THE EFFECTS OF BIAS, POPULATION MIGRATION and CREDIT ASSIGNMENT in OPTIMIZING TRAIT-BASED HETEROGENEOUS POPULATIONS

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Abstract. Population based search algorithms are becoming the mainstay in nonlinear problems with discontinuous search domains. The generic name of genetic algorithms (GAs) basicly applies to all population based methods. GAs have spawned many versions to suit new applications. Some of these alterations have reached such points that the algorithms may no longer be called GAs. One similar study may be found in [1], in which a perturbation based search algorithm was proposed, called Responsive Perturbation Algorithm (RPA). In a later work [2], instead of a population of homogenous individuals, as is the case for generic GAs, a population of heterogeneous individuals has been set to compete. Replacing the set of winner parents, the fittest individual is made the parent to yield offspring. The current work is now called, with the supplements, trait-based heterogeneous populations plus (TbHP+). Credit assignment and bias concepts in the form of immunity and instinct has been added to provide the populations with a more efficient guidance. Simulations were made through an RBF neural network training, as it was carried out in earlier works, mentioned above, for comparison. Results were prsented at the end as network testing errors which showed further improvement with TbHP+.

Keywords: Credit Assignment, Bias, Population Migration, Immunity, Instinct.

1. Introduction

Within the last two decades, population based search algorithms have become quite popular and successful. The reason behind this success story is the fact that population based

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algorithms can be both guided and random at once, allowing the ability to handle nonlinear problems in wide search spaces. There is a plethora of literature in GAs and its variants. From the early primitive genetic algorithms, many patches were introduced, such as steady state GAs (SSGA), so as to eliminate the flaws that are inherent to this method. Still yet, in all of the many proposed heuristics, the bottom line has not changed. The search has been made by homogenous populations. Other than the fitness values of the units, no discrimination could be made in between the individuals.

Different aspects to optimization methodologies have been devised. To start with the most relevant one, Ozdemir et al. [1] proposed a new, fast and robust training algorithm. Responsive Perturbation Training (RPT) is an error-driven process, which performed better than derivative-based trainings. In this new technique perturbation replaces the crossing, which guarantees that all the offspring are the variations of the best individual. Alpay et al. [2] introduced an addition to Responsive Perturbation Training, Trait-Based Coding Aging Scheme. In this method human like characteristics are given to the individuals. Each characteristic has different number of individuals and search radii.

Aparicio and Solari [3] estimated the stochastic fluctuations of the populations around these equilibrium points, and the relation with mean values. This model has an approximation to birth, contagion and death phenomena, whereby results were obtained through diffusion approximation. Pekalski [4] examines the evolution of a population subject to changing conditions. Here, the ability of a population to adapt to changing environments was investigated. Results show that populations adapt to harsh conditions to a certain extent, or else, seek new domains to colonize. Maksymowicz et al. [5] employs a computer simulation for population evolution, where fluctuations due to growth dynamics, hunting and ageing were considered. The simulation is an extended Penna model with bit-strings. As for the dominance, Chaichian and Wagner [6], discusses evolution of dominance. Workers claim the dominance to be a form of a phenotypic robustness to mutations. Turney [7] introduced the Baldwin Effect and the trade-offs between the lifetime learning (phenotypic plasticity) and instinct (phenotypic rigidity) in terms of energy, CPU consumption, adaptability, variance, reliability, learning period, bias direction etc., and claimed that, at first, learning will be an advantageous aspect in evolutionary terms but later it is not. Suzuki et al. [8] considered the Baldwin Effect in dynamic environments, and they discussed the similarities and the differences in evolutionary dynamics concerning the Baldwin Effect in a population of globally interacting agents and the one of locally interacting agents.

3. Trait-based Heterogeneous Populations Plus (TbHP+)

The TbHP+ contains features such as immunity (credit) and instinct (bias or exploitation). The concept of credit assignment goes as far back as Minsky in the 60s with his seminal work. Exploitation and exploration had been formulated as a dilemma by Sutton and Barto in the theory of Reinforcement Learning. To the knowledge of the authors, these two ideas are new to population based algorithms. Separating the individuals by traits and assigning credit to traits, and thus to the individuals, is a novel notion. Exploration vs exploitation dilemma has been articulated by various researchers in different forms, and problems had been observed as early as late 19th century by workers such as Baldwin.

Instead of a life-long learning, either of the learning (exploration) or instinct (exploitation) is turned on and off monitoring their performances. When the simulation is in the instinct mode, if the performance (fitness) worsens, it is switched off, and learning resumes. Instinct model is selected as the vector direction of the fittest individuals. After δ epochs, if the vector direction is the same, in the following epochs, the fitness evaluation will only be executed for the individuals that are perturbed in that direction, Fig. 1.

As for the immunity, it is acquired by the use of the credit system, where the fittest individual in the most recent epoch gets one credit for its trait, and that credit gives immunity to the related trait individuals in case of partial elimination. If a trait is leading the convergence in successive epochs, the chance of elimination of individuals with that trait is less than that of the others which have no credit for the case. The credit system shuns a complete extinction of the weaker traits. This is achieved by a lower limit on every trait. In a much less similar way, a renewal process also takes place. When an earlier unsuccessful trait performes better, that trait becomes the dominant trait with the addition of newer members until an upper limit is reached. This is to make sure that the population of successful individuals does not go out of proportion.

