Optimization Electrical Circuit's Parameter Using Genetic Algorithms (GAs)

PANG LU SHIN

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To my beloved family and friends

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ABSTRACT

Genetic algorithms (GAs) for automation design of analog circuits are proposed in this project. It is used to solve complex and considerable constrained combinatorial optimization problems that one generally encounters in designing electrical circuits. For the large-scale circuits, the key problems of circuit design are its large amount of calculating operations and the chance of falling into local optimal point. During the optimization, it is often needed to adjust several circuit elements simultaneously. Those parameters will have the significant effect to the circuit performance. The search space is therefore very large, and genetic algorithms have been used with success to optimize such circuit parameters. In this project, the artificial intelligence GAs is proposed to order to generate evolutionary analog circuit designs. The results show that the appropriate combination of circuit components e.g. inductor and resistor are selected by the proposed GAs is able to meet the desired design specification of the circuit. Finally, the simulation result is compared and validated with the manual hand calculation result.

ABSTRAK

Algorithma genetik (GAs) untuk automasi rekabentuk litar analog telah dicadangkan dalam projek ini. Ia digunakan untuk menyelesaikan masalah yang kompleks dan melibatkan pertimbangan sekatan cabang optimasi yang selalunya berlaku dalam isu mereka bentuk litar elektrik. Untuk litar yang mempunyai skala yang besar, masalah yang paling ketara dalam isu mereka bentuk litar adalah operasi pengiraan yang banyak dan peluang untuk mencapai local titik optimum. Semasa optimasi dijalankan, ia sering diperlukan untuk mengubah beberapa element litar dengan serentak. Parameter tersebut mempunyai kesan yang bererti kepada preatasi litar. Oleh sebab itu, pencarian ruang adalah sangat luas dan algorithma genetik telah digunakan dengan berjayanya untuk mengoptimasikan parameter litar tersebut. Dalam projek ini, kecerdasan buatan GAs telah dicadangkan untuk menghasilkan perkembangan reka bentuk litar analog. Keputusan telah menunjukkan combinasi komponen litar yang sesuai contohnya induktor dan perintang telah dipilih oleh GAs adalah berupaya memenuhi spesifikasi reka bentuk litar yang telah disediakan. Akhirnya, keputusan simulasi telah dibanding dan dibuktikan dengan keputusan pengiraan tangan.

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LIST OF SYMBOL

AC	-	Alternating Current
ACO	-	Ant colony optimization algorithm
DC	-	Direct Current
EO	-	External optimization
EP	-	Evolutionary programming
GAs	-	Genetic Algorithms
GUI	-	Graphical User Interface
HS	-	Harmonic Search
MATLAB	-	Matrix Labroratory
SA	-	Simulated annealing
TS	-	Tabu Search
VB	-	Visual Basic

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CHAPTER I

INTRODUCTION

1.1 Chapter Overview

The introduction of the project, objectives and the scope of project is briefly discussed in this chapter. After that, the implementation of the project is introduced by a methodology and lastly the contents of Chapter 1 until Chapter 5 is highlighted in thesis outline.

1.2 Introduction of Project

Nowadays, circuit design is the basis of implementing any electronic system, and its object is to make the designed system having optimal performance and reliability. Therefore, the important of the optimization of the circuit is to find the maximum or minimum value of an objective with various limitations. There are some difficulties in conducting the optimization for electrical circuit such as taking considerable amount of the trial and error testing to determine the circuit's parameter value.

Conventional design approaches produce circuits in which the designed component values are assumed to be ideal with unrestricted values. It may be required to repeat the design with a more stringent specification or to use a more

closely spaced set of acceptable values. However, a better circuit performance may potentially be achieved than that obtained by conventional method if other combinations of acceptable values are considered. Eventually, the difficulty is that the search space of all feasible combinations is too huge. In addition, circuit specifications are usually identified in terms of acceptability regions with upper and lower bounds rather than specific values. It is useful to define an estimation of the feasible region as the set of parameter values for which the design specifications are satisfied when designing a circuit according to certain specifications.

Hence, the genetic algorithm is proposed to define appropriate parameters values to meet the desired circuit performance with its ability of parallel searching through the entire solution space. In GAs implementation, the estimation of the feasible region plays an important role in the determination of the solution space volume to be searched. A search over the feasible region estimate will greatly decrease the time needed to cover all possible solutions of a problem using GAs. The proposed GAs is realized by computer program, which can provide a simplified design procedure. Furthermore, the advantage of GAs program is the capable to find a set of optimal solution for the complex and complicated electrical circuit instead of reduce the conventional design time of the circuit.

However, there is some issue that genetic algorithms need to take in consideration such as the fitness function has been created is compatible so that higher fitness is achieved and result in a better solution for the given circuit.

1.3 Objectives

The main objective of the project is to build an Artificial Intelligent (AI) algorithm which can engage on behaviors that humans intelligent in electronic circuits. Another purpose of this project is to develop an algorithm for finding the optimization electrical circuit's parameters. Besides that, the characteristics of various kinds of electrical circuits can be defined in the process to determine the optimization electrical circuit's parameters.

