Evolutionary Agents in a Competitive Environment to Develop Policies for the Management of Retirement Plans.

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Abstract: A competition environment is very common in service market, and this competition is increased when there are more than one service supplier. This is the case of the financial institutions that offer individual retirement accounts. This paper presents institutions represented by agents that evolve to survive in a competitive environment and generate a policy to survive in it.

Key words*: Evolutionary Agents, hybrid intelligent systems, fuzzy systems.*

Introduction

In México, the individual retirement plan is called "AFORE" and they are in a competitive environment and they most face financial crisis. This situation may be the same in other countries, however, this example will be the case of Mexico. Some AFOREs appears, and other disappears, there are a war to win clients offering better conditions in yields, commissions and services, however, the number of clients usually has a low increments through years, so it is important to emphasize the develop of a policy to gain the preference of the clients and survive in the competitive environment and surpass the crisis.

The evolution of agent is an idea that comes since the origin of the theory computation, principally by the works of Larry Fogel and its evolving finite state machines, now the use of evolutionary agents can be resumed in the work of Kenneth A. De Jong (Ref [1]). The study of evolutionary agents in a competitive environment is extense because it can be considered since different perspective. The first one is the Co-evolutionary optimization [2] where two species compete for the same resource to generate an armament race to survive; Other point of view is the analysis of the performance as a multi-agents system [3,4]. Similar works has been done about agents that by means of a competition, improves its performance by evolutionary competition [5, 6 , 7, 8]. The competence enrich the performance of every agent, however, it is clear that the performance depends of the performance of other agents, so other phenomenon emerges like cooperation [9].

This paper illustrate a competitive environment of AFORE agents. These agents evolve to get a policy to survive in this environment. A simplifications was made to consider a simple policy to be simulated easily. The idea is to evolve agents where the evaluation function considers the capital earned by the policy designed through time in a evolutionary way. A simulation is included to generate the capital earned considering the number of clients that belong to a AFORE agent, the spends in services and publishing made. As a preliminar work, a proper set of policies can be evolved that let to the agents to survive in the competence.

In the second section, the competitive environment is presented where it is included the architecture of the agents, the fuzzy systems to represents the decision made by the clients, a description of the evaluation function where the simulator is included and finally the evolutionary algorithm is described in detail. The experimental description and results are exposed in the third section. Conclusions and future work is included in the last section.

1. The competitive environment

The competitive environment consist of a set of agents that by means of its policy are selected by clients. An agents with high number of clients acquired, imply an increment in its capital, otherwise the agents could be disappeared and be substituted by other best competitive agent. Every agent represents an AFORE with financial goals that are very similar to any enterprise, and must take decisions to spend its profits. For simplification, only four criteria are included:

- The yield offered to the clients
- The commissions made to the clients
- The percent of the capital spend in services for the clients
- The percent of the capital spend in publishing and/or merchandise

Every client evaluate every AFORE agent. A fuzzy systems was developed to represent the decision made by a client, considering the yield offered, the commissions, the perceptions about the services offered and the publishing made per AFORE. Every AFORE agent offers a set of services, yields, commissions and publishing that can be cataloged as bad, good, very good, very bad, and medium or regular. Considering these classifications a fuzzy systems is designed to relate these classifications to the probability to be selected by the client (Figure 1). An AFORE agent that offers high yield, low commissions, regular services and regular publishing will be preferred than an AFORE agent that offers very low yields, high commissions,

low services, and regular publishing. This probability of preference is assigned to every AFORE agent per client, then a roulette selection is made and the client select only one AFORE.

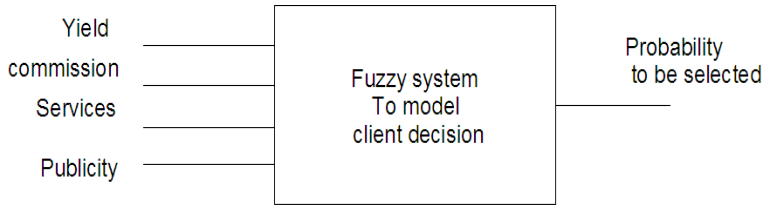

Figure 1. Architecture of the fuzzy system to represent the decision of the client to select an AFORE .

This procedure of selection is repeated again and again with of the rest of the clients. At the end, every agent has a number of specific clients. We can think that it is not necessary to design a policy by this way, because considering only high yields, low commission, could be enough to get clients. This is true if the other agents use the same criteria and all coexist in a static environment; however, this is not the reality. The decision made by the client to select an AFORE has a component difficult to be modeled, like the pleased to belong to a specific AFORE, so a dynamic exist and one rule could be not enough to survive, maybe in a moment the policy could be one, however in another moment the useful policy could be another because; in real environment, the policy is changed through time depending of the preference of the clients and the policies used by the competence. In this paper, the preference of the clients represented by the fuzzy system is permanent, constant. Changes are made in the policy of the agents in a evolutionary way. It is expected that using a roulette mechanism of selection the agents with a high fitness implies a high probability to be selected. However it is not a warranty to be selected always. If all the agents has the same policy, all have the same fitness, so all has the same probability to be selected and the risk to be eliminated will be the same for all of them. The differences between agents could be very similar, so if only one AFORE lost one or two client will be enough to be eliminated because its capital will be inferior by a tiny number.

