Volume 5, Issue 2
April 2016

ITEE Journal
Information Technology & Electrical Engineering

ISSN: - 2306-708X

An Interactive Cognitive Approach to Evaluate the State Space of the Solutions

Humera Farooq and Muhammad Tariq Siddique

Department of Computer Science,

Bahria University, Karachi, Pakistan

E-mail: humera.farooq@bimcs.edu.pk, mtariq@bimcs.edu.pk

ABSTRACT

Natural User Interface is a branch of Human Computer Interaction that deals with effectively invisible complex interfaces. These interactive environments are developed to investigate and evaluate the solutions with the help of user feedback. On the other hand, the cognitive sciences are a new multidisciplinary field that used to learn the computational and neural capabilities of a user. It is also helpful to judge and observe the human thinking and decision ability, especially when they deal with the complex problems. In the proposed approach the human interest and understanding with the solution present in the state space has been investigated. The involvement of human interest can bring the solution in less computational time. Hence, the human intervention involved to bring the optimal solution. For this purpose Genetic Algorithm has been selected to visualize on 2D Graph. The emphasis of presents research work is to evaluate the cognitive skills of human to judge their better understanding with the designed interface. The experiments were conducted to evaluate the ability of the user to understand the designed a test bed based on an interactive environment with different searching problems. The comparative study has been carried out based on different searching problems i.e. Feature Selection from Electroencephalogram data, Reconstruction of 3D objects and Modeling of Trees.

Keywords: *Evolutionary Algorithm; Visualization; Human Computer Interaction; 2-D Graph; Cognitive Science*

1. INTRODUCTION

Natural User Interfaces are Artificial Environment that enlarges the integration of cognitive sciences with computational approaches to solve the complex problems. Genetic Algorithm (GA) is a dynamic random searching algorithm based on the natural inspired methods. It is commonly used to solve the optimization problems in different fields of engineering and medical. GA that is based on the Darwin's theory was proposed by John Holland [1] to explain the adaptive process of natural systems [2].

The cognitive science is the field that involves the study of human thinking and methods to solve scientific problem. It studies how people acquire and apply knowledge or information in different environments. Another future of using Cognitive Science is to describe the mental processes of a human in terms of rules or algorithms as an information processing models [3-5]. Human Involvement in Artificial environment is used to develop friendly, interactive, usable and natural interfaces. These Natural Interfaces used to develop a computational environment that helps to understand the cognitive process in depth [6].

On the other hand the visualization technique facilitates the development of interactive environment that is based on the evaluation or selection of results in different applications [7, 8]. This technique also helps to visualize the internal process of algorithms to understand their functionality and behavior [9-11]. Several natural environments that consist of an interactive visual tools has been reported in last two decades which have been used to explorer the state space of GA [12-13]. These interactive environments have been developed to retrieve the user input.

The user input helps to accelerate the searching process or to select the solution according to the user choice. An interactive approach has been used to evaluate evolved individuals using different intensities of gray color for the application of fashion design [14]. Another application of Interactive Genetic Algorithm was to organize the room plans and the layouts of workplace [15]. In this existing work, the user selects the existing generated design layout.

Section 2 describes the prior work done on cognitive approaches, visualization and human interfaces. Section 3 covers the proposed approach. It also discusses different modules of test bed. Section 4 discusses the results of our experiments. We conclude and provide the future directions in Section 5.

2. RELATED WORK

The traditional ways of searching the best solutions is to remain continues until the optimal solution has been found, however in an interactive environment of GA the searching process stops according to the user's decision. In this way, the interactive environment becomes a continuous interactions process for the users which is a tiresome activity. Numerous works has been reported for proposing the methods to decrease and evaluate the user tiredness [16-18]. For example, a rating method has been used to estimate the human tiredness [16]. Besides evaluating the existing individuals, the different population size has been introduced to solve the tiredness problem [17]. Another approach was to propose a grid-based knowledge system to reduce the human tiredness in [18]. A three dimensional irregular memory grid has been developed in this existing work in order to save all state space solutions along with their fitness value.

Volume 5, Issue 2
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Beside a tiresome activity, this continues interactions also give unwanted solutions [19, 20]. Hence, the interactive environment is developed for evolving small number of generations and population size in order to help the user from a tiresome activity of searching [21]. Additionally, the user

Tiredness problem also being solved by using model based solutions [21, 22]. One drawback of using these visual models is that the user remains unaware with the internal complexity of problem and unable to judge the subjective requirement for designing a user interface.