1.4 Scope of Project

The scope of this project is focusing on utilization of genetic algorithms in solving various circuit optimizations with pre-defined constraints in electrical circuit. The project will be implemented by an attractive and easy way for accessing and learning tool which is Matrix Laboratory (MATLAB). This project is managing the optimization, monitoring performance, and defining stopping criteria for the electrical circuit. Several types of electrical circuit will be designed by using MATLAB M-file. It will be implemented to let the user quickly define their problem and set a variety of algorithm options to fine-tune the optimization.

1.5 Problem Statement

Genetic Algorithms were developed over twenty-five years ago, but there is not so much research and experimental work has been down to ascertain their capabilities in solving complex and considerable constrained combinatorial optimization problems that one generally encounters in designing electrical circuits. Hence, an optimization electrical circuit's parameter using genetic algorithms was proposed to speed up or eliminate a considerable amount of the trial and error testing being done by designers today. This project has emphasize genetic algorithms may be a better alternative for global optimization tools for these electrical circuits.

1.6 Methodology

The methodology of the project is starting with choosing the simulation's environment used in developing an optimization electrical circuit's parameter using genetic algorithms. As a result, MATLAB has been chosen to develop the algorithms environment. The advance tools provides in the MATLAB able to support and provide comprehensive information in implementing the genetic operators such as crossover, mutation and selection.

The next step is to characterize and define the electrical circuits which need to optimize. After that, a program is created where the defined fitness function (inputs of the function which want to minimize maximize or optimize) is used to generate a set of variables and output the desired circuit performance. The program is written in MATLAB's editor because of its advance tools and options provided in the GAs toolbox and easiest to use compare with others.

After developed the algorithms, then it will apply to a graphical user interface (GUI) of GA tools in MATLAB which has provide an approach to let the user quickly define their problem and set a variety of algorithm options to fine-tune the optimization.

1.7 Thesis Outline

This thesis is a document that delivers the idea generated, concepts applied, activities done in optimization electrical circuit's parameter using genetic algorithms and the final year project produced. It consists of five chapters which are Introduction, Literature Review, Methodology, Result and Discussion, Conclusion and Recommendation.

Chapter 1 is delivering the introduction of the project. It consists of objective, problem statement, scope of project, methodology and thesis outline of this project.

Chapter 2 is discussing the literature review of this project. The features and behavior of genetic algorithms are studied.

Chapter 3 is briefly described the project flow and the functional of genetic algorithms. It also covered the methods used in this project and the reason of choosing these methods.

Chapter 4 is deals with the analysis of result at the final stage which is complete designed the interface of optimization electrical circuit parameter by using

genetic algorithms. The result and discussion on writing an algorithm in MATLAB will be presented in this chapter.

Chapter 5 is described the conclusion and result of the project at the final stage. The recommendation and future development of this project is discussed in order to upgrade and enhance the optimization electrical circuit's parameter using genetic algorithms (GAs).

1.8 Conclusion

As a conclusion, the details of introduction of the project in this chapter are briefly described. Besides that, the objective of this project has been classified. The problem statement has defined the optimization problem facing by the user. In additional, the scope of the project is clearly defined. Finally, there is a brief description of literature review which will be presented in detail in Chapter II.

CHAPTER II

LITERATURE REVIEW

2.1 Chapter Overview

Genetic algorithms and its behaviors in finding the optimization electrical circuit's parameters are explained in this chapter. Besides, some theories and concepts of genetic algorithms are presented in this chapter. Others related optimization techniques and the simulation environment of GAs will also be discussed in this chapter as well.

2.2 Genetic Algorithms

The GAs is a search mechanism based on the principle of natural selection and population genetics. On the others hands, it can also defined as adaptive algorithms for finding the global optimum solution for an optimization problem. The primary framework of GAs was first proposed by Dr. J. Holland in 1975 [1]. The continuing performance improvement of computational systems has made them attractive for some types of optimization [2]. In particular, genetic algorithms work very well on mixed (continuous and discrete), combinatorial problems. A solution must be represented to the problem as a genome (or chromosome) in order to use a genetic algorithm. The genetic algorithm then creates a population of solutions and

applies genetic operators such as mutation and crossover to evolve the solutions in order to find the optimal solution.

2.3 Operation of Genetic Algorithms

A simple GAs is described in this section. While more sophisticated forms of the GAs exist, they are all extensions of this basic algorithm. The simple GAs provides excellent performance for a wide range of problems [7].

It begins with the creation of an initial random population of individuals. The size of the population depends on the nature of problem, but typically contains several hundred or thousands of possible solutions [8]. Values of several hundred are commonly used. Traditionally, the population is generated randomly, covering the entire range of possible solutions or the search space. The next step is to evaluate the fitness of each individual according to the predefined criteria.

After the evaluation, the individuals are ranked according to their fitness. Individuals are selected for mating based on fitness. Fitter individuals have a higher probability of mating and passing on genetic information to subsequent generations while less fit individuals have a non-zero probability of mating to preserve diversity [11]. Mating is simulated by applying the crossover operation to the chromosomes of two individuals selected based their fitness.

Mutation is simulated by randomly changing a few bits in the chromosome of the offspring [12]. Mutation provides a mechanism for exploring new regions of the solution space and prevents premature convergence to local minima. Finally, the fitness of the new generation is evaluated and the process is repeated for a specified number of generations or until a desired fitness is attained.