What is the most efficient way to wake up everyone?

Problem

Solution

Timeline

Awakening time
Move-and-Tag Problem

For given positions of robots and obstacles, find the set of robots paths (starting from robot #1), so by following them all robots would wake up in the shortest period of time.

- Complexity-wise, harder than
  - SAT
  - Travelling salesman
  - Hamiltonian paths
  - Knapsack problem
Valid Set of Robot Paths

- Has a path starting from robot #1;
- Do not cross the obstacles (but can touch their boundaries);
- All robots in the swarm are “tagged” by the end;
- Do not have “cycles” in the awakening sequences.
Task 1: Computing valid MAT solutions

• 30 instances with obstacles of different shapes;
  • File with instances: robots.mat (see Moodle page);
  • 2–400 robots
  • 0–200 obstacles;
• Compute a valid set of robots paths for each problem instance;
• Grading: 60 points, two per instance, for any valid solution.
Encoding of the problems

robots.mat

1: (-1.5, 1.5), (-1, 0), (5, 0), (4.5, 3.5), (4.6, -3)
2: (-1.5, 1.5), (-1, 0), (5, 0), (4.5, 3.5), (4.6, -3) # (0, 1), (2, 3), (4, 1), (4, 10), (0, 10); (4, 0), (2, 2), (0, 0), (0, -10), (4, -10)
Encoding of the problems

robots.mat

1:  (-1.5, 1.5), (-1,0), (5,0), (4.5, 3.5), (4.6, -3)

2:  (-1.5, 1.5), (-1,0), (5,0), (4.5, 3.5), (4.6, -3) # (0,1), (2,3), (4,1), (4,10), (0,10); (4,0), (2,2), (0,0), (0,-10), (4,-10)

- Polygon is “on the left”
- No holes in obstacles
Encoding your solutions

Solution file:

```
tiger
lt671vecrskq
1: (-1.5, 1.5), (-1, 0), (4.5, 3.5); (-1, 0), (5, 0), (4.6, -3)
2: (-1.5, 1.5), (-1, 0); (-1, 0), (2, 2), (5, 0), (4.6, -3); (5, 0), (4.5, 3.5)
```

per-instance robot paths
Encoding your solutions

Instance 1

tiger
lt671vecrskq

1:  (-1.5, 1.5), (-1, 0), (4.5, 3.5); (-1, 0), (5, 0), (4.6, -3)

2:  (-1.5, 1.5), (-1, 0); (-1, 0), (2, 2), (5, 0), (4.6, -3); (5, 0), (4.5, 3.5)
Encoding your solutions

Figure 3: Problems from Figure 1 and Figure 2 with the corresponding coordinates.

which this one is going to "tag", as waypoints, as well as points where direction is changed in order to avoid obstacles. The ordering of points in a path is important, but the ordering of paths in a solution does not matter. In each solution, there must be exactly one path that starts with coordinates of the first robot.

For instance, solutions for the problems from Figures 1 and 2 submitted by the team tiger with a password `lt671vecrskq` might look as follows:

```
tiger
lt671vecrskq
1: (-1.5, 1.5), (-1, 0), (4.5, 3.5); (-1, 0), (5, 0), (4.6, -3)
2: (-1.5, 1.5), (-1, 0); (-1, 0), (2, 2), (5, 0), (4.6, -3); (5, 0), (4.5, 3.5)
```

That is, the solution for the first problem contains two paths: for the robot A (with coordinates `(-1.5, 1.5)`), and for the robot B (coordinates `(-1, 0)`), which will wake up all other robots.

Similarly, the second line provides three paths outlining the routes for the robots A, B and C. The graphical representation of the solutions, with the corresponding coordinates, is shown in Figure 3.

Each solution will be assigned a score (rounded up to 0.001), corresponding to the actual time of the swarm awakening according to the provided paths, computed as a length of the joint timeline (1 unit of distance = 1 unit of time), where several robots can be working in parallel. For instance, the score assigned to the first solution from the example above is 10.608, whereas the score of the second one is 12.327, because of the detours, required to go around obstacles.

