

INTELLIGENT TIC-TAC-TOE BOT

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This report is submitted in partial fulfillment of the requirements for the Bachelor of
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DECLARATION

I hereby declare that this project report entitled
INTELLIGENT TIC-TAC-TOE BOT

Is written by me and is my own effort that no part has been plagiarized without citations

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ABSTRACT

Tic-tac-toe games is an interesting games that provide enjoyment in our life. This beautiful game is very familiar in our society because it is easy to play and requires simple equipment such as a pencil and a sheet of paper. The purpose of this project to build an intelligent robot that implemented in tic tac toe games. The intelligent robot is called Tic Tac-Toe-Bot. This robot can understand the rules and ways to play the game and make every decision based on the intelligence of the robot. In order to test the intelligence of this robot, the opponent must be a human. The Tic-Tac-Toe Bot will learn and play the games base on their intelligence. The Tic-Tac-Toe-Bot use light sensor to detect brightness or darkness in each block of tic-tac-toe board. This robot uses the NXT Lego Minstorm set for body design. Hence, this project is programmed by using RobotC programming language. The robot is embeded with minimax algorithm technique to make the best movement in the game. The result from this study shows that the Tic-Tac-Toe Bot able to play tic-tac-toe game with human without lose the game.

ABSTRAK

Permainan tic-tac-toe adalah permainan menarik yang memberikan keseronokan dalam kehidupan kita. Permainan ini adalah sangat biasa dalam masyarakat kita kerana ia adalah mudah untuk bermain dan memerlukan peralatan yang mudah seperti pensil dan sehelai kertas. Tujuan projek ini untuk membina robot pintar yang dilaksanakan di tic tac toe permainan. Robot pintar dipanggil Tic-Tac-Toe Bot. Robot ini boleh memahami kaedah-kaedah dan cara-cara untuk bermain permainan dan membuat setiap keputusan berdasarkan kebijaksanaan robot. Untuk menguji kepintaran robot ini, pemain lawan perlulah seorang manusia. Tic-Tac-Toe Bot akan belajar dan bermain asas permainan ini. Tic-Tac-Toe-Bot penggunaan sensor cahaya untuk mengesan kecerahan atau kegelapan di dalam setiap blok papan tic-tac-toe. Robot ini menggunakan set Lego NXT Minstorm untuk reka bentuk badan. Oleh itu, projek ini diprogramkan dengan menggunakan bahasa pengaturcaraan RobotC. Robot ini menggunakan teknik minimax algoritma untuk membuat pergerakan yang terbaik dalam permainan. Hasil daripada kajian ini menunjukkan bahawa Bot Tic-Tac-Toe dapat bermain permainan tic-tac-toe dengan manusia tanpa ada kekalahan.

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CHAPTER I

INTRODUCTION

1.1 Project Background

The purpose of this project to build an intelligent robot that implemented in tic tac toe games. The intelligent robot called Tic Tac Toe Bot. This robot will understand the rules and ways to play the game and make every decision based on the intelligence of the robot. In order to test the intelligence of this robot, the opponent must be a human. Tic-Tac-Toe Bot will learn and play the games base on their intelligence.

The robot will draw the tic-tac-oe game field containing 9 square with draw two horizontal lines and two vertical lines with square area. Each square enough for robot and human to draw any shape in order to play the game. Tic-Tac-Toe-Bot use light sensors to detect the drawing shape by differentiating the brightness or darkness.

This robot will use the NXT Lego Minstorm set for body design. Hence, this project will program by using RobotC software. The robot used minimax algorithm tp make the best and intelligent move in the game. The objectives of this project is to make this robot draw line and shape, detect different kind of shape and make decision to play the game.

In order to play tic-tac-toe game, the robot will draw tic-tac-toe board and then the robot will wait until the opponent play as the first player. After the opponent

play by shaded the selected block by its selected shape, the robot will scan each block to know the position of the block that has been played by opponent. Then, the robot is able to make an intelligent move by using the minimax algorithm technique to minimize opponent victory and maximize robot victory. After both players have made their moves, the robot will check whether there is a winner of the game. At the end of the game, the robot will show the winner of the game by displaying the result on the NXT controller interface.

1.2 Problem Statement

In order to fulfill the requirements of intelligent, strategy and game modernization which are leading to the issues of robot development cost and market availability, an intelligent Tic-Tac-Toe robot (Tic-Tac-Toe Bot) is developed in this PSM project. The robot should be embedded with tactical strategy and intelligence to win the Tic-Tac-Toe game.