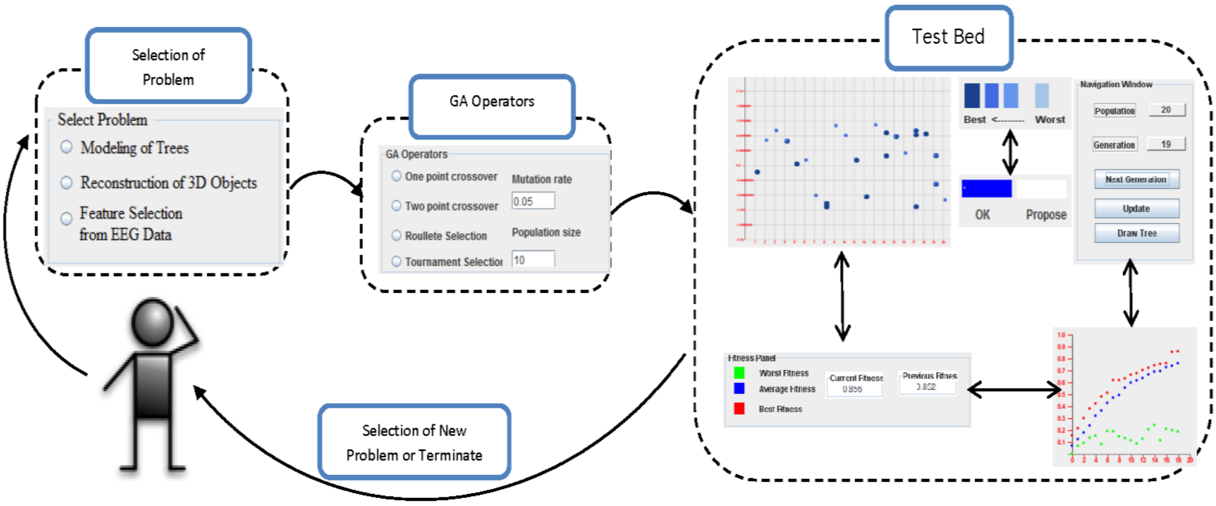

Fig. 1. A Test Bed: Interactive Environment for three different Optimization Problems

The improvement in cognitive skills is important to grasp the right solution from the provided solutions in an interactive environment. In order to evaluate and verify these problems the proposed approach is based on an interface design. This interface design is based on the visualization of the Genetic Algorithm and to solve three different optimization problems.

3. PROPOSED METHOD

In order to understand the cognitive skills of a user, a test bed has been developed that is working as interactive environment for three different optimization problems as shown in Fig 1. This interactive environment may use to evolve Feature Selection from Electroencephalogram (EEG) data, Reconstruction of 3D objects and Modeling of Trees.

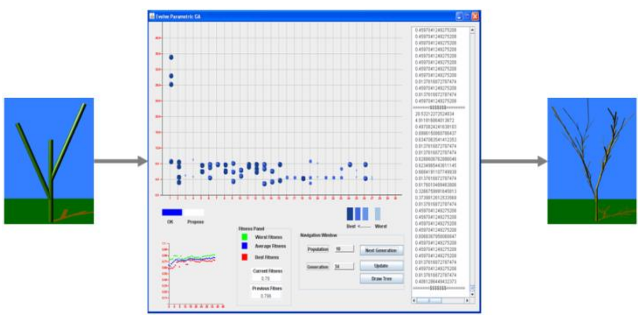

Fig 2. Modeling of 3D Trees from 2D Tree using Parametric L-System

The Genetic Algorithm has been visualized in a 2-D Plotter. The purpose of the developed test bed is to evaluate the cognitive skills of human while evaluating different applications in the same interactive environment. The user may select different crossover operation and mutation values. The termination and decision of the final output of any problem in search space is taken by the user.

A. Modeling of Trees

In proposed approach, the modeling of trees has been done using Parametric L-System. An L-system or Lindenmayer system is a parallel rewriting system and a type of formal grammar. In Parametric L-System different parameters are associated with symbols to give dynamic and different branching structures. The user provides an input L-System grammar and initial parameters. The Parameters of L-System then send to GA for initializing a random population. The fitness function is based on the Euclidian distance between initial parameters by user and randomly generated parameters by GA in every generation. The user interaction bring continues real time changes in every next generation. The user may see the resultant trees of every generation generated by Parametric L-System in a separate window as shown in Fig 2. The user may terminate the searching process after getting the desire solution.

