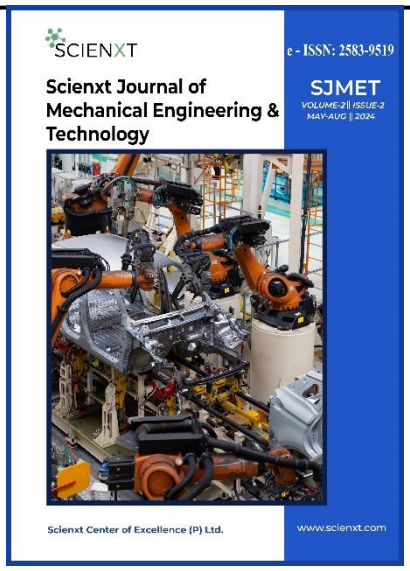

Scienxt Journal of Mechanical Engineering & Technology
Volume-2 || Issue-2 || May-Aug || Year-2024 || pp. 1-17

Study of genetic algorithm

[*1]Dr. Shweta Chourasia, [2]Bittu Yadhuwanshi, [3]Bipin Chandra Pal, [4]Bheem Chouriya, [5]Ashish Kumar Verma

[*1]Associate Professor, Department of Electrical Engineering, Bhopal Institute of Technology Bhopal
[2,3,4,5] Mtech Scholar, Department of Electrical Engineering, Bhopal Institute of Technology Bhopal

**Corresponding Author: Dr. Shweta Chourasisa*
Email: chourasia3012@gmail.com

Abstract:

Optimization become a huge problem among researchers in years of 60's, it take the researchers attention in the developing the powerful algorithm which can remove this problem. I the years of 60's-70's of 19^{th} century, the three basic approaches were proposed as an evolutionary algorithm in order to get rid of the problem of optimization. These approaches are, evolutionary programming (EP), evolutionary strategies and genetic algorithm. In this paper we will discuss the application of Genetic Algorithm, advantages etc.

Keywords:

GA, EP, Global Optimization, mutation

1. Introduction:

Genetic approach is broadly used a population. Genetic algorithm is applicable for stochastic search and various optimization techniques due to its power. It is the most popular approach in evolutionary computation methodologies. Evolutionary computation of Genetic algorithm of has encouraged by the theory of Darwin's written for the Evolution. The feature of GA is finding the possible solutions with the help of generating the number of populations. These solutions are encodes in the form of chromosomes. These chromosomes uses the fitness function is applied to check these commodores. After that in order to create the new population the two operators have been used those are mutation and crossover. These processes are repeated until the searching element is found. There are some basic elements which have been used by the genetic algorithm discussed below [1].

1. A genetic representation of solutions to the problem;
2. A way to create an initial population of solutions;
3. An evaluation function rating solutions in terms of their fitness;
4. Genetic operators that alter the genetic composition of children during reproduction;
5. Values for the parameters of genetic algorithms.

Genetic algorithm uses a special value called fitness values for specific chromosomes to achieve the replica of these activities. When the reproduction will perform, then the crossover operator needs to apply. This operation uses two single chromosomes. After that the operator exchanges their parts and its gene value is changed randomly. This action will do on the location of the any chromosome which has selected randomly. A genetic algorithm (GA) is a method for solving both constrained and unconstrained optimization problems based on a natural selection process that mimics biological evolution. The algorithm repeatedly modifies a population of individual solutions. At each step, the genetic algorithm randomly selects individuals from the current population and uses them as parents to produce the children for the next generation. Over successive generations, the population "evolves" toward an optimal solution.

You can apply the genetic algorithm to solve problems that are not well suited for standard optimization algorithms, including problems in which the objective function is discontinuous, non differentiable, stochastic, or highly nonlinear.

1.1. Genetic optimization:

Main concern of Search optimization is too minimized or maximized solutions of a function on basis of some variable with regards to dynamic constrains. Optimization serves a very vital role in engineering design, research operation and management. Traditional optimization technique cannot capable to solve many complex and difficult industrial engineering design problems. So in last decades a new novel , immerging , simple , ease to operate , minimal requirement and having very parallel and global perspective search optimization technique had introduce and got a very payable attention is known as genetic algorithms[1].

