"I hereby declare that I have read through this report entitle The Study of Robot Society using Habituation Algorithm and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Mechatronics Engineering"

Signature : ……

Supervisor's name : ……

Date : ……

THE STUDY OF ROBOT SOCIETY USING HABITUATION ALGORITHM

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A report submitted in partial fulfillment of the requirements for the degree

of Bachelor of Mechatronics Engineering

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

YEAR 2012

I declare that this report entitle The Study of Robot Society Using Habituation Algorithm is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ……

Supervisor's name : ……

Date : ……

To my beloved family, friends and lecturers.

In appreciation of supported and understanding.

ACKNOWLEDGEMENT

Alhamdulillah, thank you Allah SWT, whom with His willing giving me the opportunity to complete the Final Year Project (FYP) entitled The Study of Robot Society using Habituation Algorithm.

Here I would like to express my deepest thanks to my supervisor, Dr Muhammad Fahmi bin Miskon, who had helped me a lot to complete this project. Not to forget, my thanks to my family for their support and encouragement from the beginning of this project until the end. Also, thanks to all friends, especially those who worked together by supporting my work and helped me completing this project and to all who had guided me through finishing this project. Thank you so much for the time and help.

ABSTRACT

There are many methods to study about multi agent robots. The problem is can a group of robots develop learning behavior that is affected by the states of environment? In order to do this, habituation algorithm is applied to these robots in order to make them imitate human social behavior. Simulation on Robot Society using Habituation Algorithm will be conducted using Matlab. As a result, a swarm of robot will adapt and learn independently with the state of environment and will learn the behavior based on equation used. Besides, robots can learn not only from environment but also from dynamic behavior of other robots. All robots are identical but their behaviors are different due to reaction from the state of environment. The method used here is Artificial Intelligence, focusing on Artificial Neural Network. There are three environments in the simulation. Two methods that are used to be tested in the environments are communication between robots and sensing of charging location. Environment 1 is tested with only communication between robots, Environment 2 is sensing of the charging location, while Environment 3 is tested with both methods. Environment with both methods show the most stable energy or survivability of robots, as the robot can charge their energy faster than the other.

ABSTRAK

Terdapat banyak kaedah untuk dikaji tentang robot-robot ejen pelbagai. Tetapi, masalah yang didapati ialah bolehkah sekumpulan robot belajar mengadaptasi kelakuan daripada persekitaran? Untuk mengkaji kes ini, Algoritma Habituation digunakan ke atas robot-robot ini supaya membuat mereka dapat meniru tingkah laku sosial manusia. Simulasi Robot Society menggunakan Habituation Algorithm akan dikendalikan menggunakan Matlab. Hasilnya, sekumpulan robot akan menyesuaikan diri dan belajar dengan keadaan persekitaran dan akan belajar tingkah laku berdasarkan persamaan digunakan. Selain itu, robot-robot boleh belajar bukan sahaja daripada persekitaran tetapi juga dari tingkah laku dinamik robot-robot lain. Semua robot adalah sama tetapi kelakuan mereka adalah berbeza disebabkan tindak balas dari keadaan persekitaran. Kaedah yang digunakan di sini ialah Artificial Intelligence, menumpukan kepada Artificial Neural Network. Terdapat tiga persekitaran dalam simulasi. Dua cara yang diuji dalam persekitaran ialah komunikasi antara robot-robot dan penderiaan robot terhadap lokasi tempat makan. Persekitaran 1 diuji dengan hanya komunikasi antara robot-robot, Persekitaran 2 ialah penderiaan robot terhadap lokasi tempat makan, sementara Persekitaran 3 diuji dengan kedua-dua kaedah-kaedah. Persekitaran dengan kedua-dua kaedah menunjukkan tenaga yang paling stabil atau kelangsungan hidup robot robot yang paling baik, kerana robot mendapat tenaga mereka lebih cepat daripada robot persekitaran lain.

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CHAPTER 1

INTRODUCTION

Nowadays, many robots can imitate human movements such as running, walking, shaking hands and others, but can they learn human behavior instead? And can groups of robots adapt to their environment without any supervision?

