ARTIFICIAL BEE COLONY OPTIMIZATION ALGORITHM FOR ENGINEERING APPLICATION

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DECLARATION

I declare that this thesis entitled "ARTIFICIAL BEE COLONY OPTIMIZATION ALGORITHM FOR ENGINEERING APPLICATION is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

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Date : .....

APPROVAL

I hereby declare that I have checked this report entitled "ARTIFICIAL BEE COLONY OPTIMIZATION ALGORITHM FOR ENGINEERING APPLICATION" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Electrical Engineering with Honours

Signature : .....

Supervisor Name : .....

Date : .....

DEDICATIONS

To my beloved mother and father

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ABSTRACT

This project presents the optimization technique, the artificial bee colony (ABC), was investigated in the term of finding the best optimal locations [1]. The artificial bee colony (ABC) is a new optimization technique for simulating the honey bee swarms foraging behaviour. These algorithms technique are inspired from nature. This project also proposed their performances assessment on various benchmark functions to see their robustness. In ABC, there are a few control parameter so it easy to investigate their behaviour. In this project, the three analysis are conducted to investigate their performance using 10 benchmark functions. The analysis that have been analyze in this project are number of dimension, number of population and number of iteration. The result of analysis are presented in convergence plot. For the application, flexible manipulator system (FMS) is chosen as a testing platform. The model of FMS is designed in Simulink MATLAB using ABC algorithm in tuning the proportional--integral-derivative (PID), proportional-derivative (PD) and proportional-integral (PI) controller with error criteria to investigate their performance. The most suitable controller is choosing based on overshoot, rise time, settling time and steady state error.

ABSTRAK

Projek ini membentangkan teknik pengoptimuman, lebah koloni (ABC), adalah startegi dalam jangka masa mencari lokasi optimum terbaik [1]. ABC adalah teknik pengoptimuman baru untuk meniru kelakuan madu lebah. Teknik algoritma ini diilhamkan dari alam semula jadi. Projek ini juga mencadangkan penilaian prestasi mereka terhadap pelbagai fungsi penanda aras untuk melihat kekukuhan mereka. Dalam ABC, terdapat beberapa parameter kawalan supaya mudah menyiasat kelakuan mereka. Dalam projek ini, tiga analisis ini dijalankan untuk menyiasat prestasi mereka menggunakan 10 fungsi penanda aras. Analisis yang telah dianalisis dalam projek ini adalah bilangan dimensi, bilangan penduduk dan bilangan lelaran. Hasil analisis dibentangkan dalam plot penumpuan. Untuk aplikasi, sistem manipulator fleksibel (FMS) dipilih sebagai platform ujian. Model FMS direka bentuk dalam Simulink MATLAB menggunakan algoritma ABC dalam mensasarkan pengawal (PID), (PD) and PI untuk menyiasat prestasi mereka. Pengawal dipilih berdasarkan overshoot, masa naik, masa penyelesaian kesilapan keadaan mantap

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LIST OF SYMBOLS AND ABBREVIATIONS

ABC	-	Artificial Bee Colony
Kp	-	Proportional Gain
Ki	-	Integral Gain
Kd	-	Derivative Gain
PID	-	Proportional-Integral-Derivative
PI	-	Proportional-Integral
PD	-	Proportional-Derivative
tr	-	Rise Time
tp	-	Peak Time
ts	-	Settling Time
OS	-	Overshoot

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CHAPTER 1

INTRODUCTION

1.1 Overview

The word optimum is in Latin and it means the best. Optimization is everywhere and it is important tool in making decisions by achieving the best possible solution of multiple applications [2]. In mathematical, an optimization approach is the process of finding the maximum or minimum values based on the optimal objective function defined in the system. Optimization can be applied in engineering problems such as optimal control, minimum processing time in production lines or design a aircraft for minimum weight. It is also can implemented in non-engineering problems such as shortest route for travelling salesman and human resource scheduling time. In daily life, we always want to optimize something in engineering field whether to maximize the output, profit, efficiency and performances or to minimize the consumption of fuel. Hence, optimization is the strategy of finding the conditions that give the maximum or the minimum value of a function in the context of mathematics. Even though there are thousands type of optimization methods but there is no single method available in solving the optimization problems efficiently and accurately.