1.1.1. Global optimization:

Global optimization is use to differentiate global optimum with numerous local optima within a region of interest. Generally global optimization is serve take attention for unconfined optimized problem ie without any restriction problem can minimize and maximized the function. A traditional global optimization technique comes with two different failover where first one is deterministic methods and second one is stochastic methods.

1.1.2. Constrained optimization:

The main focused of unconfined optimized problem is to optimized objective function with equality and inequality restriction. Confine problem solution cannot model many practical problems successfully whereas unconfined optimization methods serve a very vital role in nearly every region of engineering, mathematics and operations research.

1.1.3. Combinatorial optimization:

Combinatorial optimization problems are described with the help of number of finite feasible solutions. Even the normal inventory can able to find optimal solution for such a finite problem but for frequent problem it’s impossible to generate optimal solutions every time, particularly for practical problems having realistic size where the quantity of feasible solutions can be tremendously high. Combinatorial optimizations have numerous predicaments with unlike features and properties. Even if these predicaments are moderately dissimilar from each other and can be characterized as follow [1].

- To evaluate the permutation after associate some item with their problem.
- To evaluate the combination of some items;
- To evaluate the both permutation and combination of some items;

- Any one of the above subject to some constraints.

1.1.4. Multi-objective optimization:

In earlier 1960 multiple –objective search optimization get the great attention from researcher. Multiple objective optimizations use multiple objective functions simultaneously for optimization and there is not any best solutions as genetic algorithms has, among all the objective function. So researcher introduce a genetic based multi objective optimization ie knows as evolutionary multi-objective optimization or genetic multi-objective optimization.

1.2. Genetic algorithm:

Genetic algorithms are one of the best ways to solve a problem for which little is known. They are a very general algorithm and so will work well in any search space. All you need to know is what you need the solution to be able to do well, and a genetic algorithm will be able to create a high quality solution. Genetic algorithms use the principles of selection and evolution to produce several solutions to a given problem. Genetic algorithms tend to thrive in an environment in which there is a very large set of candidate solutions and in which the search space is uneven and has many hills and valleys.

2. Genetic algorithm and digital circuit:

2.1. Search optimization:

In any type of searching keyword can search from the large number of data set. It may possible that there exist various paths to find the results. Here the search area is known as the search space. For an example, the search space is the large number of group of all protein sequences which is possible.

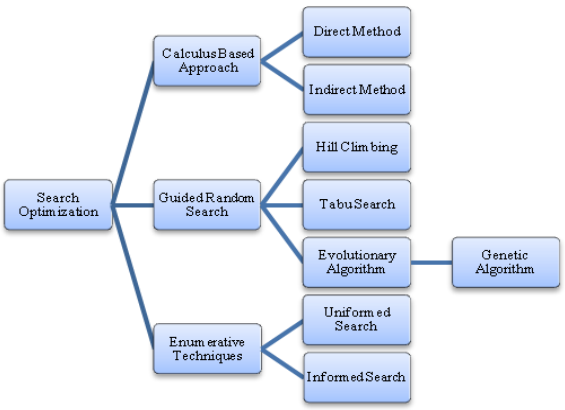

Figure. 3.1: Classification of Search Optimization

2.2 Genetic algorithm:

John Holleand is a man who introduced the genetic approach first in 1960s. He just suggested the algorithm. After that his students and colleagues helped him in order to implement the algorithm. It was done in the same year. The whole work is done in the University of Michigan. The genetic algorithm is based on the population. This approach is known as the good problem solver where the problems are very hard. So that there are no standards defined for GA. Basically GA is used as an optimization technique. An optimized technique where the solution can be find out by generating the population of the problem. It seems to be that the Genetic Algorithm is type of evolutionary algorithm. It is also a part of heuristic search in which the heuristic search is an adaptive algorithm. The whole idea is focuses on the natural selection and genetic.