Robot society or multi-agent robot systems have many benefits that human can gain. In order to develop such systems, the task of robot society is used as a new approach to develop this task. For a group of robot that has random behavior, self-adaptation is applied. Self-adaptation allows group of robots to have intelligence and can make decision critically. An author, Christian Igel Marc Toussaint has shown one of the advantages in self-adaptation by saying the method has been used in all paradigms of evolutionary computation. For the same purpose, it is also stated that self-adaptation also employed in evolutionary programming and in the original framework of finite-state machines. For example, mutation probabilities as well as crossover operators are the adaptation of self-adaptation that can be used for critical project [1].

In robot society, self-adaptation is applied as this society of robot has the intelligence to learn about the food source location and hence, making the robot survives in the environment they live. They will have the capability to spot the food source location by two methods, that are communication between each other and sensing, that is sees the food source itself.

1.1 Problem Statement

In this project, the problem statements are:

i) What are the learning algorithms that can imitate human adaptation to its environment?
ii) How is the survivability of robot in each environment? Which method is the best for information sharing?

1.2 Objectives

The purpose of this project is to design and simulate unsupervised multi-agent robot intelligence using habituation algorithm and to study the survivability of robot in communication and sensing behavior.

1.3 Scopes

The scopes of the project are:

i) To perform literature review on methods for multi agent robot learning.
ii) To use Artificial Neural Network (ANN) method based algorithm for robot's learning.
iii) To develop and evaluate unsupervised social intelligence simulation using Matlab.

Figure 1-1 shows the K-Chart of this project. It shows that there are many methods to analyze the multi-agent robot.

