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The Maze Problem Solved by Micro mouse

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ABSTRACT-* A Micromouse is a miniature Electro-mechanical robot, typical consisting of 3 main subsystems: The drive system, an array of sensors, and the control system. The purpose of Micromouse is to find its way through any type of Maze in shortest time. Aside from its being a fun, competitive challenge, the micromouse has proved to be an excellent teaching medium. It can be viewed as a small system involving interdisciplinary engineering aspects. Its successful designers often work in teams, and must consider electrical, electronic, mechanical and computer issues. Design decisions and tradeoffs involve weight, speed, and power, sensing techniques, turning methods, centre of gravity and programming. Autonomous robots have wide reaching applications. From Bomb sniffing to finding humans in wreckage to home automation. This paper covers one of the most important areas of robot, "Decision making Algorithm" or in lay-man's language, "Intelligence". The environment around the robot is not known, so it must have decision-making capabilities. For starting in the field of micro-mouse it is very difficult to begin with highly sophisticated algorithms. This paper covers very basic wall follower logic to solve the maze. And gradually improves the algorithm to accurately solve the maze in shortest time with some more intelligence. The Algorithm is developed up to some sophisticated level as Flood fill algorithm.

***Index Terms* – Lorentz force, Differential Chassis, flood fill algorithm**

I. INTRODUCTION

Micromouse is an autonomous self contained machine designed to get to the centre of a maze in shortest possible time. A micromouse essentially comprises of a drive motor or motors to move it; a steering and turning method; sensors to detect the presence or absence of maze walls; sensors or control logic to oversee the action of the rest and keep the vehicle on track or to solve the maze; batteries to provide power. The micromouse competition has been running since the late 1970s around the world. Essentially

there is a wooden maze made up of grid of cells. Mice must find their way from a predetermined starting position to the central area of the maze unaided. The mouse will need to keep track of where it is, discover walls as it explores, map out the maze and detect when it has reached the goal. The mouse will need to keep track of where it is, discover walls as it explores, map out the maze and detect when it has reached the goal. The winner is the mouse that reaches the centre in shortest possible time [3]. Although modern micro mouse are relatively sophisticated, this is an extremely challenging undertaking. As with any engineering project, there are countless ways to build a Micromouse. One has to make design

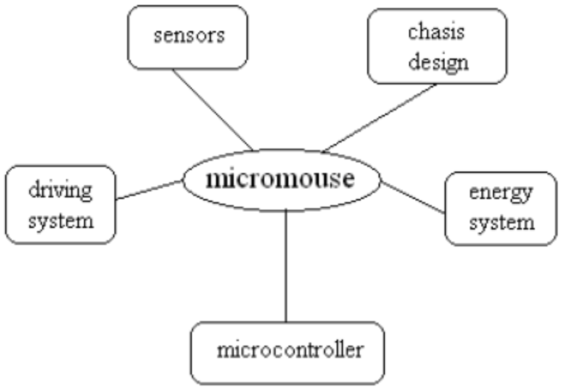

Fig. 1. Block diagram of micromouse

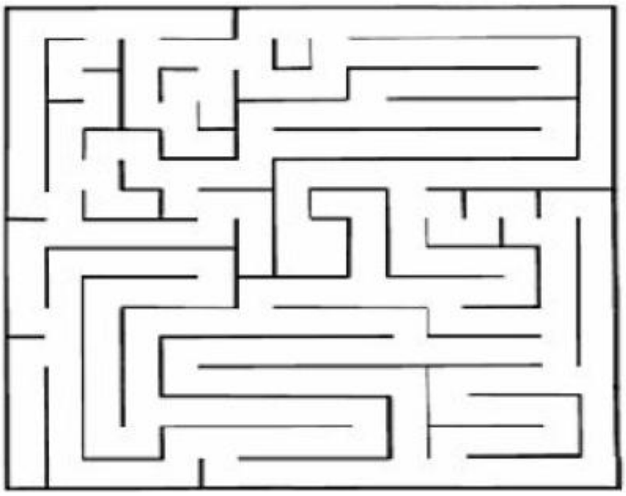

Fig. 2. Sample maze

Decisions based on the time available, the cost and specifications of the project.

