DESIGN AND IMPLEMENTATION OF AN AUTONOMOUS SUMO ROBOT

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DECLARATION

"I declare that the work submitted in this thesis entitled Design and Implementation of an Autonomous Sumo Robot is my own, except for works that I have been clearly cited in the references".

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Supervisor : MR. SOO YEW GUAN

For my beloved family

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ABSTRACT

The purpose of this project is to design and implement an autonomous robot that meets the specifications needed to compete in a sumo robot competition. The robot will react and move using various types of sensors controlled using microcontroller. Although this robot is developed to compete in a tournament, the technology can be used for unlimited applications. For example, the robot can be used to explore small or dangerous terrain, or even perform everyday tasks on its own like vacuuming an entire house. I have to see the design of this robot from many different angles like mechanical, electrical and coding. I had to approach my problem mechanically first because it is the building block for everything that I had to design, and had to fall in the specification. In the mechanical design I started by choosing a body type that will allow us to be as flexible as we can to allow other devises to be put on it and still can be under the size specification. Choosing motors was also important because I needed motors that can give the best performance in power, size consumption and cost. With similar specification for the design, I decided on what type of sensors I should use and how they can help me accomplish my goal. My choice of microcontroller to control the robot was simpler that anything else because I already had an experience with the Microchip 16F84A in a previous class and I already had an idea how to use this specific controller which is fairly inexpensive and which meet all the requirements.

ABSTRAK

Tujuan utama projek ini adalah untuk merekabentuk sebuah robot sumo yang menepati spsifikasi yang telah ditetapkan di dalam pertandingan Robot Sumo. Robot ini akan bergerak sendiri tanpa kawalan daripada manusia berpandukan pengesan yang telah dipasang padanya. Walaupun robot ini hanya dibina untuk pertandingan, teknologi yang ada pada robot ini boleh diperkembangkan kepada aplikasi yang lain. Contohnya, robot ini boleh diubahsuai untuk menjadi sebuah robot yang mana ia mampu untuk menjelajah ke kawasan yang sukar dan bahaya. Mungkin juga ia boleh dijadi sebuah robot yang mana ia berupaya menbantu manusia membuat kerja-kerja seharian seperti membersihkan kawasan rumah. Saya telah memandang rekaan robot ini dari pelbagai aspek seperti bahagian mekanikal, elektrikal dan pengaturcaraan. Saya telah memulakan projek saya ini dengan menyelesaikan masalah mekanikal dahulu kerana bahagian ini adalah penting kerana ia harus menepati segala aspek yang telah ditetapkan. Oleh itu, pada bahagian mekanikal saya bermula dengan memilih bahan yang sesuai yang mana ia mudah dibentuk, tahan serta senang diperolehi pada harga yang berpatutan. Pemilihan motor juga penting kerana motor ini akan memberikan kuasa yang dikehendaki pada saiz yang ditetapkan. Seterusnya pengesan yang digunakan menepati aplikasi robot tersebut. Akhir sekali untuk mengawal pergerakkan robot, Microchip 16F84A telah digunakan.

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CHAPTER I

INTRODUCTION

1.1 INTRODUCTION

The Sumo Robot competition originated in Japan and in recent years has become more and popular around the world. Similar to traditional sumo wrestling, the main objective is to force the competitor out of the ring while staying in the ring. The mission of these tournaments is to provide a safe and enjoyable environment for people to test their intellectual abilities with one another. Autonomous Sumo robots are self-propelled and self-controlled, without tethers. After positioning and starting the robot, no remote control, power, positioning, or other help can be provided. The robot must care for itself until the round ends. As long as all other requirements are met, Sumo robots can be made out of any material. They can use any type or size of electric motor or electric-powered locomotion. They can contain any kind of processor, electronics, sensors, or batteries desired. Scratch-built robots are most successful because they are specifically designed for their purpose. However, commercial kits and LEGO bricks are equally viable in the hands of a creative inventor. There are two popular classes of robots, based on size:

- Class A (larger, heavier)

- Class B (smaller, lighter)
- Class C (micro robot)

1.2 PROBLEM STATEMENTS

The problem in this project is how to choice a suitable microcontroller to be used in this sumo robot. Beside that, this sumo robot should have a suitable sensor for detect the dohyo ring and its opponents. In programming part, what is a suitable algorithm should used based in the sensor and how to make an autonomous sumo robot fulfill the tournament specification.

1.3 Project Objective

To archive the goal of this project, there are some objectives that should archive. The objectives are:

a) To investigate a suitable microcontroller to be used in sumo robot

b) To identify suitable sensor and implement it on sumo robot.

c) To develop a program to control the sumo robot based on data it received from sensor.

d) To study a suitable material and design of chassis for sumo robot.