The genetic algorithm is a basically used for searching and it is also an optimized technique. This approach is based on the principal of Drwins of natural selection. Genetic algorithm represents an intelligent exploitation of random search used to solve optimization problem. In short we can understand the natural selection which means “select the best, discard the rest”. GA can be applicable as direct and parallel as well. It is also the stochastic method in order to global search and optimization as well. As the classification of searching algorithm the Genetic algorithm is belong to Evolutionary Algorithms. The evolutionary algorithm always uses the basic three main principles. These are reproduction, natural selection and diversity of the species. All these steps belong to natural evolution. GA performs using the group of individuals and representing possible solutions of the problem. In this approach the selection criteria will given by the evaluation. This evaluation uses with respect to desire solution.

As we have previously discussed about the John Holland who first pioneered the genetic algorithm. Genetic algorithm is deeply studied by the various authors. Now GA has a number of experiments which shows the various applications in lots of area of the engineering worlds. Genetic algorithm is not only use in order to get the different or alternative solutions it also continues performs other conventional approaches in most of the problems. It seems to be that number if real world problems trying to get the optimal parameter, it can show that the difficulty for conventional approach but ideal for GAs [5]. Some time Genetic algorithm has been wrongly regarded as a function optimizer because of its terrific performance in the field of optimization. In fact, there are many ways to view

genetic algorithms. Perhaps most users come to Genetic algorithm as looking for a problem solver.

2.3. Genetic algorithm operators:

Genetic algorithm encompasses mainly three interrelated operation namely selection, crossover and mutation. During the process of cell division of human chromatin (present in the core and constructed from the DNA (deoxyribonucleic acid), protein and RNA (ribonucleic acid)) becomes shorter and thicker and chain forms spirals - chromosomes. These chromosomes are the genes that are inherited cellular information. Each gene codes for a specific protein and is the independent factor of the genetic information that determines the appearance of different specificities. In genetic algorithms, chromosomes together represent the genes encoding the independent variables. Each chromosome represents a solution to the problem. Individual and vector variables used other words the chromosomes

2.4. Selection operators:

The selection operator chooses chromosomes of the current generation to be parents of the next generation. The operator is responsible for the selection of the algorithm convergence. The methods may be used as operators of the genetic algorithm coded actual reproduction are:

1. Rank selection
2. Tournament selection
3. Roulette wheel selection
4. Steady state selection
5. Elitism

Selection is the scene of a genetic algorithm that individual genomes are chosen from a breeding population later (recombination or crossover).

A generic selection procedure may be implemented as follows:

1. The fitness function is estimated for each individual on the basis of presented fitness values and then normalized. Normalization means for dividing the physical condition of the subject by the sum of all values of conformation, so that the sum of all the resulting values is wrapper 1.

2. The population is arranging in descending order on the basis of fitness values.
3. Normalized cumulative fitness values are calculated (the accumulated value of the fitness of an individual is the sum of its own fitness value and adaptation of all previous individual values). The cumulative capacity of the last person who should be 1 (otherwise something went wrong in the process of normalization).
4. A random number (R) is chosen between 0 and 1.
5. The selected individuals having highest accumulated normalized value with compare R as first.
6. If this procedure is repeated until enough people selected, this selection method is called form of proportional selection or the selection of the roulette wheel. If, instead of a single pointer yarn several times, several pointers evenly spaced on a wheel which is rotated once, is called universal stochastic sampling. Repeatedly selecting the best individual from a randomly selected subset is tournament selection. Taking the best, third, or other proportion of individuals is truncation selection.
7. There are some other selection algorithms that do not consider each individual selection, but only those whose fitness value is greater than one (arbitrary) constant data. Other algorithms to select a small group in which only a certain percentage of people are allowed on the basis of the value of fitness.
8. Retaining the best individuals in a generation unchanged in the next generation, is called *elitism* or *elitist selection*. It is a successful (slight) variant of the general process of constructing a new population.
9. Retain the best individuals from one generation unchanged in the next generation, called elitism and elitist selection. This is successful (slight) variation of the general method of construction of a new population.

