3. Evolutionary Interactive Genetic Algorithm

Imagine you are walking in a garden where Summer breeze gently touches your face and the air is filled with mixed perfume of water lily and magnolia and some other flowers. There are butterflies, hundreds of them, dancing around full blossoms with their colorful wings. Imagine again, couple decades later you stand on the same site. It is Summer time again but the scene has changed. Instead of blossoms the place is crowded with bushes, their leaves covered with dusts. Butterflies still flying around but their wings are no longer colorful, only grey ones and black ones remain. This is not a science fiction, it actually happed in a western industrialized country. What actually happened was after years of industrialization, the air was polluted and the garden was changed. By and large, butterflies with colorful wings no longer fit in the environment and their offspring all evolved to wings with shaded colors.

Our point is: in an ecological system, not only the organisms evolve in their corresponding environment, but the environment itself also evolves during the course of evolution process, which means at the beginning of evolution process, the "satisfactory solutions" are not foreseeable. Looking back into the history of biological science, from fern to tree, from reptile to bird, nature seems to have unlimited solution space in the revolutionary process searching for solutions which are better adapted to the environment. That is also what happened in the above case.

Have GAs simulated all essential mechanisms of natural evolution. The answer is no. If we check the mapping relation between genotype and phenotype we find that there is no one to one mapping relation. The actual correspondence between genotype and phenotype is a many-many relation in which any given genotype corresponds to many different phenotypes and there are different genotypes corresponding to a given phenotype. Moreover, the mapping of different genotypes into phenotypes in one environment is often completely unpredictable from their mapping in another environment[7]. Although scientist working on the mapping of genotype and phenotype, it is the uncertainty and ambiguity of the mapping relation between genotype and phenotype in different environments that inspire us.

We propose Evolutionary Interactive Genetic Algorithm (EIGA) that simulates the mapping relation between genotype and phenotype as did in nature. EIGA delegate the initial step of GA to human user i.e., the design of phenotype and the mapping between genotype and phenotype. Fig. 1 shows the mapping relation in biology, IGA and EIGA correspondingly, where the relation in biology is many to many, the relation in IGA is one to one. The relation in EIGA is still one to one but since the user is able to edit phenotype according to their own preferences, the one to one relation is not fixed as did in IGA. The conceptual model of the proposed EIGA organization is presented in fig. 2. This model allows IGAs dealing with problems where "satisfactory solutions" are not conceivable at the very beginning of GA process and hence, the initial phenotype does not contain the needed phenotype(s) which are needed in the search of optimal solution(s).

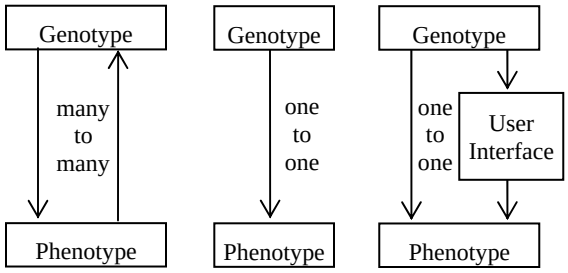

Fig. 1. Mapping function from Genotype to Phenotype
(a) Biology: many to many with some unclear redundancy.
(b) IGA: Fixed one to one mapping.
(c) EIGA: User interface gives flexibility to mapping function, where users can edit the phenotype according to their own preference.

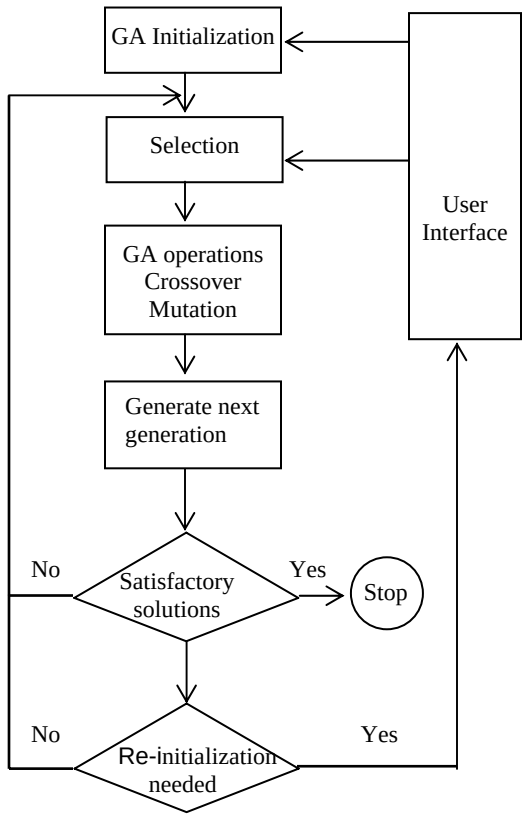

Fig. 2. Conceptual model of the proposed EIGA organization.

Looking back into the natural evolution of biological world, nature (i.e., environment) plays the role of selection function. Whenever the environment changes, the living organisms will adapt themselves accordingly. Should there a drastic change in the environment; some species will be able to adjust themselves to the new environment; some other species will disappear because they are not able to adjust themselves properly. Moreover, new species appear and become the dominant species as they fit so well in the new environment. In IGA, users replace the selection function of GA. While in EIGA, users capabilities goes beyond the selection function of GA. If users come up with new ideas which are not showed in any of the current solutions presented to them, they can edit phenotype according to their own preferences, or they can delete phenotype from phenotype pool if it is deemed necessary. This editing capability of the user actually extends the solution space of original problem. In other words, it offers one more perspective in searching for optimal solutions. Moreover, EIGA makes IGA a more complete algorithm in the sense of natural evolution.

4. Conclusion

In this paper, a new way of user interaction in GA has been proposed, which can be treated as a special breed of IGA noticed from its name EIGA. The proposed model enhances the flexibility of current IGA and extend the solution space to a new boundary. Future research about the practicality of EIGA is proceeding now.

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