In context of solving a optimization in application, optimization is a strategy to find the optimal solution for real world problems. The strategy to solve the real world problems is more complex and challenging. The solution is obtained from optimization algorithm is a best solution and can be used to solve a real world problems but there is no guarantee the result obtained from optimization is global minimum solution. Therefore, many research is going further to find a better optimization solution. The problem is solved through methodology that contained with data and parameters describing the objective function. Optimal value or optimal solution is a result from optimization algorithm to solve the real world problems. Example of the application in this project is analysis on flexible manipulator system.

Heuristic mean “to find” and meta means “beyond in an upper level” [3]. Metaheuristics is a set of algorithm that define search methods in solving a real world problems. It can solve a complex problems such as quadratic problems, timetable, scheduling and travelling salesman. Metaheuristics is also capable in solving in various sector of engineering such as mechanical, electrical, computer and sivil. Example of metaheuristics algorithms are artificial bee colony (ABC) algorithm, firefly algorithm, tabu search and genetic algorithm. Both exploration and exploitation can also be referred as diversification and intensification strategies. This algorithm is trendy and popular among researchers because accessible to find the optimal solution and solving a real world problems. Besides, the exploration and exploitation are harmony. When there are too much exploitation can lead to fast convergence speed but low accuracy. Meanwhile, when there are too much exploitation can award high accuracy but low convergence speed. The optimal solution is seized from metaheuristics algorithm because it have elitism element that can improve the performance of algorithms. Many researchers are attractive with this algorithm and further the hybrid research in improving a better results.