Table 1. “Population Distribution”

Trait	Step 1	Step 2	Step 3
Greedy	0.4 N	0.3 N	0.05 N
Curious	0.2 N	0.1 N	0.05 N
Normal	0.1 N	0.2 N	0.25 N
Conservative	0.1 N	0.3 N	0.6 N
Fickle	0.1 N	0.05 N	0.03 N
Erratic	0.1 N	0.05 N	0.02 N

N: Total number of individuals

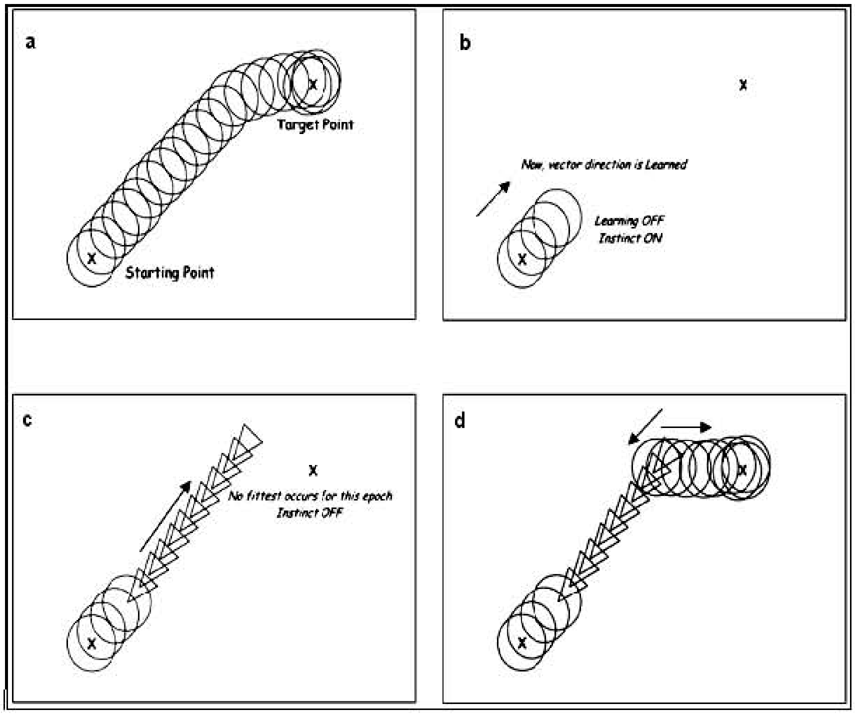

Figure 1. "Simulation of instinct"

5. Simulations

Current simulations were made on 5 different configurations in primitive to complex order. At first, the algorithm has a population that consists of just three traits. In this primitive study the aim was to construct a starting point for the development period. In the second step, aging process is added to the population, where a little time increase and error decrease are expected. Unfortunately, the output showed that error percentage and time values have increased. After the inspection, it was found that in 3 trait populations, many trial simulations resulted in divergence. The error of 3 trait population is the error of the ones which the algorithm eventually has converged. As later seen, aging proved to be the cure to the divergence problem.

For the next step, 3 more traits were added to an eventual 6. The number of individuals of a certain trait in the population and their percentage intervals are taken from the previous study [2], Table 1. CPU time increased because of the increase in trait kinds and equations; however, error percentage decreased considerably in this step. After error decrease was achieved, the trait number is fixed at 6 and the further additions were included. After the addition of instinct to the algorithm in the next step, a slight time reduction is observed. On the other hand, again error percentage decreased considerably in this step.

Data to train the RBF network weights were taken from [9]. The data belong to a machining experiment on a lathe, where a timed material removal operation under controlled conditions takes place. The results are compared with the previous study [2] and a considerable decrease in error has achieved for the case.

Table 2. "The combined effect of bias (instinct), ageing and credit (immunity)."

	3 Traits	**3 Traits Aging**	**6 Traits Aging**	**6 Traits Aging Instinct**	**6 Traits Aging , Instinct Immunity**
Error %	11,62	13,3	9,19	8,42	7,42
Time	2,74	2,84	3,07	3,04	2,4

Table 3. "Comparison of the results with [2]

Original Test Data	*RBF with SON 11 Clusters*	*RBF with SON 13 Clusters*	*RBF with SON Every datum is a center*	*RPT 10 individual (1)*	*RPT 10 individual (2)*	*Trait Based Heterogeneous Populations (TbHP)*	*Trait Based Heterogeneous Populations Plus (TbHP+)*
66	67,00	67,30	67,80	66,52	69,06	64,32	62,42
66	59,80	59,70	61,80	60,77	64,10	72,31	68,53
81	59,80	55,00	65,50	62,01	70,05	75,01	74,91
53	45,50	44,60	44,80	49,60	65,53	51,13	55,70
79	78,80	79,90	86,80	84,34	85,34	81,90	79,65
Error	*23,29*	*28,00*	*19,69*	*13,26*	*11,65*	*9,51*	*7,99*

6. Conclusions

In this study, a new version of perturbation training approach was introduced. This time populations of homogenous individuals were transformed into populations of heterogeneous individuals. Individuals with the highest fitness became the current dominant character and yielded offsprings that carry predominantly the traits of the winner parent. Ageing has caused a greater percentage of the population to concentrate in and around the center. Not only the perturbation amplitude of the individuals were dampened to pinpoint the solution set but also more individuals were put to work close to it

A phenomenon, known as "population migration", has also been simulated. Population migration occurred only as a natural extension to young frivolous populations being replaced by the conservative old. Populations are not allowed to stay fixed in the domain but rather move around autonomously.

After the addition of concepts, such as instinct, immunity, renewal of individuals and the reduction of the weaker individuals in number, it is observed that there exist a considerable decrease in CPU time consumption and a considerable increase in the efficiency of the solutions. Addition of aging to the system eliminates the divergence problem while increasing number of trait types to a value makes the system more reliable, although it increases the computational time. This increase can be negated by the addition of instinct, which can be described as the vectoral direction in the algorithm. Moreover, instinct also adds additional reliability to the system.

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