Genetic algorithm (GAs) is a stochastic optimisation technique that can often outperform classical methods ofoptimisation when applied to difficult real world problems. Genetic Algorithms are searchingstrategies suitable for finding the globally optimal solutions. The main advantage of using GAs is that they can find global optima without being stuck at local optima in the solution space. The GA technique is robust and can deal successfully on a wide range of problem areas. GAs and its variance have been extensively used in the past.

GA researchers have been aware that there are multiple solutions for a given problem but the traditional GA proves to be quite efficient, which converges to one of the best possible

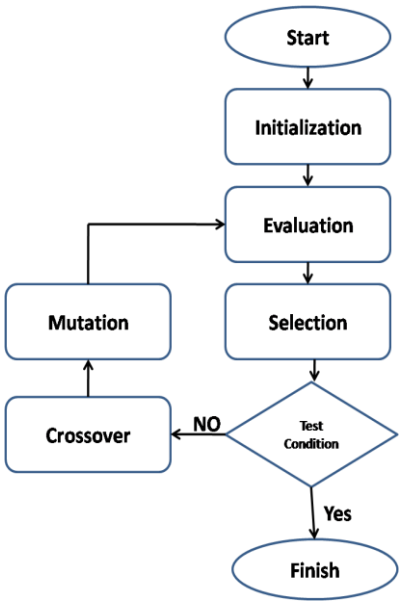

Figure. 3.2: Flow diagram of genetic algorithm

The natural law of evolution is derived from Darwin's theory of evolution. According to this theory, reproduction and mutation play vital role. While reproduction leads to amalgamation of different chromosomes and hence, creation of individuals having hybrid characteristics with genetic properties derived from both parents by inheritance, mutation is a factor that causes changes in the basic chromosomes structure itself, and thus leads to diversity of the population.

Genetic Algorithm based on the above mentioned phenomena and can be used for optimization of the given problems by processes of reproduction and mutation. Genetic Algorithm generates valuable solutions for hard optimization problems using techniques that are inspired by natural evolutionary operators, such as inheritance, mutation, selection, and crossover.

2.5. Rank selection:

Rank selection first, the population and each chromosome receives fitness from this ranking. The worst thing is a club, second worst 2 etc. and the best physical and N (number of chromosomes in the population) form.

2.6. Tournament selection:

Tournament selection is a method of selecting an individual from a population of individuals. Tournament selection involves running several "tournaments" among a few individuals chosen at random from the population. The winner of each tournament (the one with the best fitness) is selected for crossover. Selection pressure is easily adjusted by changing the size of the tournament. If the tournament size is larger, weak individuals have a small chance of selection intensity are called selected.

Table-2.1: Relation between tournament size and selection intensity

Tournament size	1	2	3	5	10	30
Selection intensity	0	0.56	0.85	1.15	1.53	2.04

2.7. Roulette selection:

Selection of roulette, the most popular method cannot cause the total transformation of genes "type in population since the method selects only one chromosome and copy it from the body before group depending on the size and the probability of a given method, itself does not change gene [12].

In addition, the method has a weakness that is not always due to the selection by the selection of the fittest for the stochastic property. Deterministic sampling is designed to cover the weakness of selection roulette wheel, and the method is comparable to the sample remains with stochastic replacement. The method is first, the entire size of the expectancy value of each chromosome. In the second, the method assigns chromosomes depending on the size of decimals of each chromosome and chromosome size selects a decimal.

2.8. Steady state selection:

This is not a method for the selection of parents. The main idea of this is that much of chromosomes to survive next generation. GA then operates as follows. To create a new offspring chromosomes - each generation are some selected (with a strong good fitness). Then some (bad - with low fitness) chromosomes are removed, and offspring will be put in their place. The rest of the population survived the new generation.

2.9. Elitism:

Idea of elitism has been established. When creating new population by crossover and mutation, we have a big chance that we will lose the best chromosome. Elitism is the name of the method that first copies the best chromosome (or at best a few chromosomes) to the new population. The rest is the conventional manner. Elitism rapidly increases performance of GA, because it prevents the loss of the best solution found.