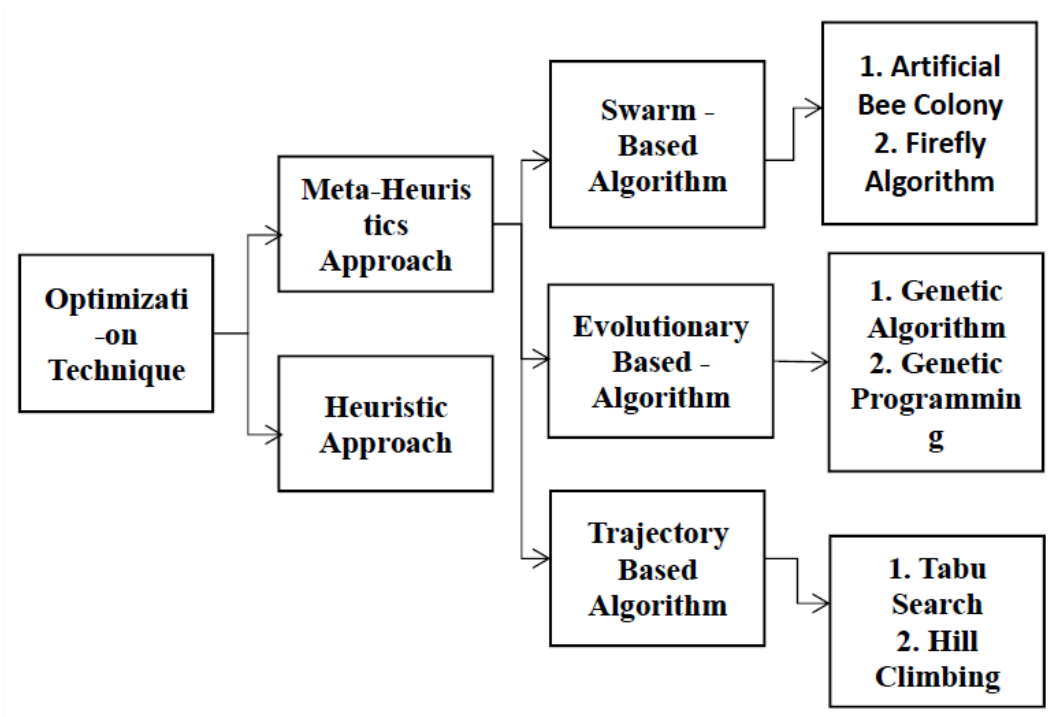

Figure 1.1: Classification of Optimization Technique

Figure 1.1 shows the classification of optimization technique that have been applied in many engineering and non-engineering problems. Swarm Intelligent (SI) is one of the type of optimization that mimic the natural biological or behaviour of species. In early 60's, many SI have been introduced. SI is a self-organized of the intelligence behaviour. Example of SI such as foraging of inserts, nest building of inserts, cooperative transportation and collective sorting. There are several type of swarm intelligent that have been developed in past several years. These algorithms include Genetic Algorithms (GA), Ant Colony Optimization (ACO), Particle Swarm Optimization (PSO), Differential Evolution (DE), Artificial Bee Colony (ABC), Glowworm Swarm Optimization (GSO), and Cuckoo Search Algorithm (CSA) [4]. For this project, artificial bee colony algorithm is chosen to investigate their performance on 10 numerical benchmark functions and engineering applications.

1.2 Project Motivation

The main motivation which give drives to investigate Artificial Bee Colony Algorithm are such as:

1. The employer want to maximize the production of products in every parts to maximize the profit but did not exceed the available parts in store.

2. In non-engineering problem, a travelling salesman is also a optimization problems. A travelling salesman need to find the shortest way between the cities and cost to travel from one city to another. This problem can be overcome by using the ABC algorithm.

3. To minimize the payroll costs, human resource department need to schedule park employees for weekly shift which is five works days plus two consecutive days off.

1.3 Problem Statement

There are many technique or method to be used in solving a problems such as "try and error" method but it is not guarantee to solve it. There are some of example that we have faced on daily life such as following:

1. Today there are number of optimization techniques in market to solve the several problems in engineering, economic and management. Optimization technique is a way to find the most cost effective, highest performance, highest efficiency, by maximizing desired factors and minimizing undesired other factor. So, using ABC algorithm can solve that problem.

2. In application, the robotic system is important to improve robot performance by keep the rotating angle and eliminate the oscillation angle of end effector. The position and trajectory is controlled by PID controller. So, by using the ABC algorithm can tune the PID controller to get a best performance of robot.

3. Hence, the experiment is repeated to investigate the suitable controller with error criteria in application FMS by to get a better performance between the controllers.

1.4 Objective

The objectives of this project as stated below:

1. To investigate the performance of ABC algorithm with parameter settings by using 10 numerical benchmark functions.

2. To investigate the suitable of controller with error criteria for application flexible manipulator system (FMS).

3. To investigate the performance of ABC algorithm with parameter settings in tuning proportional-integral-derivative (PID) with error criteria for application flexible manipulator system (FMS).

1.5 Scope of Research

Scopes of this project as stated below:

1. Investigate the performance of ABC algorithm in 10 numerical benchmark function by using MATLAB simulation.
   - The coding is run using a 10 different benchmark function to investigate the performance of ABC algorithm. The performance is measured by using three analysis: number of dimension, number of population and number of iteration. Every of benchmark function is run over 30 independent runs.

2. To investigate the suitable of controller with error criteria for application flexible manipulator system (FMS).
   - The ABC is tune the value of controller in flexible manipulator system. The controllers that used in this project are PI, PD and PID controller. The performance of the controllers based on their value of overshoot, rise time, settling time and steady state error.

3. To investigate the performance of ABC algorithm with parameter settings in tuning proportional-integral-derivative (PID) with error criteria for application flexible manipulator system (FMS).
   - The ABC algorithm is tune the value of PID controller in flexible manipulator system. It is to control the position and vibration of flexible manipulator system. The tuning PID controller is tune with error criteria to see ABC aalgorithm performance.

1.6 Report Outline

A brief description of this report is described in this section. Generally, this report contains five chapters and all these chapter will deliver the overall information about this report.

