Mazes: An Introduction

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Overview
- What is a Maze?
- Types of Maze
- Properties of Mazes

Mice
- What's one of thems?
- Abilities & Limitations

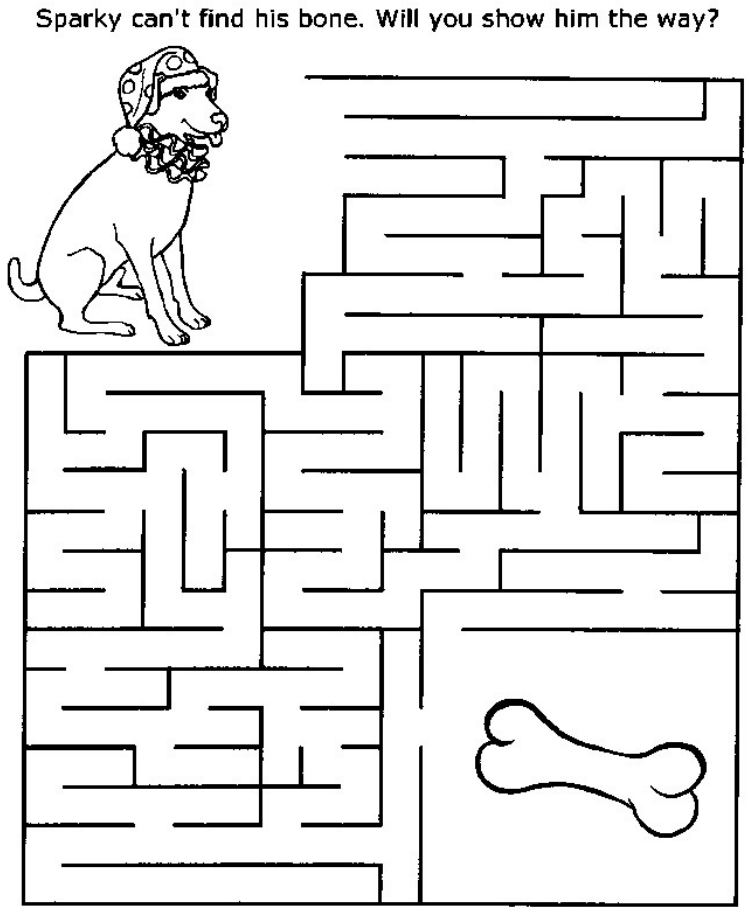
Control Theory & Agent-based AI
- Overview, Sensing and Actuating
- Types of Agent
- Limits to Computability

Introduction to Maize
- The Framework
- Code Introduction

Challenges

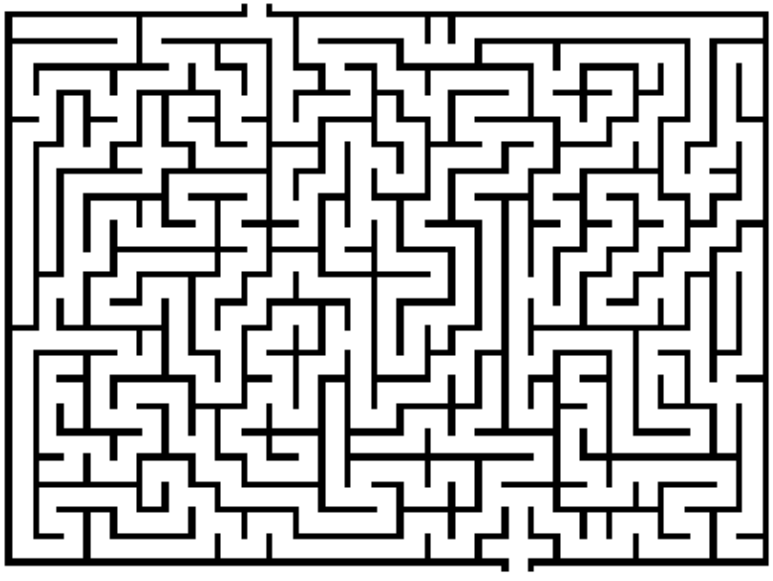
What is a Maze?

