CSE473 Final Project: Vision-based Micromouse Maze Wall Detection

Scott Will, Mack Ward
University at Buffalo
Amherst, NY 14261
scottwil@buffalo.edu, mward4@buffalo.edu

Abstract

Since the late 1970s, students and professional engineers alike have competed in Micromouse, an event in which teams of participants construct wheeled robots that attempt to autonomously traverse and solve planar mazes in as little time as possible. A common solution strategies adopted by competitors is a two-stage process: first, a mouse explores the maze and incrementally generates a virtual representation of the maze layout in its internal memory, then computes the optimal path from the starting position to the center of the maze, and finally returns to the starting position and moves along the optimal path. Although this approach is effective and reliable, most of the total time spent in transit by the mouse tends to be devoted to the exploration phase. To reduce this time, we propose a much different strategy: using a camera mounted on the mouse at sufficient height and techniques from computer vision and image processing, generate an image of the maze from the perspective of a viewer looking down from above, extract the locations of the maze walls programmatically, and proceed to solve the maze by directly moving to its center.

1. Introduction

1.1. Competition rules

In order to lessen the burden of constructing appropriately-sized vehicles, typical Micromouse events follow standard rules and maze-guidelines. We reproduce them here for thoroughness (adapted from the official rules from the IEEE Region 1 Micromouse Competition) []:

1.1.1 Rules for the micromouse

1. A Micromouse shall be self-contained (no remote controls). A Micromouse shall not use an energy source employing a combustion process.

2. A Micromouse shall not leave any part of its body behind while negotiating the maze.

3. A Micromouse shall not jump over, fly over, climb, scratch, cut, burn, mark, damage, or destroy the walls of the maze.

4. A Micromouse shall not be larger either in length or in width, than 25 centimeters. The dimensions of a Micromouse that changes its geometry during a run shall not be greater than 25 cm $\times$ 25 cm. There are no restrictions on the height of a Micromouse.

1.1.2 Rules for the maze

1. The maze is composed of multiples of an 18 cm $\times$ 18 cm unit square. The maze comprises 16×16 unit squares. The walls of the maze are 5 cm high and 1.2 cm thick (assume 5% tolerance for mazes). The outside wall encloses the entire maze.

2. The sides of the maze walls are white, the tops of the walls are red, and the floor is black. The maze is made of wood, finished with non-gloss paint.

3. The start of the maze is located at one of the four corners. The start square is bounded on three sides by walls. The start line is located between the first and second squares. That is, as the mouse exits the corner square, the time starts. The destination goal is the four cells at the center of the maze. At the center of this zone is a post, 20 cm high and each side 2.5 cm. (This post may be removed if requested.) The destination square has only one entrance.

4. Small square zones (posts), each 1.2 cm $\times$ 1.2 cm, at the four corners of each unit square are called lattice points. The maze is so constituted that there is at least one wall at each lattice point.

5. Multiple paths to the destination square are allowed and are to be expected. The destination square will be positioned so that a wall-hugging mouse will NOT be able to find it.

1.2. Common Solution Methods

As briefly described above, a great majority of teams tend to follow roughly the same high-level steps for producing a mouse capable of reaching the center of a maze meeting the above specifications:

1. Fully traverse the maze (including all dead-end routes) and generate an internal representation of the maze topology

2. Use one or more searching algorithms such as breadth-first or depth-first search, to find the optimal path from the starting point to the maze center

3. Move along the optimal path to reach the maze center

A less-popular method is the so-called ”wall-follower” approach, which seeks to eventually reach the center of the maze by simply moving along a given wall for its entire length. This is not guaranteed to be effective for all possible maze structures, and is officially discouraged by the competition organizers (see §1.1.2).

1.3. Our Solution

As members of the IEEE student chapter at UB, we have competed in the annual IEEE Region 1 Micromouse Competition, which is open to student teams from universities across the northeastern United States, twice. We conceived the idea to engineer a vision-based Micromouse implementation after observing the weaknesses of the ”traditional” style of implementation, which, in our opinion, spent too much unnecessary time determining maze layouts before being able to arrive at, and traverse, solutions. We realized that because of the regularity of competition mazes, which were composed of equally-sized unit squares, uniform-height walls, and so on, that it might be possible to extract all of the necessary information to produce an accurate representation of maze layout using only visual data obtainable from the Micromouse's perspective.

2. Related Work

We are not the first to suggest using tools from computer vision to improve the capabilities of Micromouse implementations. In 1997, Ning Chen suggested to revise the Micromouse competition to encourage solutions more relevant to real-world engineering challenges, by introducing uneven mazes resembling real terrain [1]

3. Algorithm

4. Results

5. Discussion

References

[1] N. Chen. A vision-guided autonomous vehicle: An alternative micromouse competition. *IEEE Transactions On Education*, 40(4):253–258, 1997.