1.3 Objectives

- i. To develop a robot that can move forward and backward in the tic-tac-toe game.
- ii. To fix the robot with the suitable sensors to accomplish tasks in the tic-tac-toe game.
- iii. To embed the robot with intelligent techniques to plan a winning strategy during the game.

1.4 Scope

Tic-Tac-Toe Bot is an intelligent robot implementing the tic-tac-toe game. This robot will understand the rules and ways to play the game and make every decision

based on the intelligence of the robot. In order to test the intelligence of this robot, the opponent must be a human. Tic-Tac-Toe Bot will learn and play the game based on their intelligence. In order to play the game, the opponent needs to play first and the robot will recognize opponent move by scanning in each block on tic-tac-toe board. After that, the robot will make intelligent move to less opponent victory and increase chance for robot victory. The robot will not play if it cannot find the selected block that has been played by opponent. The intelligence of this robot is to not draw shape at the block that already been played or shaded.

1.5 Project Significance

The robot is developed to play exciting tic-tac-toe game into physical intelligent product. The robot will be a strong opponent to human because Tic-Tac-Toe Bot is an intelligent robot that programmed with “not to lose” algorithm. Hence, this robot also can draw the shaped whether “O” shape or “X” shape and detect the opponent shape in order to play the game.

1.6 Expected Output

- i. The robot can move forward and backward.
- ii. The robot fix with suitable sensor in order to play tic-tac-toe game.
- iii. The robot make intelligent move in tic-tac-toe game.

1.7 Summary

In a nutshell, this project expected to develop a robot that has intelligent decision making during playing tic-tac-toe game. The robot will be strong opponent to human. In addition, the tic-tac-toe, but can draw lines and shape in tic-tac-toe board and detect the brightness and darkness in each block of tic-tac-toe board.

CHAPTER II

LITERATURE REVIEW AND PROJECT METHODOLOGY

2.1 Introduction

In this chapter, the literature review and project methodology will review. All of the sources of the literature review will support all the argument in this project to be developed. The sources can be any valid source from known researchers and institution.

2.2 History of Robot

The phrase of 'Robot' is taken from a Czech word (*robot*) which means force labor. In 1921, a Czech playwright Karel Capek in his play *Rossum's Universal Robots* introduced the word of 'robot' and translate it into three different languages. The importance of a robot to increase both imagination and reality (Felger JE, 2002) . The robot is the programmable, multifunction manipulator designed to move material, parts, tools or specialized devices through variable programmed motions for the performance of variety tasks (Robot Institute of America, 1979). There have three laws of robot, firstly, a robot not allow to harm a human being through inaction and allow human to touch or harm them. Secondly, a robot must obey orders given by human being and lastly, a robot must protect its own existence as long as such protection does not conflict with a higher law (Asimov I. , 1950). Nowadays, robot used to perform any task that cannot afford by human such as dangerous and

repetitive task. There have various way to implementing robot in this world. Robot can be used in medical, engineering, military defense, social, aerospace and tournament.

2.2.1 Existing Robot

Robot has been used in many applications and researchers invented many type of robots. The following section will discuss the types of robots.

2.2.1.1 Mobile Robot

Nowadays, mobile robot become one of the fastest growing robot in the world. Usually mobile robot able to move and perform the tasks that cannot be done by human beings. Mobile robots and their application can detect variable in the environment (G. Amato, 2012). In military, mobile robot has been used to perform dangerous tasks such as defusing bomb, operating in mountain caves and underwater (al., 2009). One of mobile robot application is Unmanned System (UMS) develop by military force which operating remotely and provide more capacity to the weapon for autonomous action (Excell 2007; Braybrook 2007). In the future, the technology will become more sophisticated and intelligence because the robots will make their own decision without supervision by human (Sparrow, 2011). In addition, one of mobile robot called Mars Explorer has been develop by National Aeronautics and Space Administration (NASA) designed to roam the Mars surface (Stephen J. Hoffman, 1997).

2.2.1.2 Walking Robot

Walking robot usually have legs or wheels to able them walking imitate human behavior. In process, the robot having hard time to balancing the shift and keep the robot from fallen. Because of that, most of walking robot have at least have 2 to 4 of legs or wheels to stabilize and balancing of the robot. One of popular

walking robot used bipedal locomotion is humanoid robot. The zero-moment-point theory (ZMP) is an approach introduced by Vukobratovic (Borovac., 2004) used stabilize the movement of the bipedal locomotion robot. Locomotion robot such as Honda Asimo (Honda Motor, 2008) or Toyota Partner Robots (Toyota Motor, 2008) able to walking, running, climbing stairs, playing musical instruments and conducting orchestras.

