Optimized Navigation behavior of multiple robots based on motor-schema

DIS course project 2014

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Project Description

- Scenario
  - 1 goal
  - 4 robots
  - Obstacles

- Tasks
  - Move to goal
  - Obstacles avoidance
  - Robots avoidance
  - Formation maintenance

- Two-phase progress
  - Basic navigation control*
  - Optimization with Particle Swarm Optimization (PSO)

Navigation control

- Motor Schemas*

- Formation Control

*Arkin R. C., “Motor Schema Based Mobile Robot Navigation”. Int. J. of Robotics Research
Navigation control

• Information interaction

Supervisor:
- Goal location
- Robot location
- Unit-center of robots

Local perception:
- Braitenberg vehicles

<table>
<thead>
<tr>
<th></th>
<th>IR0</th>
<th>IR1</th>
<th>IR2</th>
<th>IR3</th>
<th>IR4</th>
<th>IR5</th>
<th>IR6</th>
<th>IR7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>17</td>
<td>29</td>
<td>12</td>
<td>10</td>
<td>8</td>
<td>-38</td>
<td>-56</td>
<td>-76</td>
</tr>
<tr>
<td>Left</td>
<td>-72</td>
<td>-58</td>
<td>-36</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>28</td>
<td>18</td>
</tr>
</tbody>
</table>

Table 1: Sensor weights matrix
Optimization

PSO Implementation
- Schema vector weights
- Middle zone radius
- Team diversity: Homogeneous
- Performance evaluation: group fitness
- Solution sharing: Public

Fitness function design with time ratios

- First:

\[
\text{Fitness} = (1 - \text{TotalTime}) \times \text{TimeInFormation}
\]

- Last:

\[
\text{Fitness} = w_g \times \text{GoalReached} + w_f \times \text{TimeInFormation} + w_c \times (1 - \text{TimeInCollision})
\]

\[
W_g = W_f = W_c = 0.33
\]
Results

• Basic navigation control

<table>
<thead>
<tr>
<th>Avoidance w</th>
<th>Move to goal w</th>
<th>Formation keeping w</th>
<th>Noise w</th>
<th>Middle zone radius</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>12</td>
<td>5</td>
<td>1</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Fitness = 0.91

Table 2: hand tuned parameters
Results

PSO optimization

• Number of particles : 10
• Number of iterations : 10
• Number of tuned parameters: 5

Best set of parameters provided by PSO

<table>
<thead>
<tr>
<th>Avoidance $w$</th>
<th>Move to goal $w$</th>
<th>Formation keeping $w$</th>
<th>Noise $w$</th>
<th>Middle zone radius</th>
</tr>
</thead>
<tbody>
<tr>
<td>16,4</td>
<td>9,43</td>
<td>17,1</td>
<td>7,46</td>
<td>0,12</td>
</tr>
</tbody>
</table>

Table 3: optimized parameters

Fitness = 0,97
Results

PSO particle in first iteration

PSO particle in last iteration
Conclusions

- Motor schema model works very good for the task
- Unit-centered formation control is robust to different formations
- Using intuition, hand-tuned parameters create a good controller
- PSO was able to learn a good controller
- But, small improvement
- High simulation time
- What could have been done differently?
Thank you for your attention and questions!!!