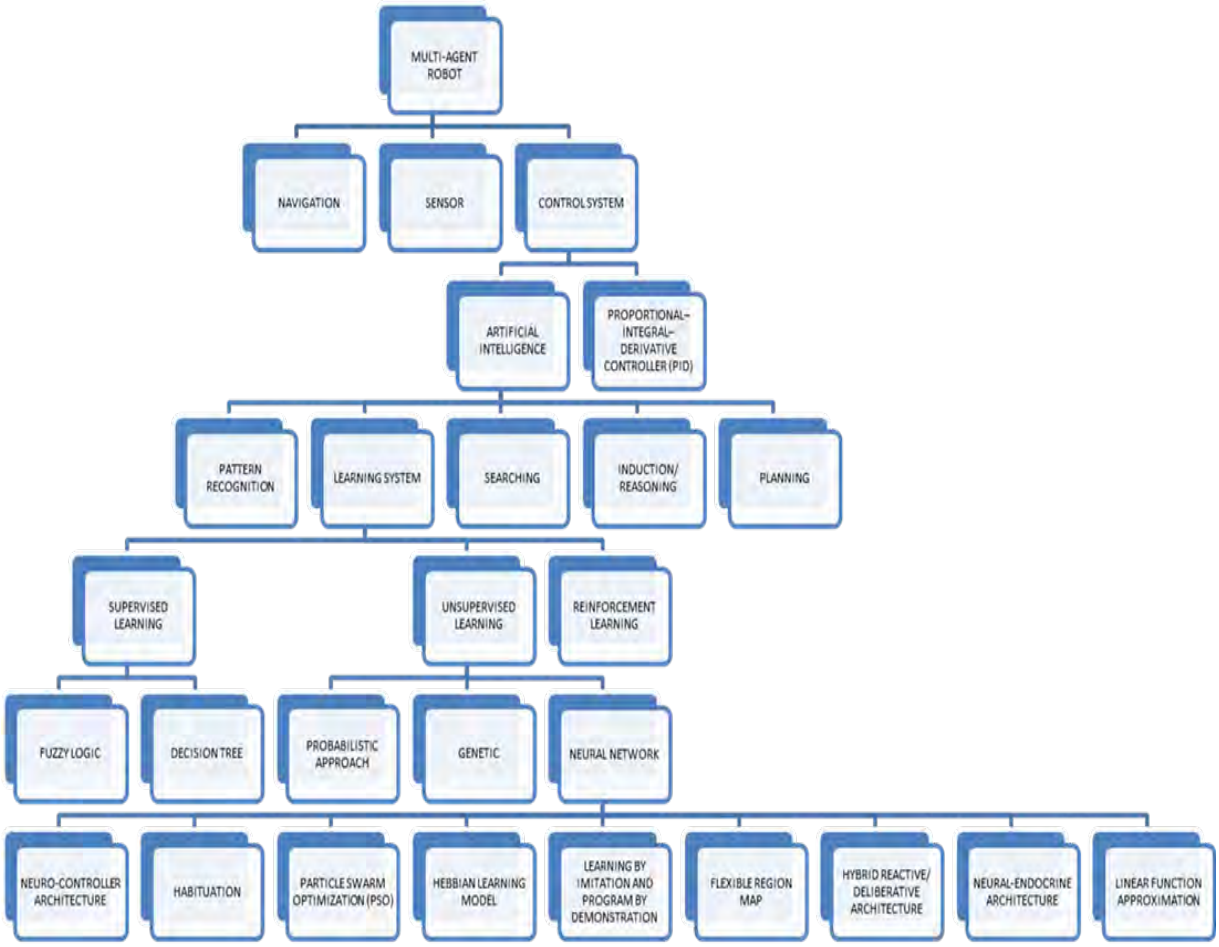


Figure 1-1: K-Chart of Multi-agent Robot

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Literature review is an evaluation of previous research. It is a summary of previous research of particular research to pursue studies on the same topics. This chapter discusses about available multi-agent robot's learning behavior.

2.2 Multi Agent Learning Algorithm for Adapting To an Environment

There are various ways of multi agent robot learning. From the work done by Timmis et. al., A Neural-Endocrine Architecture for Foraging in Swarm Robotic System [4], the method used is Neural-Endocrine Architecture, which its approach can be used for the development of swarm system as it combines standard perceptron artificial neural networks with a novel artificial endocrine system. It has the ability to affect the weights of the neural networks. The disadvantage of this project is that too many robots can cause potential problem. To avoid this, Particle Swarm Optimization (PSO) method can be implemented as this technique ties to artificial life in general, and to bird flocking, fish schooling, and swarming theory in particular, which is most likely very suitable for many robots project [5]. There are a total of eleven behaviors that being study in this paper, the majority of which can

be categorized into three groups that are taxes, reflexes, and fixed action pattern. There is also neural-endocrine design to make different neuron of the same network sensitive to different hormones. The result is that the robots can collect amount of rubbish and the effectiveness is count on how much the rubbish is collected per second. The results shows an interesting observation from simulation that the emergence of certain types of behavior, also strong positive correlation in graph between number of robots and pieces of rubbish collected, but the performance drop when five robots were used. However, the effectiveness and effect of speed up on the swarm is not shown in this paper.

MultiRobot Learning with Particle Swarm Optimization by Jim Pugh and Alcherio Martinoli [6] and Using the Particle Swarm Optimization Algorithm for Robotic Search Applications by James M. Hereford, Michael Siebold and Shannon Nichols [7], the method used is Particle Swarm Optimization (PSO). PSO initialized with a population of solutions and find optima by updating the mathematical formula and is perform through the problem space. The advantage of PSO in MultiRobot Learning is that the algorithm maintained good performance for groups of robots of various sizes. The tradeoff is that it does not indicate the real-world multi robot scenarios. For Robotic Search Application, each particle has limited mobility. For both articles, PSO algorithm had helped in unsupervised learning in many robots as PSO algorithm maintains a swarm of particles, where each particle represents a potential solution and is able to find approximate solutions to extremely difficult or impossible numeric maximization and minimization.

Linear function approximation method is used in Adaptive Robot Learning in A Non-Stationary Environment by Kary Framling [8]. This function often used with Reinforcement Learning, as in this journal. Reinforcement Learning (RL) allows machines and software agents to automatically determine the ideal behavior within a specific context to maximize its performance. RL methods usually model the environment as a Markov Decision Process (MDP), where every state of the environment needs to be uniquely identifiable. This is why the model used for RL learning is often a “lookup-table”, where each environment state corresponds to one row (or column) in the table and the columns (or rows) correspond to possible actions. But look-up table is not suitable in this project, hence state generalization techniques; ANN is used [9]. Linear function approximation offer rapid learning and have

small memory and processing requirements. But due to the small memory, Artificial Neuron Network (ANN) learning may become too slow to be practical because of limited memory and computing power needs of Adalines make them easy to use in embedded systems.