- A space with walls
- Has a start and finish (or entrance/exit)
- Stops you from finding your bone
- **Has some feature making it hard to follow the path**



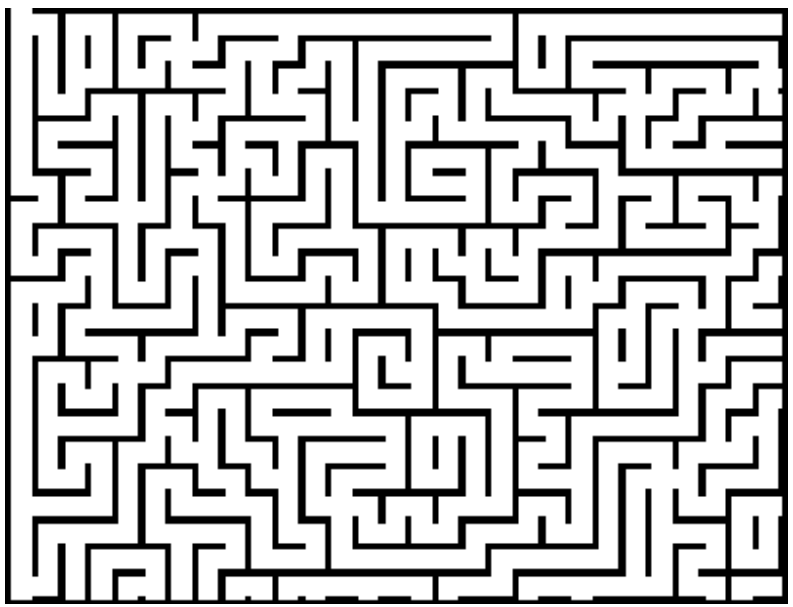
Perfect

- Has no loops
- Has a route to every point in the maze



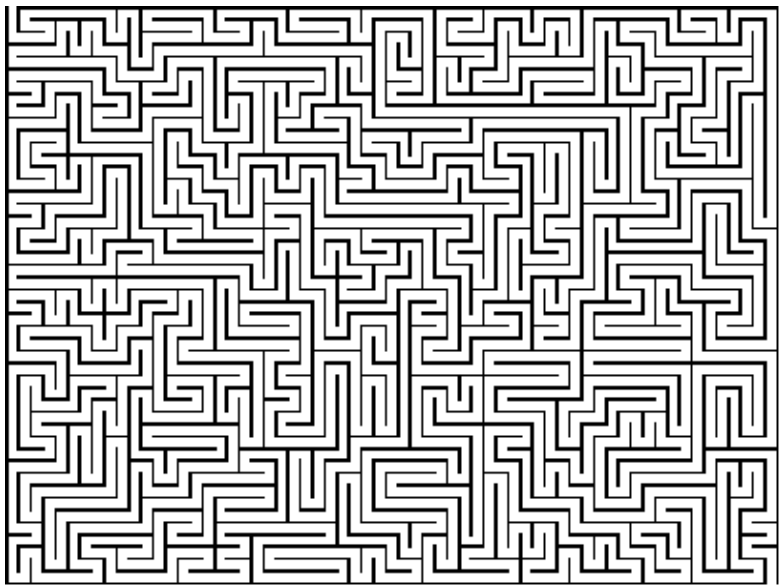
Braid

- Has no dead ends, instead using passages that run around and join up again
- Much harder to solve (and generate!)



