OPTIMAL CONTROL OF AUTONOMOUS UNDERWATER VEHICLE (AUV)
USING GENETIC ALGORITHMS

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ABSTRACT

This thesis describes the optimal control of autonomous underwater vehicle (AUV) with Genetic Algorithms (GA) Optimization. Due to the harsh and unstable condition of underwater environment, the demand of AUV in underwater exploration field is increasing rapidly.

AUV use in this project is low cost, small and light. Thus, it is more unstable compare to other huge sized AUV. Its stability is easily affected by several factors, such as underwater wave current and other unpredicted underwater condition. As a result, the process of capturing data is more difficult and the quality of data obtained is low and inaccurate.

. Objective in this project is to overcome the current weaknesses, by implementing GA in Matlab environment for stability control and obstacle avoidance purpose. Genetic algorithm is a search technique used in computing to find exact or approximate solutions to optimization and search problems. Besides, fitness functions are developed in order to optimize the movement of AUV.

Initially, analysis of the fitness function developed is done by using some data create manually. Data generated from the sensors will be fed to GA and applied it into fitness functions. The best fitness value will be fed back to AUV in order to control the motors propulsion force.

By implementing GA, AUV able to maintain its stability, avoid obstacles and also travels at the certain distance from the seabed. The fitness functions of the stability problem and simulation results are presented in this thesis.

ABSTRAK

Tesis ini membahaskan kawalan optimum kenderaan bawah air autonomi (AUV) dengan Algoritma Genetik (GA) Optimasi. Oleh kerana keadaan yang keras dan tidak stabil di persekitaran bawah air, permintaan AUV dalam bidang eksplorasi bawah air meningkat dengan cepat.

Disebabkan penggunaan AUV dalam projek ini adalah kos rendah, kecil dan ringan. Jadi, perbandingan dengan AUV lain yang besar, kestabilannya adalah mudah dipengaruhi oleh beberapa faktor, seperti gelombang air dan keadaan bawah air lain yang tidak dijangkakan. Akibatnya, proses penggambilan data adalah lebih sukar dan juga tidak tepat.

Objektif projek ini adalah untuk mengatasi kelemahan AUV dengan menerapkan GA di lingkungan Matlab untuk pengendalian kestabilan dan tujuan mengelakkan rintangan. Algoritma genetik adalah teknik carian yang digunakan dalam komputasi untuk mencari atau anggaran penyelesaian yang tepat untuk optimasi dan masalah carian. Selain itu, fungsi kecergasan dikembangkan untuk mengoptimumkan pergerakan AUV.

Pada awalnya, analisis fungsi kecergasan yang diujikan dengan menggunakan beberapa data yang dibuat secara manual. Data dihasilkan dari sensor akan diberi kepada GA dan diterapkan ke dalam fungsi kecergasan. Nilai fitness terbaik akan dikembalikan kepada AUV untuk mengawal kekuatan penggerak motor.

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Dengan menerapkan GA, AUV mampu menjaga kestabilan, mengelakkan rintangan dan juga bergerak pada jarak tertentu dari dasar laut. Fungsi kecergasan dan hasil simulasi dibincangkan dalam tesis ini.

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LIST OF ABBREVIATION

AUV	-	Autonomous Underwater Vehicle
GA	-	Genetic Algorithms
MATLAB	-	Matrix Laboratory
DNA	-	Deoxyribonucleic acid
CACSD	-	Computer Aided Control System Design

LIST OF APPENDIX

CHAPTER I

INTRODUCTION

1.0   Introduction

Chapter one is discuss about the background, problems statement, objectives, scope and important of the projects. For background, the basic idea of Autonomous Underwater Vehicle (AUV) and Genetic Algorithm (GA) is introduced. Next, the problem statements faced in this project is clarified. Furthermore, based on the problem statement, the objectives and scope of the project is set and indentified. Lastly, the important of this project is discussed.

1.1   Background

Autonomous Underwater Vehicle (AUV) is a type of underwater robotic device which can drive through the underwater propulsion system without any human controls. It is self-piloted where it is using the feedback received from the surrounding in order to determine its actions and movement during operation.

Genetic Algorithms (GA) are adaptive methods which may be used to solve search and optimization problems. They are based on the genetic processes of biological organisms. Over many generations, natural populations evolve according to the principles of natural selection and survival of the fittest. GA can quickly scan a

vast solution set. Bad proposals do not affect the end solution negatively as they are simply discarded. The inductive nature of the GA means that it doesn't have to know any rules of the problem - it works by its own internal rules. This is very useful for complex or loosely defined problems.