As for [10], [11] and [12], the method used is almost the same. Both are robot learning by imitation and implemented other learning mechanism such as demonstration and mimicking but for Environment for Robot Learning, it is more to the interaction of mobile robot with environment. The advantages of these methods are analysis of relaxed versions of imitation learning can be done and the robot can be able to learn either by a direct learning process with a human teacher or through observation where the robot is able to extract new information and learn new skills just by looking at human. Other than that is the robot can develop a value system for evaluating the benefit of its action using limited information available. This project is not very related because the robot seems to be just imitating but not having intelligence to do certain behavior unsupervised.

Hebbian Learning Model and Neuro-Controller Architecture methods are used in the Learning and Foraging of Robot-bees [13]. Foraging robot is defined as robots that are capable of searching for and, when found, transporting the objects to one or more collection points. Foraging robots is important for a metaphor for a broad class of problems integrating exploration, navigation and object identification, manipulation and transport; secondly, in multi-robot systems foraging is a canonical problem for the study of robot-robot cooperation, and thirdly, many actual or potential real-world applications for robotics are instances of foraging robots, for instance cleaning, harvesting, search and rescue, land-mine clearance or planetary exploration [14]. The objectives of [13] are firstly, to investigate insect behavior and navigation in environment and secondly, to study the merging of unsupervised learning and reinforcement learning. The method used, that is Hebbian Learning Model, is very simple and biologically plausible. But this project does not implement the real-world application. As for Foraging Robots, Finite State Machine (FSM) technique is used. It is a technique that provides a simple computational model with many applications. FSM is defined as a finite set of states, a finite set of event categories and transitions mapping some state-event pairs to other states. The actions are normally associated with transitions. The advantage of this project is that with

mathematical models any claims about the correctness of foraging algorithms are strong. However, the engineering realization of foraging principles remains a research problem.

Autonomous Mapping Using a Flexible Region Map for Novelty Detection [15] used Algorithm that is inspired by habituation principal for performing autonomous update. This novelty detection also used reshaping flexible region map. The advantage of this project is any new robot or a robot which is equipped with a new sensor could easily learn its new environment or adapt to changes in the environment. The disadvantage is that the region map must be fixed to avoid any conflict. The habituation principal can be used in habituation project and thus can be implemented. Habituation is defined as a behavioral response decrement that results from repeated stimulation and that does not involve sensory adaptation/sensory fatigue or motor fatigue. It is the most basic form of plasticity within the brain. Studies of habituation also used to measure cellular or molecular responses or neuronal activity, including population activity. These responses at the molecular, cellular or population levels may be monitored in an effort to identify underlying mechanisms or they may be used as indices of habituation [16].

Last but not least, [17] is by using the Hybrid reactive/deliberative architecture. It is one of the artificial intelligence methods to define emotions. Artificial emotions can motivate a robot to reprioritize its goals, modulate its behavior parameters, and provide learning rewards. These interactions should improve a robot's ability to adapt to conditions that exceed its original design constraints [18]. In this project, the artificial emotion mechanisms improve the adaptive performance of a complete hybrid reactive/deliberative navigation system incorporating control, path planning and dynamic mapping capabilities. However, equivalent performance improvements cannot be guaranteed in real world. This project also can be implemented in habituation project as artificial emotions have been modeled in system as modulations of decisions and actions, complementing rather than driving cognitive processes.

2.3 Comparison of Different Method

The Table 2.1 shows the summary of the journals and the differences between the method used, robot's configuration and the behavior of robot.

Table 2.1: Comparison of Different Method of Multi-agent Robot

Journal	Method	Many robots	Unsupervised robot	Robot behavior
A Neural-Endocrine Architecture for Foraging in Swarm Robotic	Neural-Endocrine Architecture	Yes	Yes	11 behaviors using Neural-Endocrine design
An Environment for Robot Learning	Adaptation of robot in environment	No	Yes	Only learning ability
Exploiting Social Partners in Robot Learning	Social Learning Mechanism	Yes		Social learning; mimicking, imitation, stimulus enhancement and emulation
Robot Learning from Demonstration	Learning by imitation and Programming by demonstration	No	No	Learning from demonstration
Adaptive Robot Learning in a non-stationary Environment	Linear Function Approximation	No	Yes	Robot adapts to environment