3. Crossover operator:

After completion of the process of reproduction, we check the chromosomes generated unit populations and exchange information on genes. The arithmetic crossing on a theory of convex sets based expansion of an intersection which discontinuity has occurred in a simple intersection. A crossover operator is used to recombine the two channels so as to obtain a better channel. In the cross recombination operation generates various individuals in successive generations by combining materials of two individuals of the previous generation. During playback, good strings in a population, a greater number of copies and a mating pool are probabilisticment affected formed... Our crossover operator is performed with an intersection point randomly selected along the line and the exchange of all bits to the right of the intersection, as shown in Table. 2.2.

Table. 2.2: One point crossover

Parent 1		Parent 1	
1011010	010100110	0011010	110110101
Child 1		Child 2	
1011010	110110101	0011010	010100110

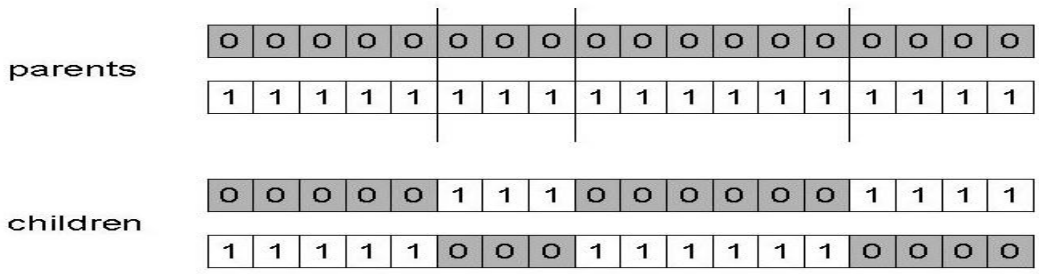

Figure. 3.3: Multi point crossover

3.1. Mutation operator:

Mutation adds new random information on the process of genetic research and ultimately contributes to avoid trapped at a local optimum. It is an operator of diversity in the population, while the population tends to be more consistent with repeated by operators of reproduction and crossover use. Mutation may cause the chromosomes of individuals from those of their parents are individuals. Mutation way interferes with the process of genetic information at random. The mutation is the need to provide a point in the vicinity of the current position, and thus to achieve a local search to the current solution. The mutation is also used to obtain the diversity of the population. For Example:

Before mutation	after mutation
s_1 = 1110110101	s_1` = 1110100101
s_2 = 1111010101	s_2` = 1111110100

It should be noted that the four channels, a 0 in bit position left. If a true solution in this position requires then the reproduction and crossover operator described above is able to produce in this position. The application of these operators on the current population creates a new population. The new population is used to produce these and further to obtain solutions which are closer to the optimal solution populations. The values of the objective function for the new population of individuals again determined by decoding the channels. These values indicate the ability of solutions to new generations.

4. Some applications of genetic algorithms:

The algorithm described above is very simple, but rebasing son dina I use many problems and scientific and technical turbidity of the following models:

- Optimization: gas has been used in a variety of optimization tasks, including numerical optimization and combinatorial optimization problems, such as circuit layout and job-shop scheduling.
- Automatic Programming: gas was used for specific tasks to develop computer programs and other computer design structures such as cellular automata and sorting networks.

- Machine learning: tasks gases are used, such as predicting the weather or the structure of proteins for many machine learning applications, including classification and prediction. Gas were also used to develop particular aspects of machine learning
- Systems, such as weights for neural networks, rules for learning classifier systems or systems and sensors symbolic production robots.
- Economic models: gas was used to model the process where the innovation, development strategies tender and the emergence of economic markets.
- The models of the immune system: gas was used to model different aspects of the innate immune system, including somatic mutations throughout life and the discovery of multiple genes during evolution.
- The ecological models: the gas has been used to model ecological phenomena such as biological arms race, host -parasite co- evolution, symbiosis and resource flow in ecology.