The first chapter of this report contain the introduction of this project. The overall idea of this project is briefly explained in this chapter. The objective and scope of research also explained in this chapter.

The second chapter in this report will explain the literature review of this project. The previous work related to the project will be analyzed in detail. Besides, the background of the research also need to be include.

The third chapter in this report explain the methodology that is being implemented to execute this project. All the formulas and theory used will be explained in this chapter.

The fourth chapter in this report will show the early results of the progress from the methodology used for this project. The data obtained from the results will be analyzed to verify the objective of this project. Also, this chapter show the analysis of the result.

Lastly, the fifth chapter in this report will summarize of the entire work, results of this project. The weakness, shortcomings and strength of the project are presented.

CHAPTER 2

LITERATURE REVIEW

This chapter reviews the basic concepts of ABC algorithm. Several ABC algorithm have been investigated. In this chapter, a ABC algorithm is the nature inspired algorithms is presented which are known as swarm intelligence. This algorithm is focused on bee colony behaviour in order to develop some meta-heuristics which has ability to solve the engineering problems. Finally, the behaviour of real honey bees have been inspired many researches to study this algorithm and their application are reviewed.

2.1 Theory of ABC Algorithm

Natural metaphors is a famous and trend among scientific community to model and solve the complex optimization problems. A swarm intelligence is a insert behaviour such as honey bee and firefly which can solve the problem using mimic of insert ability. Bonabeau has defined the swarm intelligence as “collective behavior of social insert colony is inspired to design algorithms or problem solving devices” [5]. ABC algorithm is proposed by a Karaboga in a very easy and simple strategy in finding a foods [3]. The ABC algorithm is a swarm based, meta heuristic algorithms proposed on foraging behaviour of real honey bees. This algorithms inspired by the intelligent of the real honey bees in finding food sources known as a nectar. They also sharing the information about the food source among other bee in the nest using dancing language. The model of foraging of the honey bees consists the three important components: food source, employed foragers and unemployed foragers.

From the previous work, ABC algorithm is the algorithms with a good performances to solve many optimization problems. ABC algorithms was initially published by Dervis Karaboga in 2005 [6]. ABC algorithm is motivated by the swarm intelligent foraging behaviour of honey bees. The ABC algorithm able to implemented in wide range of real world problems because its a population-based evolution.

In ABC algorithm, it is inspired from the intelligent behaviour of real honey bees in finding a food source that known as nectar. The algorithm has a three groups in foraging which are employed bees, onlooker bees and scouts. They have given a specific task in foraging activities. Honey bees used a dancing language as a communication behaviour among them. ABC algorithm is a attractive than other optimization algorithms because it has a following characteristics. This algorithm has a few control parameters. The control parameter that ABC algorithm are the population size, limit and maximum cycle number. Besides, it also flexible, simple and fast convergence speed. This algorithm also easy to hybrid with other optimization algorithms.

2.1.1 The Flow Chart of ABC Algorithm

The figure 2.1 shows the flow chart of ABC algoirthm. The phases of employee bee, onlooker and scout bee will expain in detail in the next sub-section.

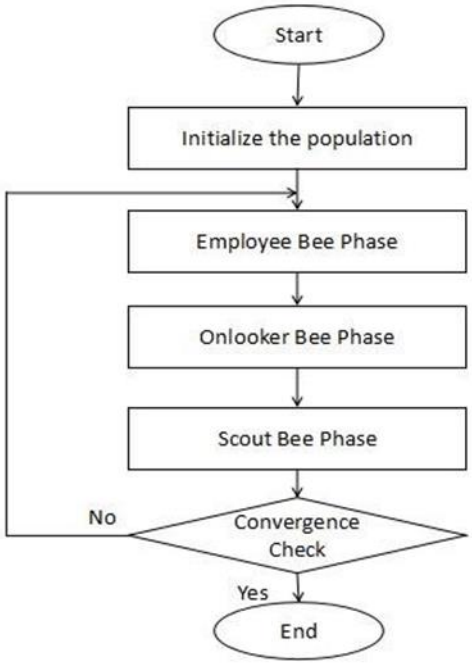

Figure 2.1: The Flow Chart of ABC Algorithm

2.1.2 Phases of ABC Algorithm

The working principle have been approached. The investigation process of ABC has three steps:

a) Employed bee as a search agent. Sending the employed bees to a food source and memorize the amount the food source which is nectar.

b) Employed bee will share the information of the food source with the onlooker bees in the nest. The onlooker bees will calculate the approximately their quality of nectar.

c) Scout as a replace agent. Sending the scout bees to the possible food sources.