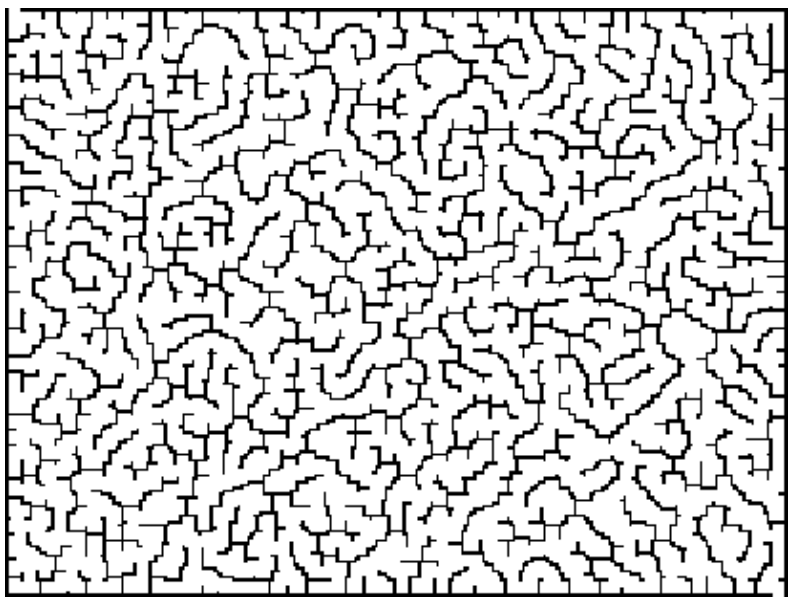
UNICURSAL

- Has no junctions, so is a single path
- Sometimes called a labyrinth
- Trivial to solve with automated means



Sparse

- Wide, irregularly-spaced passages.
- Often come in cool designs (not shown here).

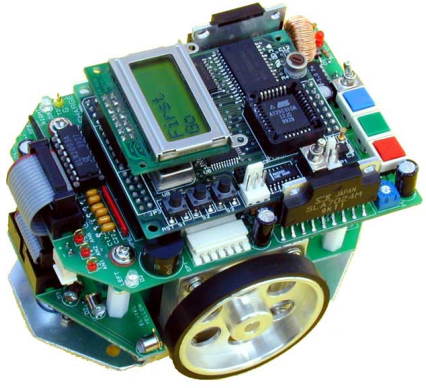


Properties of Mazes

- **Bias**—The tendency of a maze to have horizontal or vertical passages. Makes it hard to go 'against the grain'
- **Run**—A long, straight, uninterrupted passage
- **Elitism**—The ratio of the maze's shortest path against its total path length

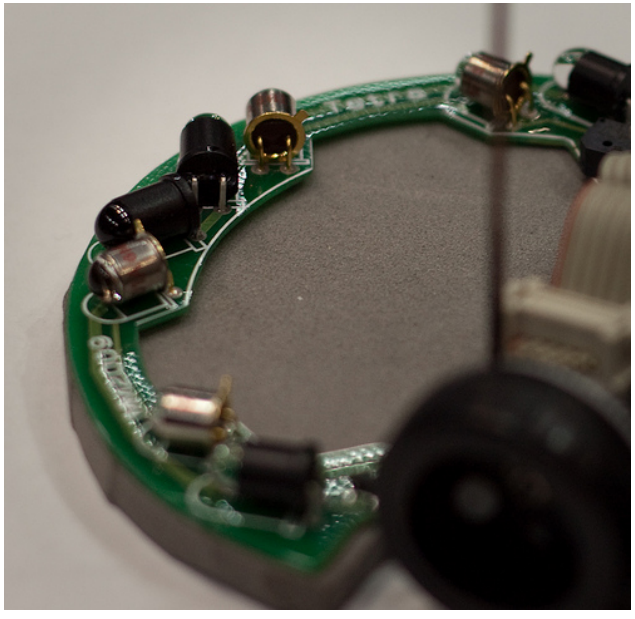
Mice

- Mice are **Maze-solving robots**
  Mice are also mice
- Compete in many competitions, solving real-life mazes (Click me!)
- Limited view of the maze, limited processing power
- No awareness of the maze other than what is learned