4.1. Advantage of genetic algorithm:

1) This technique is robust and can deal with successfully with wide range of problem areas.
2) GAs is not guaranteed to find the global optimum solution but they generally provided good solution with quick result.
3) GAs out perform in both speed and accuracy.
4) GA is used to solve every optimization problem where chromosomes encoding are used to describe it.
5) It is easy to understand and practically does not demand the knowledge of mathematics.

Genetic algorithms (GAs), robust and systematic optimization paradigms, have been successfully applied to many scientific and engineering problems. Genetic algorithms are inspired by Darwin's theory about evolution. Solution to a problem solved by genetic algorithms is evolved. Algorithm is started with a set of solutions (represented by chromosomes) called population. Solutions from one population are taken and used to form a new population. This is motivated by a hope, that the new population will be better than the old one. Solutions which are selected to form new solutions (offspring) are selected according to their fitness - the more suitable they are the more chances they have to reproduce.

5. Conclusion:

A Digital circuit is a need of current generation in these days but it has a huge number of outputs. So there is a need of selecting one of the best outputs among all of the outputs. The Genetic algorithm is one of the Artificial Intelligence approaches to simulate the idea of adaptation to the process of evolution and natural selection of nature through the development of computer work. Genetic algorithm is one used by a number of tools that artificial intelligence in problem such as optimization, planning, processing of data, clustering, trend analysis and path finding.

The proposed work shows that it is possible to find the maximum output of a digital circuit. The proposed work has been used the genetic algorithm with the help of VHDL implementation. In this dissertation, Optimization of the digital circuit is done on the basis of Genetic Algorithm (GA) for achieving maximum output of the digital circuit in terms of speed. These works have been using some digital circuits and evaluating the maximum output of the circuits using GA.

The result has been shown in terms of comparator required and the time required for searching the maximum output. The time taken by proposed work is less than the previous work. There is a large difference between numbers of comparator. Finally the proposed work is better than the previous methods. The overall improvement of both parameters is 78.20 %.

6. Future work:

GA is the better choice for development in the different areas of communication, medical, mathematics, manufacturing and other fields.

In this work, we have used Roulette wheel and Elitism selection methods for selection. In future, we can use other selection methods like Rank selection, Tournament selection, and Steady state selection. In this work, the length of the population we have used is 10 chromosomes. In future, we can increase the length of the population to improve the performance. In this work, we have used multipoint crossover technique and variable mutation technique. In future we can use different crossover and mutation techniques to improve the performance.

7. References:

(1) Nurizwani Bt Mohd Noor, "A Study on Genetic Algorithm", Thesis of University technology mara oct. 2004.

(2) Srinivas, M. and Lalit M. Patnaik, "Genetic Algorithms: A Survey", IEEE Computer 27(6): 17-26, July 1994.

(3) Rong Yann" Solving Large Travelling salesman Problems with Small Populations" IEEE 1997 pp 157-162.

(4) Yi and QIU Yuhui ET all "A Parallel Tabu Search Approach Based on Genetic Crossover operation" IEEE 2005.

(5) T. Srikanth and Dr. V. Kamla "A Real Coded Genetic Algorithm for Optimization of Cutting Parameters in Turning" IJCSNS International Journal of Computer Science and Network Security, VOL.8 No.6, June 2008.

(6) Jui-Yu Wu and Yun-Kung Chung "Real-Coded Genetic Algorithm for Solving Generalized Polynomial Programming Problems" Journal of Advanced Computational Intelligence and Intelligent Informatics Vol.11 No.4, 2007.

(7) Y. Deng, F. T. S. Chan, Y. Wu and D. Wang, A new linguistic MCDM method based on multiple-criterion data fusion, Expert Systems with Applications, vol. 38, 2011, pp 6985-6993.

(8) Xinyang Deng, Yajuan Zhang, Bingyi Kang, Jiyi Wu, Xiaohong Sun and Yong Deng, "An Application of Genetic Algorithm for University Course Timetabling Problem", 2011 IEEE, pp-2119-2122

(9) Yuehua Dong & Jidong Peng, "Automatic Generation of Software Test Cases Based on Improved Genetic Algorithm", 2011 IEEE, pp- 227- 230.