II. MECHANICAL DESIGN

The mechanical design of the mouse was completed using Pro/Engineer CAD tools, and fabricated using computer controlled milling machines. The use of computer controlled milling machines enabled a high degree of precision in the design; clearances as tight as one-quarter millimetre were successfully utilized. Most of the components are plastic, to save weight; the motor and bearing assemblies are aluminium for strength and rigidity, and the top surface is made of aluminium to allow it to act as a heat-sink for the power and control electronics.

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A drive system consists of many components. The following is a logical list of such components, starting with the one that contacts ground.

· Tyre
· Motor
· Wheel
· Motor drive circuit
· Axle
· Gear
· Motion control software

The process of alternating the current through the coil is described above is known as commutation and is commonly achieved through the use of a brush arrangement attached to power supply.

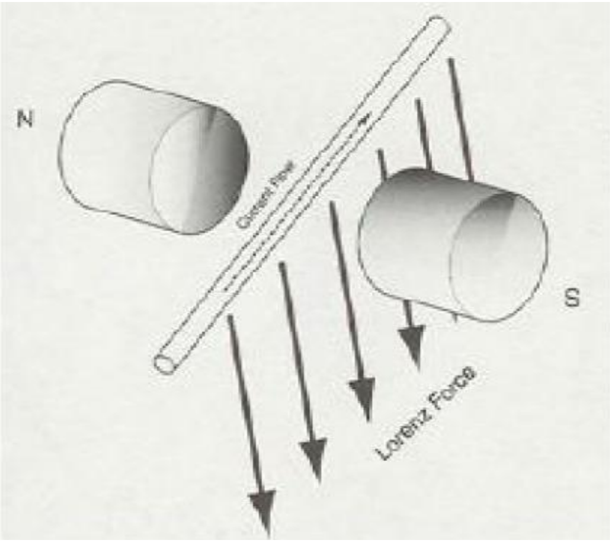

Fig. 3. Lorentz Force

Real motors use coils with more than one turn to increase the overall torque (or rotational force) on the armature, ensure that the armature never becomes stuck in a state of equilibrium with the magnetic field, and achieve greater efficiency in the design.

III. SENSORS

The sensors are the part of control system which is responsible for collecting and preparing process status data and for processing it into a processor. An intelligent robot is a remarkably useful combination of a manipulator, sensors and controls. Sensors permit them to adapt the environmental changes Greater use of sensors and more intelligence should lead to a reduction of this uncertainty and because the machines can work 24 hours a day, should also lead to higher Productivity [4]. There are some very serious technical challenges associated with this task. First, we need not only to be able to detect obstacles, but also to measure our distance from them at very close proximities. When our mouse traverses a diagonal path, the maximum spacing between posts is exactly 16.8/1.414 = 8:4×1.414=11:76cm. Because of space constraints imposed by the sizes of our motors and batteries, the mouse. The exactly 9cm wide, which leaves 1.38cm of clearance on either side of the mouse. At top speeds of >15 ft/sec, it is clear that we must have accurate distance measurements at short distances in order to avoid hitting the posts. Problems with traditional short range sensors make this difficult. In order to get the