The text file with the solution should be submitted in the form of the following page:

http://scenario.cs.ucl.ac.uk

WARNING!
Parts of the input are specified via double-precision floating points, which assumes working with "equality instead of equality.

1
Your solutions may contain double-precision floating-point numbers, as well. The server uses "=0.000000001, therefore all values with difference smaller than 1
Checking and submitting solutions

• **Warning:** *double-precision floating-point* arithmetic
  • all equalities are up to $\varepsilon = 0.000,000,001$
• Details on acceptance criteria are in the *specification* (on Moodle)
• Submit your solutions here:

  http://scenario.cs.ucl.ac.uk

Solutions are accepted until 14:00 GMT 24 Feb 2017
Task 2: Visualisation

• Implement a visualiser for robots, obstacles and paths:
  • drawing obstacles;
  • drawing paths for each robot;
  • drawing movement of robots.

• Grading: 10 points

• Assessed by the organisers from 14:00 till 17:00, 24 Feb
  • book a slot for your team!
Visually by Organisers (could be prettier...)

- 2 robots
- 150 obstacles
Visuals by Organisers (could be prettier…)

- 250 robots
- 11 obstacles

Robot #1
Task 3: Implementation report

• Describe your implementation experience
  • language, tools, algorithms, heuristics, etc.
  • details in the specification (see Moodle)

• Grading: 10 points

• Submit on Moodle by 17:00, 24 Feb 2017 (one per team)
Task 4: The Competition!

- Compete with other teams for the best MAT solutions
- Check the score table [http://scenario.cs.ucl.ac.uk](http://scenario.cs.ucl.ac.uk) for details
- Grading: up to 20 points.

\[
\text{Reward} \text{ (team)} = 20 - \min(20, \text{ rank} \text{ (team)} - 1)
\]
## Overall grading

<table>
<thead>
<tr>
<th>Task</th>
<th>Max grade</th>
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<tbody>
<tr>
<td>Computing valid MAT solutions</td>
<td>60</td>
</tr>
<tr>
<td>Visualisation of the solutions</td>
<td>10</td>
</tr>
<tr>
<td>Implementation report</td>
<td>10</td>
</tr>
<tr>
<td>The Competition</td>
<td>20</td>
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</table>
This week schedule

<table>
<thead>
<tr>
<th>Time</th>
<th>Monday 20 Feb</th>
<th>Tuesday 21 Feb</th>
<th>Wednesday 22 Feb</th>
<th>Thursday 23 Feb</th>
<th>Friday 24 Feb</th>
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<tr>
<td>10:00-11:00</td>
<td>Royal National Hotel Galleon Suite B</td>
<td>IOE - Bedford Way (20) - 305 - Clarke Hall</td>
<td>Cruciform Building B304 - LT1</td>
<td>Birkbeck Malet Street B36</td>
<td>Birkbeck Malet Street B36</td>
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<tr>
<td>11:00-13:00</td>
<td>Royal National Hotel Galleon Suite B</td>
<td>Wilkins Building (Main Building) Gustave Tuck LT</td>
<td>School of Pharmacy 228</td>
<td>Royal National Hotel Galleon Suite A</td>
<td>Bedford Way (26) G03</td>
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<td>14:00-16:00</td>
<td>School of Pharmacy 225</td>
<td>IOE - Bedford Way (20) - 103 - Jeffery Hall</td>
<td></td>
<td>Birkbeck Malet Street B36</td>
<td>Bedford Way (26) LG04</td>
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<td>16:00-17:00</td>
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<td>Anatomy G29 J Z Young LT</td>
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<td>17:00-18:00</td>
<td></td>
<td></td>
<td>Anatomy G29 J Z Young LT</td>
<td></td>
<td>Bedford Way (26) G03</td>
</tr>
</tbody>
</table>

Helpdesk (green) — time and location where the staff and/or TAs will be present to answer your questions
Lectures (blue) — introductory and concluding lectures
Demonstration (red) — checking the visualisation of the algorithms by the staff and TAs (book your slot!)
Good luck!