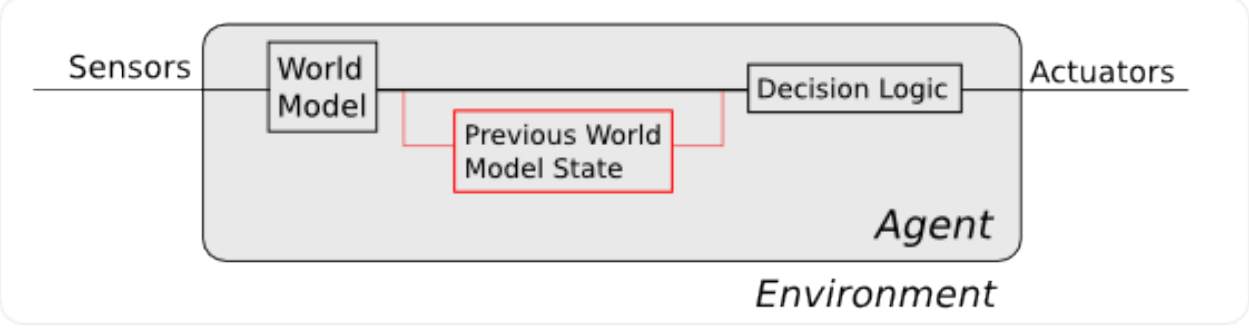
Abilities & Limitations

- Solving a maze is easy, if you can see it all (Click me!)
- Mice rely only on pactical real-world input from sensors
- So how do they do it?



Measure–Model–Respond

- Similar to control theory—each mouse is an 'intelligent agent', judging the state of the world from its inputs
- Three basic stages, repeated *ad infinitum*:
  1. **Measure** the world about you;
  2. **Model** the rest of it to create a virtual world;
  3. **Respond** by using information from the model.



Measure–Model–Respond Problems

- Sensors are often inaccurate, or tell us confusing, simple things (data is not information)
- The world changes, even when we're not the ones changing it
- Modelling even simple worlds is difficult!
- We have to know what to do, even if our model is incomplete

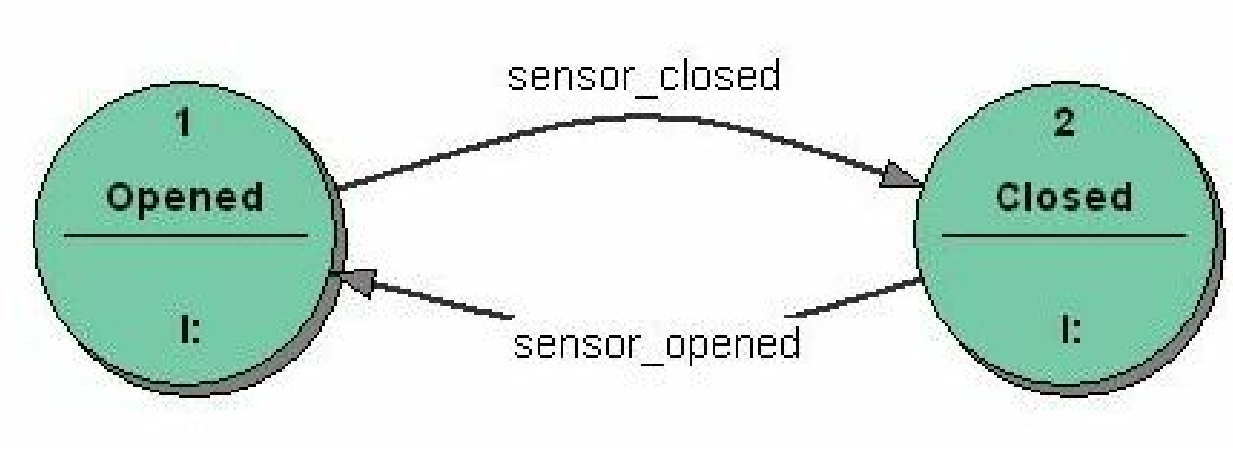
The items in red are all you have to worry about in Maize.