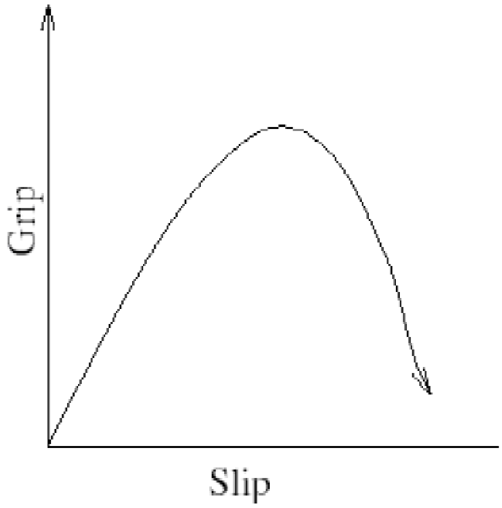

Fig. 4. Grip versus curve for typical tyre

Resolution we need to keep our control system stable at high speeds, we need to limit the maximum visible distance of our short range sensors to a maximum of 8cm. Now consider a mouse accelerating at 1g to a maximum velocity of 10 ft/sec. physically, the wheels must slip when accelerating; fig. 4 is what automotive engineers call a gripslip" curve for a typical rubber tire. It is obvious that some amount of wheel slip is necessary to exert the acceleration force. Worse, the actual grip-slip curve is dependent on floor material and thus unknown to us. All we know about the floor is that it absorbs light. However, we must have a reliable way to measure the distance we have travelled. It is clear, then, that any distance

measure we make cannot totally rely on the motion of the wheels or the motors. Typical advanced mouse designs get around this problem by mounting idler wheels on the ground that are not powered by the motors, but merely roll on the ground. While this solution is attractive, it uses precious space under the mouse, and, in our design, this space is at a premium. It was therefore necessary to design a solution on top of the mouse. This led to the design of our long range sensing mechanisms.

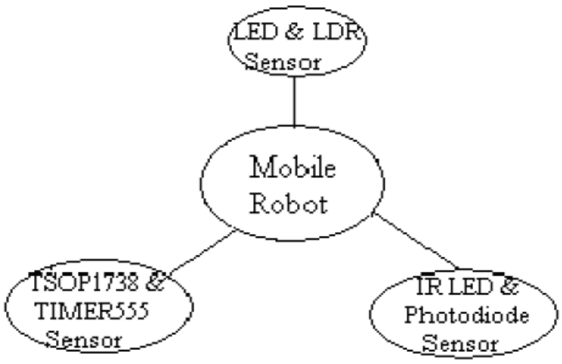

Fig. 5. Differential of low cost robotic sensors

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The range of different sensors is listed in table I

Table I:Range of sensor for reflect or proximity type detection

S. No.	Sensor	Range
1.	LED & LDR Sensor	About 5 cm.
2.	IR LED & Photodiode	5-10 cm.
3.	TSOP1738 & Timer 555 sensor	Around 10 cm.

The rating of the battery is then calculated taking the difference between the discharge rate and the reserve power and multiplying it by the number of hours under test. What this means is that it's an unusual battery that provides the stated amps in the 1-h.

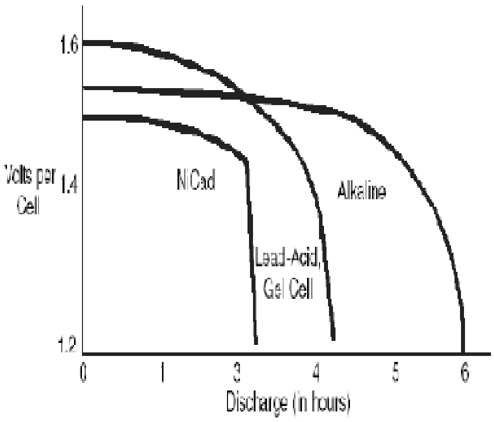

Fig. 6. Representative Discharge curves for several common battery types

IV. MICROCONTROLLER AND ALGORITHMS

The principal goal of a micromouse is to solve the maze and find its centre as quickly as possible. To accomplish this task, the micromouse uses a particular maze searching algorithm. A vast amount of research on searching techniques already exists and is currently being undertaken. As a result micromouse robots generally use some variation of the following three searching algorithms: Wall following, Depth First search and Flood Fill.