Autonomous Mapping using a Flexible Region Map for Novelty Detection	Habituation Principle inspired algorithm	No	Yes	Robot adapt to environment
Mobile Robot Navigation Modulated by Artificial Emotions	Hybrid reactive/ deliberative architecture	No	No	Artificial emotions
Foraging Robots	Finite State Machine (FSM) and Fully Autonomous System	Yes	Yes	Searching and collecting an object and return it
Learning and Foraging in Robot-bees	Hebbian Learning Model, Reinforcement Learning	Yes	Yes	Robot learned an appropriate state space partion and perception to action mapping (insect behavior)
Multirobot Learning with Particle Swarm Optimization	Particle Swarm Optimization (PSO)	Yes	Yes	Learning robots
Using the Particle Swarm Optimization Algorithm for Robotic Search Application	Particle Swarm Optimization	Yes	Yes	Searching and localized

CHAPTER 3

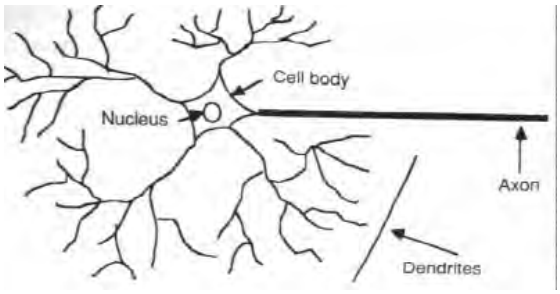
THE STUDY OF ROBOT SOCIETY USING HABITUATION ALGORITHM

3.1 Introduction

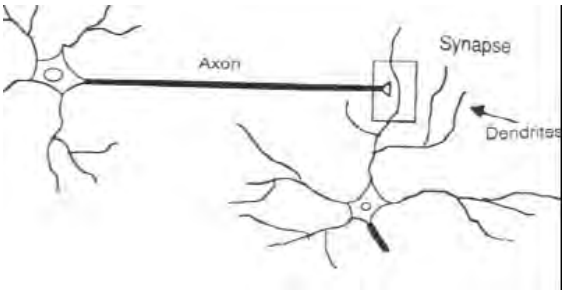
Artificial Neural Network (ANN)) [20] is a system that process information and paradigm which enable robots to extract patterns and detect trends that are difficult to be noticed by human or computer techniques. The paradigm is the main structure of the information system and is composed of a huge amount of highly interconnected processing elements working in unison to solve specific problems. This is advancement in robots intelligence as it provides the ability to derive meaning from data collected. Advantages of ANN are:

1) Adaptive learning: Ability learning tasks based on the data given for training or initial experience.
2) Self-Organization: An ANN can create its own organization or representation of the information it receives during learning time.
3) Real Time Operation: ANN computations may be carried out in parallel, and special hardware devices are being designed and manufactured which take advantage of this capability.

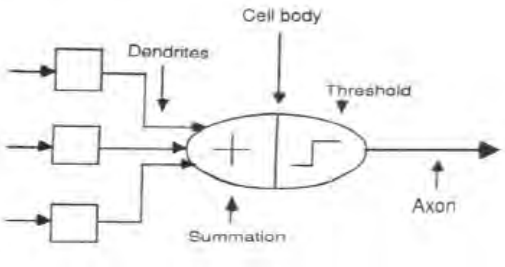
4) Fault Tolerance via Redundant Information Coding: Partial destruction of a network leads to the corresponding degradation of performance. However, some network capabilities may be retained even with major network damage.
5) A trained neural network can be thought of as an "expert" in the category of information it has been given to analyze



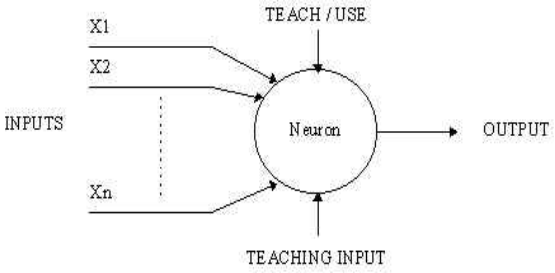
(1) Components of a neuron



(2) The synapse



(3) The neuron model



(4) A simple neuron

Figure 3-1: Neuron Network

Figure 3-1 shows that the model of neural network in human brain and artificial network. In human brain, the neuron will collects information and send it to the brain. In artificial neuron, it applied the same principal as the human brain. It is a device with many