2.2.1.3 Autonomous Robot

Autonomous robot is a robot autonomously move and make own decision. Autonomous robot is self-supporting or self-contained because the ways the robot used their own 'brain' to perform tasks. Other that, autonomous robot run a program that has been written with intelligence technique give them the opportunity to perform tasks depending on their environment. Furthermore, autonomous robot also can learn new behavior base on their environment. Autonomous robot can learn to walk and avoid obstacles that blocked their way. One of autonomous robot is tic-tac-toe robot programmed with intelligence technique to play tic-tac-toe game without supervision by human (Pointeau.G, 2013) and one of tic-tac-toe robot is TTT Tickler (Benedettelli, 2009). Another autonomous robot is soccer playing robot used reinforcement learning method to learn crucial skills and movement (Riedmiller, 2009).

2.2.1.4 Virtual Robot

Virtual robot is a robot that can be used in the virtual world. This robot used for programs, building blocks of software inside the computer. A virtual can perform repetitive task or simulate the real robot. Usually virtual robot used to test any code or program in simulation before programmed into the real robot. One of popular virtual robot is Robot Virtual World (RVW). RVW is high-end simulation environment that enables students to learn programming without real robot and help to increase accuracy and efficiency to the program of the physical robot (Robot Virtual World, 2015).

2.2.1.5 Humanoid Robot

Humanoid robot is a robot that develops to imitate the human body shape and behavior. In recent year, humanoid robot received significant attention and play central role in robotic research and many applications because it is human-like robot. Humanoid robot have bipedal legs and the movement of the robot depending on the atmosphere and for example humanoid robot are able detect different types of terrain such as stairs and try to climb it. Humanoid robot such as Honda Asimo (Honda Motor, 2008) or Toyota Partner Robots (Toyota Motor, 2008) able to walking, running, climbing stairs, playing musical instruments and conducting orchestras. In space mission also used humanoid robot such as NASA Robonaut (R.O. Ambrose, 2004) and DLR's Justin (T. Wimbock, 2007) and both have wheel to move. Furthermore, a Japanese company Yaskawa develop human-like-dual-arm called Motoman-SDA10 robot in manufacturing industries (Corp, 2008) and Yaskawa aims is to replace human in production lines.

2.2.2 Parameter and Sensor

Robot parameter is all element that used in order to achieve the project objectives. The parameter of this project are tires, pen, board, motor and lego set. The condition of all this parameter influences the result of the experiment and the best way to get consistence result. In this project only require four tires, 3 motors and three Lego set. Tic-Tac-Toe Bot designed four wheel robot and only one motor used to move the robot. The length of the robot move was measured to make sure the robot move to the exact location. Another motor used to move the pen horizontal consistently and third motor used to move the pen vertical in order to draw on the paper. In this project, only two sensors have been used which are light and ultrasonic sensor. The light sensor will be used to differentiate between colors and ultrasonic sensor use to play and stop the games. In order to achieve very good results, the light sensor need to play an important role by differentiating the value of color by range

for example the range orange color is 100-150. The ultrasonic sensor usually uses to avoid an obstacle or barrier from a distance.

2.2.3 Robot Application

Robot has been used in many applications such as manufacturing, games, medical and aerospace. The following section will discuss the types of robot applications.

2.2.3.1 Soccer Robot

Today, the most popular game in the world is football or soccer. Soccer robot application has been develop to make real life sport into intelligence robot game. There is a soccer robot tournament organized by RoboCup Federation that require machine learning algorithm to solve real world problem such as evolutionary algorithm for gait optimization (Chernova, 2004) or optimization of team tactics (Nakashima, 2005), unsupervised and supervised learning in computer tasks (Kaufmann, 2004), lower level control tasks (Oubbati, 2005). One of the learning called reinforcement learning react as an acting agent obtains its behavior policy through repeated iteration with its environment on trial and error basic.

2.2.3.2 Sudoku Robot

Nowadays, Sudoku is one of interesting puzzle game to play. The board of this puzzle game content 81 blocks, 9 x 9 cells and divided into 3 x 3 sub blocks and only have set of number from 1 to 9. The rules of the games quiet simple each row and column must have the combination from number 1 to 9. There are plenty approach for Sudoku solving puzzle such as genetic algorithm (Timo, 2007), SAT (Ines, 2006), integer programming (A. Bartlett, 2008), meta-heuristics (Rhyd, 2007),

neural network (V. Mladenov, 2011) and particle swarm optimization (J. Monk, 2012).