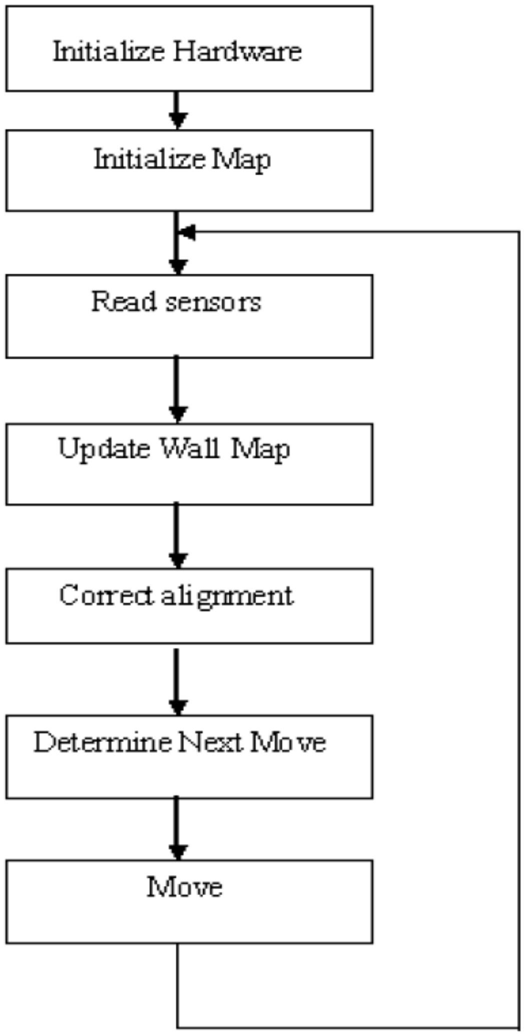

Fig. 7. Flow Chart for micromouse

The maze problem has an extra complication, which is not apparent when one consider for the first time. For each of the cells and a specific goal position, there is more than one equally good direction [5].

A. Maze Interpretation

The maze is interpreted in the form of a two dimensional array, with each cell having its own coordinates. Rows and columns distinguish the array, rows denoted by 'R' and columns denoted by 'C' hence, the increment and decrement in R and C will signify different cells. Now, the movement of the micro mouse on the maze is purely celling wise mapping.

B. The Wall Follower Algorithm

Here, we are developing the wall follower logic. This works on the rule of following either left wall or right wall continuously until it leads to the center. The micro mouse senses the wall on the left or right, and follows it to wherever it leads until the center is reached. This simple logic used for solving the maze [7, 8] is mathematically demonstrated by the following approach.

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C. Mathematical approach

Here, we have an array of 16 rows and 16 columns. If the array is denoted by M, then each cell is represented by M[R][C]. We assume the present position of array as M2 [R2] [C2], the previous position as M1[R1][C1], and the next position as M3[R3][C3]. Now we proceed as follows:

If R2-R1>0, then it is currently moving straight, upwards through the maze array.

If R2-R1<0, then it is currently moving straight, downwards through the maze array.

If C2-C1>0, then it is currently moving rightwards, through the maze array.

If C2-C1<0, then it is currently moving leftwards, through the maze array.

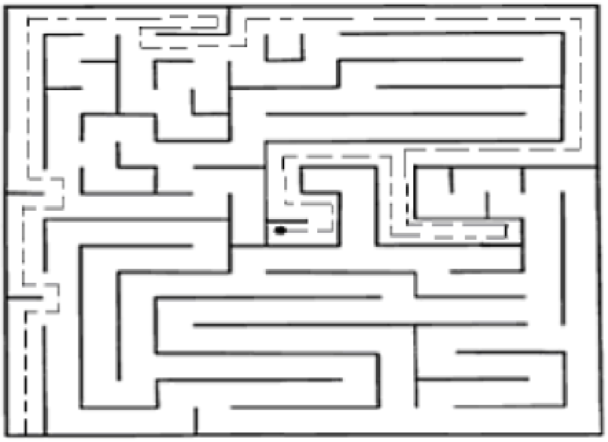

Fig. 8. Left wall follower: solvable maze

The time taken by the robot can be calculated [9]. If we assume the cell to cell movement time to be 2.5 sec. and the turning time to be 1 sec. then the total time taken by the robot is (140×2.5) + (27×1) = 377 sec. for reaching the centre of this maze.