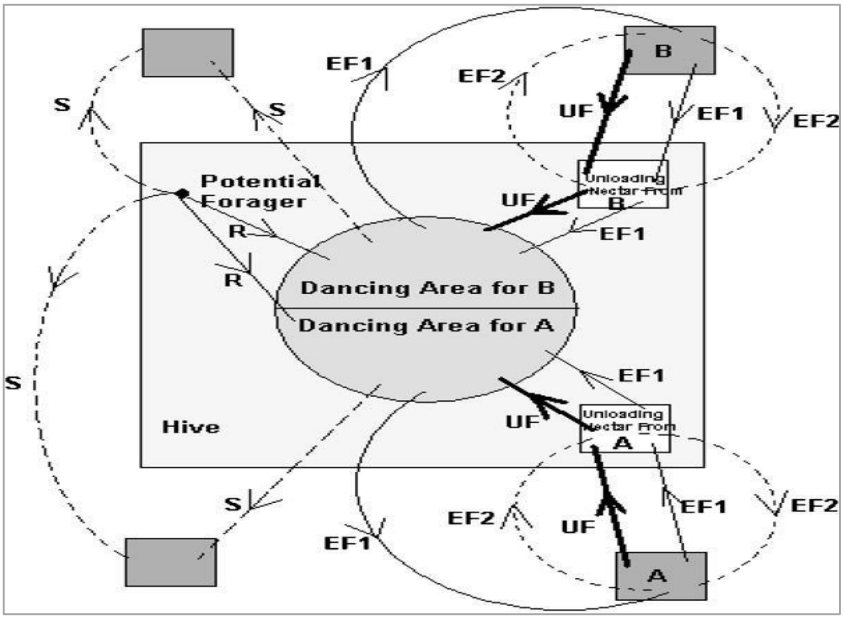

Figure 2.2: Foraging of Honey Bees [7]

2.1.3 Food Source

Food source for a honey bees represent the possible solution of the optimization problem. The concentration of its energy, proximity to the nest and extracting the

energy are the factors that effect the value of food source. As for a test case, nectar amount correspond to the quality (fitness) of the solution. The ABC algorithms that have a extraordinary foraging behaviour of real honey bees has three important constraints. The first constraint is the population which is the number of food source. The second constraint is a limit which is number of tries when the employed bee reject the foos source. The third constrain is the iteration, the maximum number is the criteria to stop the process of foraging. The location of food sources are randomly initialize according to the equation:

$$x_y = x_j^{min} + rand(0,1)\left(x_j^{min} - x_j^{min}\right) \quad (2.1)$$

Where i = 1 and j = 1; y = ij; x_j^{min} is lower bound and x_j^{max} is upper bound of xij.

2.1.4 Employed Bee Phase

The second phase of ABC algorithm is employed bee phase. The employed with them the information of nectar about amount of nectar, distance and direction from their nest. They shared the information with onlooker bees using the dancing language. The food source depends on the employed bees. In other words, the number of food source equal to the employed bees for the hive. The probability to be selected by employed bees increases with the increases the nectar quality. After sharing the information of food source with onlooker bees, employed bees return to the food source from the previous cycle to select the another food source. The employed bees that have a information of food source with the highest nectar quality recruits the onlooker to get the nectar. The resulting food source is generated according to the equation below.

$$v_{ij} = x_{ij} + \emptyset\left(x_{ij} - x_{kj}\right) \quad (2.2)$$