The capital of every AFORE agent is calculated . Usually in a very simplistic way, every AFORE make investment using its capital (in Mexico, there was constrains to invest the client money in high risk investments) so a profit is generate per period of time. This profit is reduced by the service, yield and publishing offered and the commission made increase the profit. An evolutionary algorithm is used to evolve efficient policies for the competitive environment. The evaluation function considers the capital generated per AFORE agent to assign a fitness, so a resume of the operation are mentioned below including mathematical operations:

(1) Per agent of the population, extract its policies (The population contains policies) A normalization is made and a fuzzy system is used to determine the probability to select the AFORE agent.

(2) A selection by the clients is made. Per client and considering the probability to be selected, an AFORE agent is selected. The client is assigned. All the client are assigned by this way.

(3) The capital is calculated per agent considering its clients acquired and its policy. A maximum percent of the profit (MR) is given. Considering a constant saving per client (SC) and a number of the total of acquired clients (TC), the profit of the AFORE (PA) agent is determined using equation (1).

$$PA = MR*S\_Cx*TC \quad (1)$$

The capital is calculated using equation B, where a new capital is determined considering the actual capital (CP), the services for the clients (SC), the publicity or merchandise made (PC), these last two is a percentage of the actual capital. Several spends are included as a constant value (SS). The incomes are calculated as the yield taken from the commissions (CM) made from the yield of the saving (YC) of all the client.

$$CP(t) = CP(t) + PA - SC*CP(t) - PC*CP(t) - CM*(YC*SC) - SS \quad (2)$$

The policy is defined by the four variables YC, CM, SC, and PC.

The evaluation of the fitness consider a normalized capital, so the evolutionary algorithm tries to increase this fitness. This evaluation criteria could generate agents with better policies to get more clients and be permanent in a competitive environment. An evolutionary algorithm of stable state or non- generational is considered because this situation is more realistic. AFORE agents are in a competitions to get more clients, so, since an evolutionary point of view, this agents are adapted to be more strong and survive in the environment. The wicker could be eliminated.

In this paper, an non generational genetic algorithm with *n* individuals are substituted by *n* offspring generated. The evaluation function not consider directly the total clients acquired. To avoid an advantage of a specific AFORE agent, all the agents have the same initial capital.

2. Experimentation and Results.

A non- generational genetic algorithm was used with a population of 25 individuals of AFORE agents through 100 generations. The policy is described by a vector of four parameters. A chromosome of 32 bits was used to represent every parameter of the policy of 8 bits. A mutation and crossover of probability of 5% and 90% respectively were used. A deterministic selection of two individuals was used. Only four individuals are selected to generate offspring and four individuals are selected to be substituted by the offspring generated by the selected parents. The algorithm that emulates the environment runs 100 generations. In every simulation a projection is made about the performance of the policy thought five years.

Table 1 illustrate the policies developed with its corresponding capital generated and the number of client acquired. This table is only a sample of the performance because depends strongly of the initial population. Some agents could disappeared in the future if more runs are used; however, it is important to observe the policies generated because these policies only work in this particular environment.

yield	commission	services	publicity	capital	clients
0.1061	0.1575	0.2704	0.0862	2221	61
0.0989	0.3516	0.2022	0.2215	2310	63
0.1193	0.3089	0.1158	0.1044	-383	3
0.0841	0.7671	0.0134	0.1590	-338	4
0.0138	0.3089	0.0362	0.1920	2131	59
0.0841	0.3089	0.0362	0.1920	1143	37
0.0836	0.8059	0.1158	0.2409	-293	5
0.1017	0.7632	0.0362	0.1942	4420	110
0.0841	0.7671	0.0271	0.2852	2400	65
0.1055	0.1575	0.2704	0.0862	1862	53
0.0539	0.3555	0.0805	0.1544	2400	65
0.0989	0.3089	0.1158	0.2409	4331	108
0.1033	0.3167	0.0976	0.2670	-338	4
0.0989	0.3089	0.1158	0.1942	-383	3
0.0841	0.7632	0.0362	0.1942	-428	2
0.0995	0.7632	0.0362	0.1942	3343	86
0.1000	0.8913	0.1760	0.1795	2490	67
0.0841	0.7671	0.0180	0.1942	4061	102
0.1429	0.7787	0.0873	0.0589	1278	40
0.0803	0.3516	0.0566	0.2033	2310	63

Table 1. A sample of the policy and performance of every agent through a run of 100 cycles.

4. Conclusion and future work

The behavior of the agents depends of its competitors, however, the policy of all the agents are initialized following an uniform random generator. This situation generate different conditions of competitions so all the agents evolve to generate a policy that permits to survive in competence again all other agents. As a future work or a continuity of this work is to follow a specific agent (a strong one) to determine its parents or origins of its survive through time.

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