Managing the World

- **Stateful/Stateless**—Do we want to remember past events, or treat each sensor reading as a new event?
- **Deterministic/Stochastic**—Do we want to respond in a purely predictable manner?
- **Discrete/Continuous**—Are all of our values smoothly variable? Can we react partially/smoothly?

Inferring State—FSMs

- Display how the world **is**, based on how it **has changed**
- Can be interrogated without needing new sensor data
- Make transitions between states based on arbitrary, even probabalistic, rules
- Underpin all of computing!



Determinism

- Given the same (sequence of) input, will **always** produce the same output
- Very reliable
  but also reliably bad if the rules are poor
- Nondeterminism can involve fuzzy logic, probability, or guesswork
  Closer to human judgement, but very hard to get 'just right'

Discrete & Continuous Control

- Continuous control allows for small tweaks and improvements
- Can be hard to rationalise logically—needs threshold values or statistics
- Can offer better control and progressive feedback
  Confident bots can rush quickly; Unsure ones can creep to gather more information

Demos

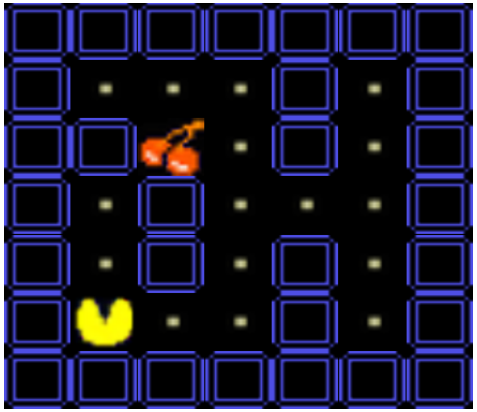
- Deterministic vs. Stochastic
  - DaveBot is stochastic, has no rules
  - LeftBot is deterministic, has only rules
- Discrete vs. Continuous
  - LeftBot is discrete, one move per assessment
  - AdvancedBot has some continuous properties: command queueing
- Stateful vs. Stateless
  - LeftStateBot is stateful, remembers a long sequence of actions
  - LeftBot is not

Complexity of Maze Solving

- Algorithmically, the best solution to a maze is to choose the best right path each time:
  The maze is just a big tree of choices
- The best case is thus equivalent to a binary search, plus the time needed to move
- This becomes $O(nlog_2 n)$, where n is the number of choices (plus a bit of time to travel from start to finish).

Overview

- Manages `Bots` and `Mazes`, and simulates a virtual world
- Tile-based environment
- A tile can be a start, finish, space, or wall.



The Life of a Bot

- Bots get restricted data:
  - Their immediate surroundings (3x3 array around them)
  - Bot co-ordinates in the maze
  - Bot orientation
  - Finish point co-ordinates

  (Technically, all that's needed is the red one, but the other things make it more fun)

- Bots can move only one tile per 'tick', and only Left, Right, Forward and Back (like kings in chess)

Bot Classes

- **Bot**
  - Simplest API available
  - Maize calls `nextMove()` on every tick.
  - Simply return a direction to move.
- **AdvancedBot**
  - Like `Bot`, but only requests a move when it has emptied its queue
  - Has a queue commands can be added to, and a more powerful high-level API (`moveLeft()`, `turnRight()` etc)

Demo, Code Rundown

A quick overview of the bots we have

`http://extremetomato.com/projects/maize/`

Challenges

1. Beat `DaveBot` on any Maze
   (An `EmptyMaze` might be simplest, a ScatterMaze might be hardest)
2. Solve a DFS Maze without using a wall following algorithm
   (this requires building a model of the decision tree)
3. Write a wall follower that can also solve `Empty` and `Scatter` mazes.
4. Improve an existing wall follower with heuristics

Getting Started

- Decide on a maze type to run on
- Decide on a strategy to try
- Code, or pair up with someone who wishes to, and hack at it
- Submit to `stephenwattam@gmail.com` for a glorious battle, with prizes if I can be arsed.

Fin

All resources available from

`http://extremetomato.com/projects/maize/`