ITEE Journal
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ISSN: - 2306-708X

B. Reconstruction of 3D Objects

Reconstruction of 3D objects depends on the 2D primitives of an image that will be provided by the user [23]. For experimental purpose, we have selected geometrical shapes only. The developed interface is capable to retrieve the geometrical primitives from the 2-D images or hands free sketching by the user.

The chromosome encoding is based on the randomly generated values for third dimension as shown in Fig 3. Then the fitness function has been formulated to calculate the third dimension primitives. The fitness function is based on the Euclidian distance between 2D parameters given by user as input and randomly generated third dimension parameters by GA in every generation. The user intervention may lead to decide the desired shapes and may terminate the searching process in any generation.

C. Feature Selection from EEG Data

The Feature Selection of EEG data is based on the user's input that is based on the required channels from EEG data [24]. The fitness value is set according to the user's input and the randomly generated solutions based on the channels information. The user may monitor the output of each generation; interact with the current generation by providing the required data information again. The user may terminate the process on any generation number.

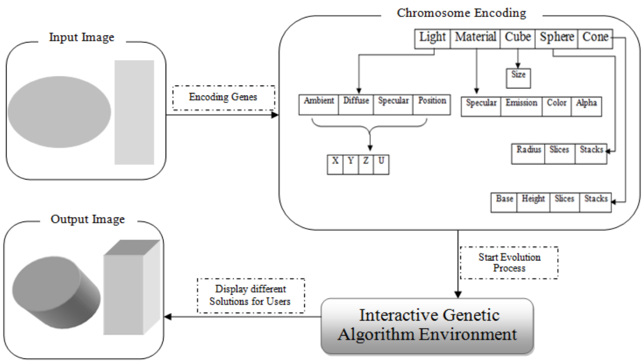
4. EXPERIMENTAL RESULTS

In the presented research work, the cognitive skill of humans has been evaluated to select the best solution from the state space. Ultimately, the searching ability of human has been used to obtain the best solution. The experiments were carried out based on the comparative results or observations of user experience with different problems using same interactive environment. For comparative evaluation, the same GA parameters and operators, i.e. length of chromosome, size of population, same number of generations, selection method, and crossover and mutation rate were used. In order to evaluate the performance of the proposed approach, following are the some parameters that remained same for all experiments.

- The same group of users requested to evolve at least two problems
- Each experiment was performed 10 times with initial population size =10
- A Each experimental result was performed with maximum 10 interactions
- 100 generations was evolved for every run.

The purpose of the proposed approach is to evaluate the understanding of users with Interactive Environment of GA and to decide the interactions according to tips given in the environment for understanding gene convergence and to do interaction. On the other hand, in proposed approach the interactions are not fixed to some pre-defined parameters. Additionally, the termination of proposed approach is based on user perception.

Fig. 3. Chromosome Encoding for Generating 3D from 2D Objects



A. Evaluation of Performance of Interactive Environment

For the experimental results, 10 participants were invited to run the interactive environment with different problems. These participants were undergraduate and postgraduate students of the ages 22 to 40 years old. All the participants do not have equal background relevant to the proposed approach. For this reason, the proposed approach evaluated on the basis of different users' abilities and perceptions. For example, a few of these users have a good knowledge of the Parametric L-System but have no knowledge for GA. Moreover, some of the users having knowledge regarding EEG data but do not know about the rules or the grammar of the L-System. In this way, the results and convergence rate were recorded with different observations, based on the users' skills. Experiment demo were given to these users for understanding the nature of the proposed approach. The participants were also informed that they can interact at any generation during the searching process. They were also informed about the different colors used in visualization for understanding the searching process. Table 1 shows different observations and analysis based on the understanding of different users with different features of proposed approach.

TABLE I. DIFFERENT INTERACTIONS AND THEIR DIFFERENCES.

Runs	**Interactions**			
	Total	***Accepted***	***Discarded***	***Pop-Size***
R1	10	10	0	20
R2	10	9	1	19
R3	10	10	0	20
R4	10	10	0	20
R5	10	8	2	18
R6	10	8	2	18
R7	10	7	3	17
R8	10	9	1	19
R9	10	10	0	20
R10	10	8	2	18
Average Generation for Interactions	9.6	8.9	1.1	18.9

ITEE Journal
Information Technology & Electrical Engineering

ISSN: - 2306-708X

Fig 4 shows a graphical representation of accepted, discarded, population size after interactions and the overall performance during different experiments.