2.2.3.3 Tic-Tac-Toe Robot

Tic-tac-toe games is an interesting games that provide enjoyment in our life. This beautiful game is very familiar in our society because it is easy to play and only require simple equipment such as a pencil and a white sheet of paper. In tic-tac-toe games (Wikipedia, 2015) only two player allow to play where the board content square block (3 x 3) or nine square that can be filled by different shape whether a cross (X) or circle(O). Each player need to select one of this shapes and toggle every time they make their move. Then, the winner will be display by this program when a player that make a combination of 3 same shape in horizontal, vertical or diagonal line. In addition, the tic-tac-toe game is very good game to play in our daily life. This game can release our pressure and stress. Furthermore, this game will make our physically and mentally improve. Tic-tac-toe robot programmed with intelligence technique to play tic-tac-toe game without supervision by human (Pointeau.G, 2013). One of tic-tac-toe robot is TTT Tickler (Benedettelli, 2009).

2.2.4 Robot Intelligence Technique

Robot has been embedded with many techniques to make it more intelligent in making a decision. The following section will describe three main techniques that available to make a robot more intelligent.

2.2.4.1 Fuzzy Logic

Fuzzy logic is an artificial intelligences technique that provide efficiency and effectiveness to the system. Fuzzy logic was develop by Professor Lotfi Zadeh of University of California Berkeley in 1965 used to reduce the complexity of modelling nonlinear problem (Zadeh, 1976). In early stage, fuzzy logic is a

multivalued logic and defined value between conventional evaluations (Hellmann, 2001). The engineers can use this method in natural language to describe and implement the control system. Fuzzy logic has been used to design of obstacle avoidance for mobile robot help to increase the robot performance because of small control rule and less travelling time and the result of this research show increase of effectiveness to avoid obstacle with fast time in unknown environment (C.Byung-Jae, 2013).

2.2.4.2 Neural Network

Neural network (NN) technique is a method to build intelligence robot such as autonomous robot. There are three learning paradigm of NN classified as supervised, unsupervised and reinforcement learning on pattern class information. Supervised learning assumes the availability of a teacher or supervisor and unsupervised learning identify the pattern class information heuristically and reinforcement learning learn through trial and error interactions with its environment (R. Sathy, 2013). There are many advantages of NN such as able to learn from experience, able to generalize and associated data and fault tolerance (Kriesel, 2005). Neural network algorithm has been used for dual Wheel Mobile Robot (WMR) as it deals tuning and properly optimized because one of the capabilities of neural network is good performance for approximation of non-linear function (Soomro, 2014). Then, neural network approach is easier to implement and provide good image features used in visual servoing of robotic manipulator (S.Partap, 2014).

2.2.4.3 Minimax Algorithm

Minimax algorithm used to determine the best move for robot or computer in strategy games such as tic-tac-toe, chess and checker game. This algorithm is the best effective algorithm for creating agent for board games and find the solution to win the game (Luger., 2009). The algorithm starts by opening child node and evaluate its value and then the child node will open another node until it reaches the end node and if it reaches end node, the parent node will select the highest node value in each level until

the original board state, original board will select the highest node value for the next move (Millington, 2006.) .The minimax algorithm can be more efficient by execute alpha-beta pruning technique because alpha-beta pruning technique will reduce searching time by selected the higher value of node and cut-off the lowest node value in the searching tree (Korf., 2000).

2.3 Project Methodology

Project methodology use to know the flow of the project to achieve the objectives. Each phase content sub topic that is very important in order to develop this project. There have 5 phase of methodology in this project firstly is problem definition, secondly is literature review then third is robot development, fourth is robot testing and last phase is documentation.

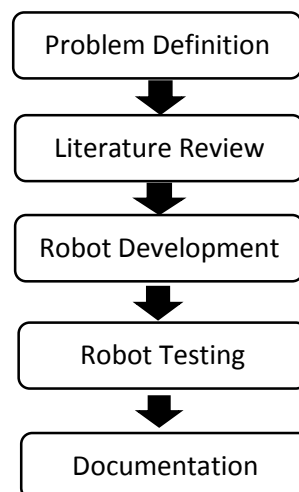


Figure 2.1: Project Methodology

2.3.1 Problem Definition

In this early phase we need to identify the challenges or issue to develop this project. In addition, we also need understand the problem and overcome it by our