1.4 SCOPE PROJECT

The main scope in this project is to design and build an autonomous sumo robot that follows the specification that has been set by American Sumo Robot and Official Rules of the FSI All Japan Robot Sumo Tournament. This design and sumo robot can be use in a national or international tournament. Beside that, this project only includes a basic electronic component that we have seen everyday in our life like Infra red and dc motor. There are no electronic kit install in this robot. This sumo robot can move to the left, right forward and backward inside the dohyo. Lastly this sumo robot can detect the line and detect it opponents using the sensor or other device that available on the sumo robot.

1.5 REPORT STRUCTURE

This report starts with literature review about the sumo robot rules and specification, the previous robot, about line detection, object detection using infrared, DC motor, motor controller, microcontroller, microcontroller programming and about the material that suitable to design the chassis. In next chapter, will be discuses the project methodology on the process to build an autonomous sumo robot. Chapter 4 shows all the result and algorithms. Project hypothesis will be done decide either the project archive the objective. Lastly in this report, some discussion and conclusion on this overall project.

CHAPTER II

LITERATURE REVIEW

2.1 ROBOT-SUMO TOURNAMENT GAME RULES

2.1.1 Overview

In this sumo robot tournament, two self-controlled robots are placed in a ring. The robots try to avoid falling out or void being pushed out by the opponent robot. The first robot that touches outside of the ring loses the round. The first robot to win two rounds, wins the match. Different robots compete one-on-one against each other throughout the contest. The robot that wins the most matches wins the contest.

2.1.2 Mass

Class A Sumo robots may have a mass of 3 kilograms (6.6 pounds) or less. Class B Sumo robots may have a mass of 500 grams (1.1 pounds) or less. Lift can't reduce the robot below the required limit because the limit is specified in mass (universal constant) rather than weight (gravity component). For example, a helium-filled balloon can't be used to lighten a robot during weigh in. Because this is a pushing contest, it is to the robot's advantage to be as heavy as possible. Many builders bring extra weights or washers to increase the robot's mass to the maximum amount as measured at the contest location.

2.1.3 Dimensions

At the start of each round, Sumo robots must not exceed a specified width and depth. Class A Sumo robots may be 20 centimeters (7.87 inches) or less in width and 20 centimeters (7.87 inches) or less in depth. Class B Sumo robots may be 10 centimeters (3.93 inches) or less in width and 10 centimeters (3.93 inches) or less in depth. There is no height limit to either class. Also, as soon as movement is allowed in a round, the robot may then twist, fall, or expand without size limits.

2.1.4 Harmlessness

At all times, robot behavior must be non-offensive, non-destructive, and non-harmful to humans, robots, and the facilities. This is an immutable principle, even if the behavior is unintentional or not by design. During inspection (and at any time during the event), the judges may require safety changes or other modifications to meet the harmlessness requirement. Harmful robots are either not allowed to compete at all or are later disqualified if potential harmful issues are proven or revealed in battle. Judges also examine to see if a robot's design is sufficient to survive the expected pushing, shoving, and physical rigors of competition. Suggestions may be made to avoid damage to the robot. A weak robot is usually allowed to compete at its own risk. During the contest, the judge must determine if a robot's failure was due to its own lack of durability. Failures due to exposed wires or unsecured or flimsy parts shall be the responsibility of the robot with such weaknesses. At all times, Sumo Robots must not:

- Emit smoke or fire
- Leak, stain, or soil
- Disperse powder, grit, or grime
- Spray, throw, or use projectiles
- Jam, shock, or electromagnetically interfere
- Snare, entangle, or employ nets/rope
- Scratch, gouge, or scrape

However, as for the last point, naturally some damage occurs from scoops, changes in starting orientation, and from the battles themselves. This is expected and acceptable to any reasonable extent. Another rule: Sumo Robots must not fly or generate lift to isolate themselves from the ring surface. The "no-fly" rule isn't intended to prevent a robot from having a floating portion (such as a camera, sensor, flag, or distraction) nor to prevent jumping or other interesting behavior. The robot qualifies as long as a major portion of the robot is generally available to be pushed out by the opponent robot.

2.1.5 Suction, Magnets, and Sticky Wheels

Some contests disallow suction, glue, "sticky wheels", magnets, or other methods of increasing downward force. In those contests, a common method of determining a violation is to place the robot on a piece of paper and lift up the robot to see if the paper lifts too. With a little bit of advance thought put into the design, a configurable robot might still qualify for contests with such restrictions. Suction can be turned off, sticky wheels can be swapped out, and magnets become ballast.

