What is the MicroMouse Competition?

- Contestants must build a robotic mouse that can navigate a real maze.
- The mouse totally must be totally autonomous, and built from scratch!
- There are student and professional level competitions.
- Typically the student built robots take four students a year to build.

The Mouse

- Here are some pictures of actual robots that students built:

More Meees

The Maze

- The maze is 16x16 cells.
- The Goal is to get to the center of the maze from one of the corners.
- It is not a “perfect” maze. A “perfect” maze has one path from start to finish. A Micromouse maze has many.
- This makes the maze solving much more difficult.
Example Maze

Maze Solving
- There are many algorithms.
- Most are best suited for “perfect” mazes.
- Most don’t work with imperfect mazes like the Micromouse mazes.
- I studied these three:
  - Dead Reckoning
  - Dead End Remembering
  - Flood Fill

Dead Reckoning
- Simplest Algorithm
- Mouse goes straight until it finds a fork. Then it chooses a path at random.
- There is no “learning” involved here.

Dead End Remembering
- Simplest algorithm that implements machine learning
- Same as previous except the mouse maps the maze as it travels.
- When a dead end is found it is remembered.

How does it work?
Step 1: Mouse finds a dead end
Step 2: Mouse turns around and places a virtual wall
Step 3: Continue placing walls until out of dead end

Flood Fill
- Too complicated to explain in a 9-minute presentation.
- Advantages:
  - Almost always better than previous two
  - Can find the shortest distance between start and finish in any maze
  - Systematic and predictable, not random
Flood Fill

- Disadvantages:
  - Much harder to implement
  - Processor intensive: It is an \( N^2 \) algorithm
  - Requires lots of memory

- Impractical or impossible for a simple mouse.

Why is this algorithm so complex?
- You need to check every cell in the maze.
- If you change one, you need to check the entire maze again! Sometimes 100+ iterations are required.
- This means that a mouse may have to execute several million instructions for each move!

But wait… There’s more.

What did I actually do?
How does this relate to the class?
- I programmed a Java-based simulation that students can use as a test bed for real robots.
- I also checked the various algorithms against one another for many different mazes.

The Program

- Includes all three algorithms
- Includes two mazes that were used in a real competition and a random maze generator.

Results

- The three algorithms were evaluated against one another for three different mazes:

Chicago 1986

- Time required to solve the maze:
  (Estimated 1 sec to move, 1/2 sec to turn)
  - Dead Reckoning (units in seconds)
    \[ \mu = 1167 \quad \sigma = 601 \quad N=30 \]
  - Dead End Remembering
    \[ \mu = 2043 \quad \sigma = 1012 \quad N=30 \]
  - Flood Fill
    \[ \mu = 153 \quad \sigma = 0 \quad N=1 \quad (Same\ every\ time) \]
    \[ \text{Pooled}\ \text{std} = 0.0455, \quad \text{Pooled}\ \text{std} = 0.0507 \]
- Flood Fill is better with 99% confidence.
Japan 1982

- Time required to solve the maze:
  (Estimated 1 sec to move, 1/2 sec to turn)
  - Dead Reckoning (units in seconds)
    $\mu=973$, $\sigma=355$, $N=30$
  - Dead End Remembering
    $\mu=755$, $\sigma=289$, $N=30$
  - Flood Fill
    $\mu=66.5$, $\sigma=0$, $N=1$ (Same every time)
    $p_{\text{Dead End}} = 0.0054$, $p_{\text{Dead Reckoning}} = 0.0087$
    - Flood Fill is better with 99% confidence.

Random Maze

- Time required to solve the maze:
  (Estimated 1 sec to move, 1/2 sec to turn)
  - Dead Reckoning (units in seconds)
    $\mu=131$, $\sigma=82$, $N=30$
  - Dead End Remembering
    $\mu=81$, $\sigma=40$, $N=30$
  - Flood Fill
    $\mu=126.5$, $\sigma=0$, $N=1$ (Same every time)
    $p_{\text{Dead End}} = 0.519$, $p_{\text{Dead Reckoning}} = 0.292$
    - Flood Fill is not better. It’s not even close.

Conclusions:

- Flood Fill is usually better in terms of time.
- In general, maze solving is hard!
- It looks easy from our perspective. But picture what the mouse actually sees:

  See the world from the Mouse’s point of view.
  Click here...