B. Utilization of the Cognitive Skills of Users

The proposed test bed has been used to evolve three different problems using GA. The efficiency of the proposed approach has been monitored by the results retrieved by user interactions. A statistical analysis shows that the designed interface gives a suitable understanding to the users for the distribution of the gene values in different generations. It was noted that for a user, it was a difficult to take decision to make the interactions in the initial 20 generations. However, it was observed that after 20 generations, the gene distribution on 2-D graph became easy to understand and to do the interactions.

Fig 5 (a) shows the visual representation of Modeling Trees for generation 10, in which the gene values are distributed in the overall search space. Fig 5 (b) shows the gene distribution with 3 interactions and Fig 5 (c) shows the gene distribution without interactions after 40 generations. A prominent difference was noticed in the gene distribution with and without interactions for the same generation numbers. It was also noticed that the proposed approach has some limitations especially from the human interaction perspective, i.e. lengthy chromosome that create user fatigue.

Therefore the maximum length of a chromosome suggested was 20. In the proposed method, every successful interaction of user will increase population size. Thus, for the proposed method the initial population size that was 10 and 20 became 18 and 29 after 100 generation with 8 and 9 successful interactions. Thus this dynamic increment in population size gives a larger state space interactively. The decision to go for the interactions was a critical point in the proposed approach.

A continuous observation had been done on the users to gauge their understanding for the next interactions. For example the evaluation of human understanding for location of gene values, the color of gene values and also the convergence graph of fitness versus generation. The impact on population size due to the interactions was also observed. In most of the experiments, the resultant population size was 50 percent bigger than the initial size. This feature gives a facility to use a wider search space interactively.

C. Discussion and Observations:

The experiment was done to elaborate the advantage of using cognitive skills in order to improve the searching ability of Genetic Algorithm. For this reason, the understanding of gene distribution of the search space on 2-D Graph play vital role for optimal user interactions. It was noted that in the first 20 generations, the decision of interactions was based on the color intensity as compared to the higher generations in which all the gene values were distributed at some specific location. It was observed that the user' decisions for interaction became easy with the more number of generations.

The results show that the better usage of cognitive skills of human can bring a prominent difference between convergence rates from generation to generation. It was noticed that proposing new individuals in several generations brings a prominent change in the searching process. Additionally, in the proposed approach an increment in population size after each successful interaction also gives a wider search space, which helps the proposed method to converge actively as compare to SGA.