2.1.6 The Dohyo

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The Dohyo interior is defined as the Dohyo area surrounded by and including the border line. The dohyo ring is a large, flat disc. It is made of a smooth, rigid material, such as wood, aluminum, or steel. (Steel or another iron-based material is required if magnets are to produce downward force.) The top is usually painted or made of hard rubber. The top surface is dull black, except for a thin border that is shiny white. Two starting lines in the middle are brown. All of these areas are "in" bounds. The ring is raised slightly to make it easier to determine when a robot has been pushed out. The height isn't very much though, to avoid damaging robots that fall or get pushed out. An external area of at least 100 centimeters (3.3 feet) of empty space exists around the ring. This space must not contain any people, objects, lights, or anything else that would distract or interfere with the robots. The floor may be any color but white. The external space and the raised-edge wall of the ring are "out" of bounds. The ring should be as level and sturdy as possible. Fancy rings include feet with built-in level screws. There are two ring sizes, one each for both popular Sumo robot class sizes.

2.1.7 Edge Sensors

A surprising number of Sumo robots drive out of the ring without even being pushed. A well designed and built Sumo robot should be able to navigate the ring indefinitely without falling out. The flat black ring surface contrasts with the gloss white border so that a robot can easily use a light sensor to detect the edge. Although less popular, physical switches can also detect ring edges.

2.1.8 Inspection

Each robot is measured and inspected to verify qualification. To avoid arguments over analog needle interpretation, usually a digital scale is used for determining mass. Allow for a little free weight that can be added or removed in case your home scale doesn't match the tournament's scale. For width and depth, a carefully measured box or cube is placed over the robot. Actually, the box is more of a tube really, because it is missing the top and bottom. The box avoids arguments over ruler interpretation, because the robot qualifies if the robot fits in the box. The robot must start each round of the contest in an orientation and physical position that would fit in the box. It would be unfair to measure the robot in one position (sticking out of the top of the box) but then manually rotate the robot to an unqualified length before beginning a match. The robot is inspected to be sure it is non-damaging and generally safe.

2.1.9 Playoffs

Depending on how many robots participate, the organizers can choose a number of different elimination methodologies. A few popular methods are presented here, but obviously creative variations can be designed to meet the needs of a particular contest.

Single Elimination: Upon losing a match, the robot is out of the contest. This is the harshest method and least likely to convincingly determine winners. It also means half the participants get to compete only once.

Double Elimination: Upon losing two matches, the robot is out of the contest. This is common practice when a large number of robots are entered.

A good way to run a double-elimination playoff is to have the set of winning robots pitted against other winning robots, and losing robots against losing robots. That way, a robot won't have the bad fortune to compete against two top robots in row. For example, robot A loses to robot B, and robot C loses to robot D. Robot A would then play against robot D, with the losing robot being eliminated.

Round Robin: Each robot faces each other robot (one at a time) in a match. Although this can take a long time, it is the most fun because every robot gets a chance to compete against every robot. This method also has the advantage of determining all robots' actual rank, not just a sole winner.

Heats: The robots are divided into smaller groups and a method above is used within each group to organize one-on-one matches. The winners of each group advance.

2.1.10 Records, Tie Breaking, and Championship Match

Records should be kept to facilitate dispute resolution and tie breaking. The number of match wins is most important, but some good tie breaking criteria are: round losses, round wins, lightest weight, and total time taken per match win. Sudden death rounds could also be used. Regardless of the method chosen, organizers should communicate the scoring method well in advance, in writing, so that the participants can design according. An excellent ending to the contest is to extend the championship match to be the first robot to win by two rounds.

2.1.11 A Match

At the beginning of a match, the contestants approach the ring and bow to each other. Most Americans aren't accustomed to bowing, and so may desire to skip this ritual. However, this is an important step in breaking the ice and establishing the friendly, respectful tone of the event and therefore must not be omitted. The robot must be ready at the appointed times. Contest organizers may grant reasonable leeway, but a referee may declare a round or entire match lost if a robot isn't punctually prepared to compete. Throughout the contest, the algorithms, settings, and components on the robot can be shaped, angled, or configured differently for facing each opponent and being placed in different starting positions. In some contests, although a reasonably identifiable core must remain, whole pieces may even be added or discarded. However, these changes must bear in mind appointed time constraints and class restrictions.

2.1.12 Positioning

The better-ranked robot or the robot that just won the prior round is positioned first. The contestant may place his or her robot in any position, angle, or location on the ring except that no portion of the robot may cross the extended starting line nearest the contestant. The robot must fit within the required starting dimensions (20 cm x 20 cm or 10 cm x 10 cm depending on the robot's class). The lesser-ranked robot or the robot that just lost the prior round is positioned second. It is an advantage to be the second contestant to place a robot in the ring, so one shouldn't forget or dismiss this opportunity. By placing the second robot out of the direct line of sight, at sideswiping angle, or closer/further to the first robot, it may be possible for the second robot to gain a quick victory. Depending on who wins this round, the order may change in which the robots are placed next round. The second contestant may place his or her robot in any position, angle, or location on the ring except that no portion of the robot may cross the extended starting line nearest the contestant. The robot must fit within the required starting dimensions (20 cm x 20 cm or 10 cm x 10 cm depending on the robot's class). By the way,