1.2   Problem Statement

The Autonomous Underwater Vehicle (AUV) in this project is low cost, small and light; it is more unstable compare to other huge sized AUV. Since it is a light-weight type AUV, its stability is easily affected by the propagation of wave underwater and the force of wave will make it out of course. Furthermore, its stability is also easily affected by several factors where they are unpredicted such as sea creatures and earthquake. As a result, the process of capturing data is more difficult and the quality of data obtained is low and inaccurate. Therefore, GA which is an adaptive method needed to be study and applied in the Matlab environment to solve the search and optimization problems.

Besides, sensitivity of AUV can be increased by increasing number of sensors; therefore, there is a lot of sensor data needs to analyze and optimize on real time simulation. These sensors need to process in order to produce corresponding output and subsequently control the movement of AUV. As a result, fitness functions of GA are needed to develop and apply in AUV. Subsequently, the best fitness value obtained from the fitness functions will be used to optimize the movement of AUV.

In current technology, there is lack of AI or GA implementation into AUV purpose. Generally, GA is commonly used in path-finding which it is used in finding the closet and shortest path between two places by given many different routes. Therefore, GA is only used in particular field as it is not a very common algorithm to people.

1.3   Objectives

In this project, there are four objectives are stated for the achievement of the project.

    i.   To study Genetic Algorithm
    ii.   To develop Genetic Algorithm in Matlab environment
    iii.   To apply fitness function in AUV, in order to optimize its movement
    iv.   To control the stability of AUV by analyzing data from sensors

The main objective of this project is to study Genetic Algorithm (GA) in order to apply in AUV. Therefore, basic model and elements of GA will be understood and analyzed. Basically, GA contains of three main stages, which are selection, crossover, and mutation.

Secondly, Matlab environment is used in order to develop the GA. Using Matlab, it has the toolbox that support GA and very suitable for beginner to study the process and flow of GA.

Thirdly, the fitness function of GA is required to apply in AUV. The development of fitness function for stability optimization is first undergoes and the final best fitness value is integrated into the AUV.

Finally, the data fed in by sensors used is analyzed in order to control the stability of AUV. The sensors first get data from surrounding as parameter to determine its actions and movements later by using GA.

1.4   Scope

The scope of this project is using GA as the controller of AUV in order to control AUV's stability. Moreover, the implementation of GA is developed in Matlab environment with the aid of GA Tool as fundamental tool to further understand the characteristic of GA.

Furthermore, optimization of a group of sensors data that feedback from AUV is undergoes through GA analysis in Matlab. After the analysis, the result will be perform as the optimized output to control the movement and position of AUV back to its stable state.

Besides that, the development of the fitness function for stability optimization and obstacles avoidance is carry out using Matlab. Eventually, the best fitness function will be used and implemented in GA for stability control and obstacle avoidance for AUV.

1.5   Important of Project

The important of project is the implementation of GA in Matlab environment. By using the GA concept, AUV always can be optimized in balance position and will not crash onto obstacles. Through GA, variety of sensors data can be analyzed and optimized in real time simulation.

This project also contributes to provide the solution to the stability control and obstacles avoidances problem by implementing GA in AUV. Sensors data from AUV will always being optimized and feedback to AUV for further processes.

Besides, through this project, the AUV can react autonomously by itself which it will depend on the data feedback from the sensors. As the outcome of this project, the AUV designed will be fully autonomous without the needs of remote control.

1.6   Report Layout

This thesis consists of six main chapters where all the chapters are essential to describe all the architecture and functionality of the project itself. Chapter I describes briefly about the project's introduction. It is also discuss about the objectives, scopes of project and project application.

Chapter II describes about the literature review that consists of the background of the project. It also describes about the same projects that have been done of previous person and it is more to make research on different, advantages and disadvantages of previous project.

Chapter III describes about the methodology of this project. It defines the physical block diagram and flow chart operation of GA. Chapter IV describes matters regarding results and analysis on the subjected items. Chapter V will discuss about the experimental results and the validation part. Lastly, Chapter VI is describes about conclusion and recommendation. This section will conclude about knowledge that comes out from the project and some recommendation to the further study regarding to the GA.

CHAPTER II

LITERATURE REVIEW

2.0   Introduction

This chapter is discussed about the literature review that consists of the background of the project, which includes Autonomous Underwater Vehicle (AUV), Genetic Algorithms (GA), Matlab and the comparison between the several algorithms are made.