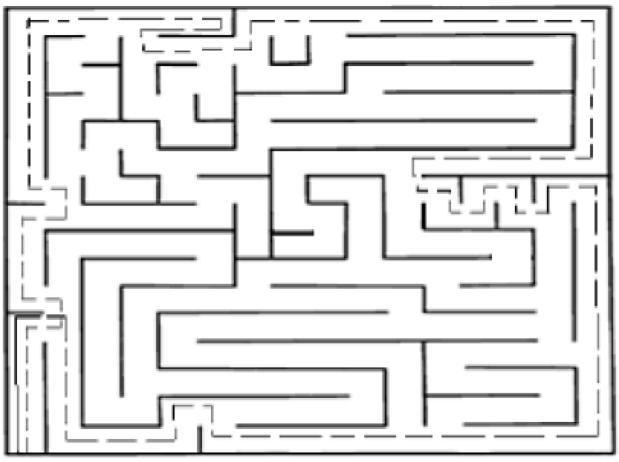

Fig. 9. Left wall follower: unsolvable maze

The above maze is not being solved using the left wall follower logic. This is one of the drawbacks of this logic.

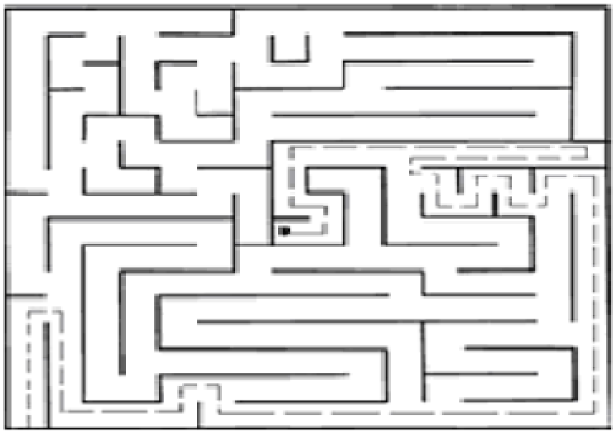

Fig. 10. Right wall follower: solvable maze

The above maze is solved using the right wall follower logic. The total time taken by the robot is (124×2.5) + (25×1) = 335 sec. for reaching the center of the maze.

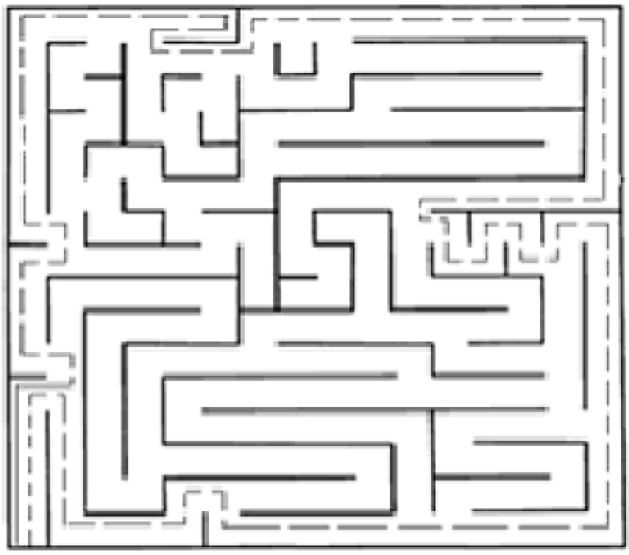

Fig. 11. Right wall follower: unsolvable maze

D. Depth-First algorithm

Depth- First search is an intuitive algorithm for searching a maze in which the mouse first starts moving forward and randomly chooses a path when it comes to an intersection. If that path leads to a dead end, the mouse returns to his intersection and choose another path. This algorithm forces the mouse to explore each possible path within the maze, and by exploring every cell, the mouse eventually finds the center. It is called “depth first” [10] because if the maze is considered a spanning tree, the full depth of one branch is searched before moving onto the next branch. The relative advantage of this method is that the micromouse always finds the route. Unfortunately the major drawback is that the mouse does not necessarily find the shortest or quickest route and it wastes too much time exploring the entire maze.