(10) Di Jin, Dongxiao He, Dayou Liu & Carlos Baquero, "Genetic Algorithm with Local Search for Community Mining in Complex Networks", 2010 IEEE, pp- 105-112.

(11) Saurabh Chaudhur and A nirban Duttrl, "Genetic Algorithm Based Variable Ordering of Bdds for Multi-Level Logic Optimization with Area-Power Tradeoffs", IEEE 2010, pp 627- 630.

(12) M. A. Abido and A. Elazouni, "Improved Crossover and Mutation Operators for Genetic- Algorithm Project Scheduling", IEEE 2009,pp- 1865-1872

(13) Elnaz Zafarani Moattarl, Amir Masoud Rahmanil, Mohammad Reza Feizi Derakhshi, "Job Scheduling in Multi Processor Architecture Using Genetic Algorithm", 2008 IEEE, pp -248-251.

(14) Masanao Aoshima and Akinori Kanasugi, "A Processor for Genetic Algorithm based on Redundant Binary Number", IEEE 2008, pp- 581-586.

(15) H.A. Rahim1, A.A. A. Rahman, R.B. Ahmad1, W. N. F. W. Ariffin1, M.I. Ahmad1, "The Performance Study of Two Genetic Algorithm Approaches for VLSI Macro-Cell Layout Area Optimization", IEEE 2008, pp- 207-212.

(16) Ernesto Mininno, Francesco Cupertino and David Naso, "Real-Valued Compact Genetic Algorithms for Embedded Microcontroller Optimization", IEEE 2008, VOL. 12, NO. 2, APRIL 2008 pp- 203-219

(17) Pei-Yin Chen, Ren-Der Chen, Yu-Pin Chang, Leang-San Shieh, "Hardware Implementation for a Genetic Algorithm", IEEE 2008, VOL. 57, NO. 4, APRIL 2008 pp- 699-705.

(18) Y. Deng, X. Y. Su, D. Wang and Q. Li, Target Recognition Based on Fuzzy Dempster Data Fusion Method, Defence Science Journal,vol. 60, 2010, pp 525-530.

(19) Y. Deng, W. Jiang and R. Sadiq, Modeling contaminant intrusion in water distribution networks: A new similarity-based DST method, Expert Systems with Applications, vol. 38, 2011, pp 571-578.

(20) Y. Deng and F. T. S. Chan, A new fuzzy dempster MCDM method and its application in supplier selection, Expert Systems with Applications, 2010, Article in Press.

(21) N. Boland, B.D. Hughes, L.T.G. Merlot and P.J. Stuckey, New Integer Linear Programming Approaches for Course Timetabling. Computers & Operations Research, vol. 35, 2008, pp 2209-2233.

(22) P. Avella, B. D'Auria, S. Salerno and I. Vasil'ev, A Computational Study of Local Search Algorithms for Italian High-school Timetabling. Journal of Heuristics, vol. 13, 2007, pp 543-556.

(23) D. Causmaecker, P. Demeester and G.V. Berghe, A Decomposed Metaheuristic Approach for a Real-world University Timetabling Problem. European Journal of Operational Research, vol. 195, 2009, pp 307-318.

(24) Socha, M. Sampels and M. Manfrin, Ant Algorithms for the University Course Timetabling Problem with Regard to the State- of-the-art. Applications of Evolutionary Computing, vol. 2611, 2003, pp 334-345.

(25) R. Lewis and B. Paechter, Application of The Grouping Genetic Al- gorithm to University Course Timetabling. Evolutionary Computation in Combinatorial Optimization, Proceedings, vol. 3448, 2005, pp 144-153.

(26) P. Wilke, M. Grobner, N. Oster, a Hybrid Genetic Algorithm for School Timetabling. Advances in Artificial Intelligence, vol. 2557, 2002, pp 455-464.

(27) Yingjie Xing "An Improved Genetic Algorithm with Recurrent Search for the Job-shop Scheduling Problem" IEEE 2006 pp 3386-3390.