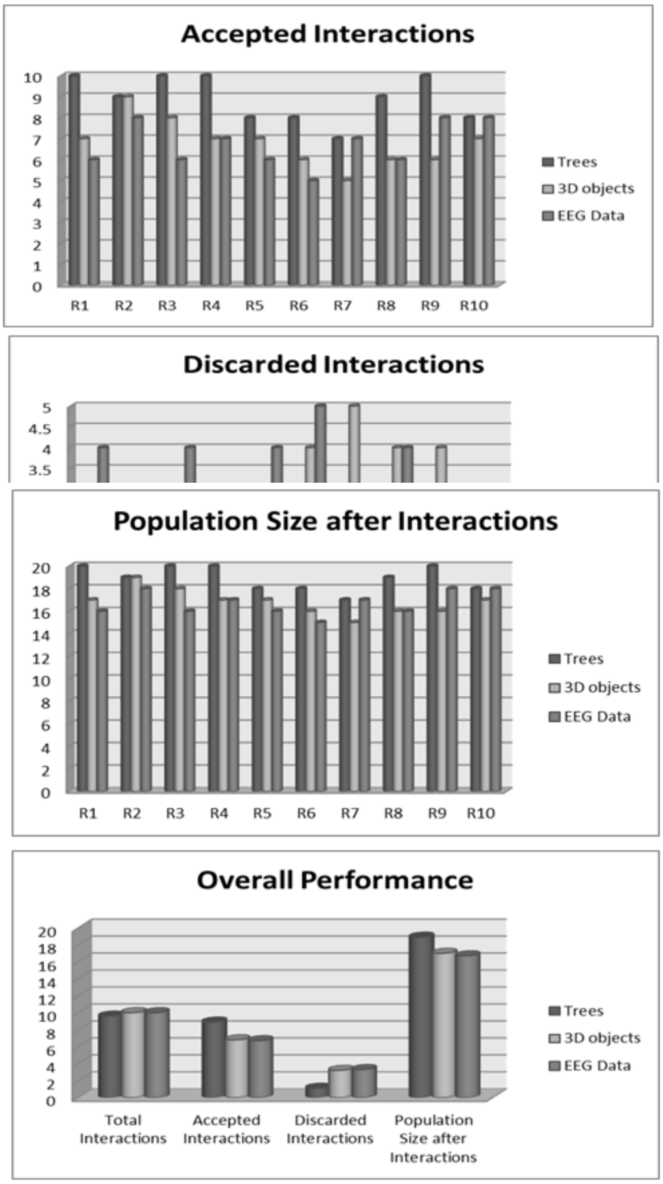


Fig.4.Performance of Proposed Approach with Three Different Problems

5. CONCLUSION AND FUTURE WORK

The purpose of presented research work was to evaluate the cognitive skills of human to understand the search state. Another objective of the proposed approach was to accelerate the performance of GA searching by proposing a fitter solution in the search space with the help of user interactions.

Through different experiments and observations, it was found that the 2-D graph visualization technique is a better technique to monitor all changes going on in the search space. By using 2-D visualization technique, interaction of user, can be controlled and monitored easily and clearly. The user can monitored the gene values at different locations using 2-D Graph. Further, a 2-D graph also helps to look into details the process of the searching behavior used by GA, specifically, which part of search space has optimal or less optimal gene values.

For testing the performance of proposed method with parameters, different variable lengths of chromosomes were input to proposed method. Different selection methods, crossover and mutation rates were also used to do the experiments. Multiple runs of the proposed approach also show that there is a difference in the performance of GA by using different operators or their values and with different problems. Working on the proposed test bed has generated several interesting and promising ideas which will be explored in the future to address the problem of visualization of the Interactive Genetic Algorithm more efficiently.

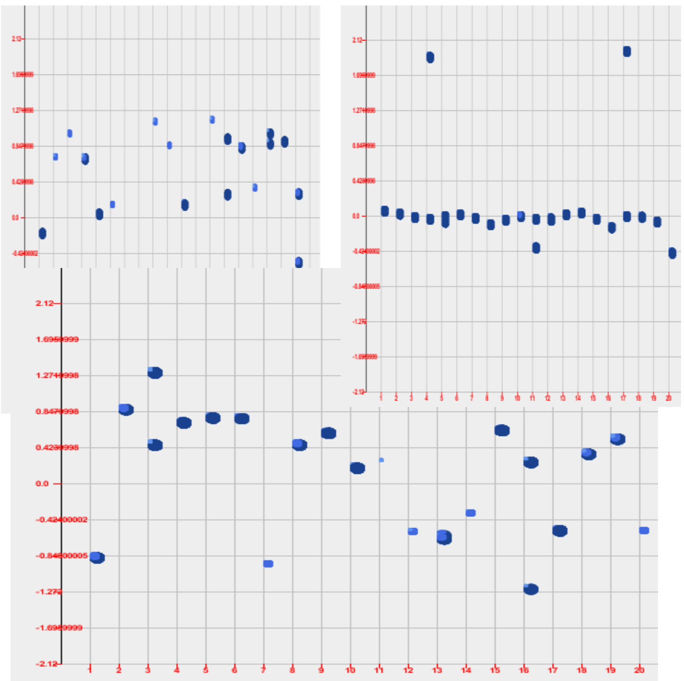


Fig 5 (a) : Gene Distribution at Generation 10

Fig 5 (b): Gene Distribution at Generation 40

Fig 5 (C): Gene Distribution at Generation 80

Fig 5: Gene Distribution for Modeling Trees at different generations

6. ACKNOWLEDGMENT

This work is conducted and supervised under the 'Intelligent Systems and Robotics' research group at Computer Science Department, Bahria University, Karachi, Pakistan.

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AUTHOR PROFILES

Humera Farooq received her Ph.D. in Computer Science from Universiti Teknologi PETRONAS, Malaysia. She is currently working as an Assistant Professor in Bahria University, Karachi, Pakistan. She is also head of Intelligent Agents and Robotics research group. Her research interests lie in the field of Image Processing and Artificial Intelligence with special focuses on Genetic Algorithm, Crowd Analysis, Brain Computing and Cognitive Informatics.

Muhummad Tariq Siddique received his master’s degree in Computer Science from BZU University, Pakistan. He is currently working as an Assistant Professor in Bahria University, Karachi. His research interest lies in the 3D Animations, computer graphics, computer vision and evolutionary algorithms.