E. Flood Fill algorithm

The speed of robot to find its path, affected by the applied algorithm, acts as the main part in the present project. The flood-fill algorithm involves assigning values to each of the cells in the maze where these values represent the distance from any cell on the maze to the destination cell. The destination cell, therefore, is assigned a value of 0. If the mouse is standing in a cell with a value of 1, it is 1 cell away from the goal. If the mouse is standing in a cell with a value of 3, it is 3 cells away from the goal. Assuming the robot cannot move diagonally [6]. The maze is represented as a 16x16 array in the memory. The centre is given the value (0, 0). All cells in its immediate vicinity are assigned 1, the cells next to it as 2, and so on. The array is divided into 4 symmetrical regions and then the assignment is done.

1. Upper left quarter, loop decrements the column, increments the row: R = R + j, C = C - i, i, j vary from 0 to 8.
2. Upper right quarter, loop increments the column, increments the row: R = R + j, C = C + i, i, j vary from 0 to 8.
3. Lower left quarter, loop decrements the column, decrements the row: R = R - j, C = C - i, i, j vary from 0 to 8.
4. Lower right quarter, loop increments the column, decrements the row: R = R - j, C= C +i, i, j vary from 0 to 8.

V. RESULTS AND DISCUSSIONS

Motion planning is a key requirement of autonomous robots. When given a task to fulfil, the robot has to plan its actions including collision-free movement of actuators or the whole robotic platform. A comparative study on the pathlength & time performance of the robot with regards to different algorithms is also done. Both simulation and real tests are performed. The problem encountered in wall follower algorithm [13, 14] either left wall or right wall follower is solved by flood fill algorithm. The comparison of different algorithms is shown in table II.

Table II:Comparison of different algorithm

	Left wall Follower	Right wall Follower	Flood fill Algorithm
Cell to cell movements	140	124	50
turns	27	25	16
Time taken (in sec.)	377	335	266

Elaborated analyses of the above algorithms give us the base to proceed in path planning of intelligent devices capable of navigation. The speed of robot [12] to find its path, affected by the applied algorithm, acts the main part in the present projects that are concerned with robot navigation. While there is no limitation to improve the algorithms, there are some restrictions on developing robot's mechanic or electronic. Developing an algorithm is usually cheaper than the other parts. We discussed the commonly used sensors in mobile robotics [11]. They are tested in various different environments or different applications [15, 16]. Conclusion of their analysis is tabulated in table III.

Table III: Comparison of sensors for reflex or proximity type detection

S. No.	Sensor	Reliability	Cost
1.	LED & LDR	Very Poor	Cheapest
2.	IR LED & Photo-diode	Poor	Low
3.	Timer 555 & TSOP 1738	Moderate	Moderate

VI. CONCLUSION

Micromouse is a prime example of an engineering challenge in which the shortcomings of theory are exposed. Many real-world constraints conspire to render standard techniques for problem solving inappropriate. We have presented our solutions to some of these problems. Solving mazes is a problem that has been explored in great detail in Computer Science, but none of the standard extant solutions were appropriate for our problem. We have created a new maze solving technique appropriate for use in a physical device that fully accounts for its physical characteristics. In addition, we have created a cross platform micromouse [17] development environment that facilitates investigation of new micromouse algorithms. Our system shows great promise for physically correct simulation and solutions of real-world problems that are not fully addressed by standard theoretical results. In addition, we have created a hardware platform that is able to support international-level micromouse contest competition [20]. The crossdisciplinary nature of the project has required us to learn elements of mechanical, control, signal, and computer engineering. In this paper we have studied and analyze various sensors, energy system, motors and microcontrollers and find out the most suitable one for designing the micro mouse [19] according to our problem statement. This paper has covered one of the most important areas of robot,

"Decision making Algorithm" or in lay-man's language, "Intelligence". The environment around the robot is not known, so it must have decision-making capabilities. We have used basic wall follower logic to solve the maze. And gradually improves the algorithm to accurately solve the maze in shortest time with some more intelligence. The Algorithm is developed up to some sophisticated level as Flood fill algorithm. The speed of robot [18] to find its path, affected by the applied algorithm, acts the main part in the present projects that are concerned with robot navigation.

While there is no limitation to improve the algorithms, there are some restrictions on developing robot's mechanic or electronic.

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