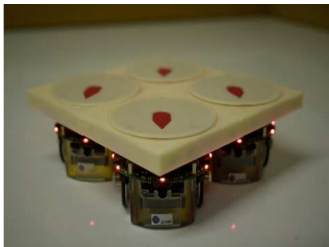


Self-reconfigurable Modular e-pucks

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Intelligent Systems Group, University of York

September 13, 2012



Modular Self-reconfigurable Robotics

An autonomous robotic system in which several relatively simple modules physically connect to form complex robotic structures of variable morphology.



CKBot
Yim et al.
(2007)



Molecubes
Zykov et al.
(2004)



Swarmanoid
Dorigo et al.
(2011)

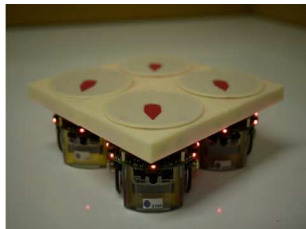
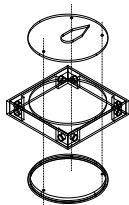
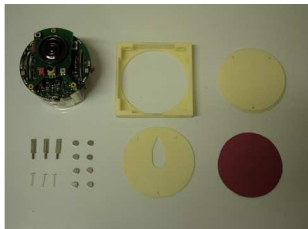


Symbricator
Kernbach et al.
(2010)

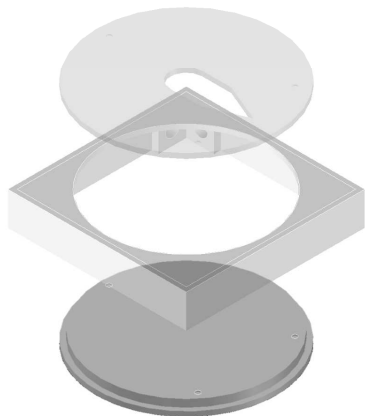
- ▶ Why do we need another one?
- ▶ The majority of existing systems are **not publicly available** and would be **expensive to design and manufacture** from scratch

Modular e-puck Extension

- ▶ Simple design
- ▶ Cheap (less than €5 per unit)
- ▶ Design freely available online:
www-users.york.ac.uk/~ljm505/modular_epucks.html

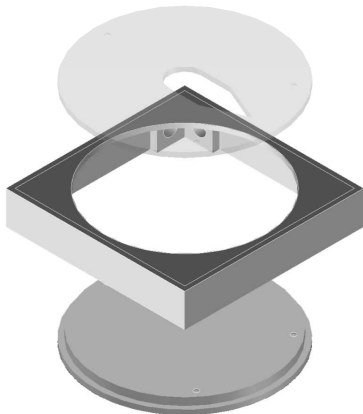


Design



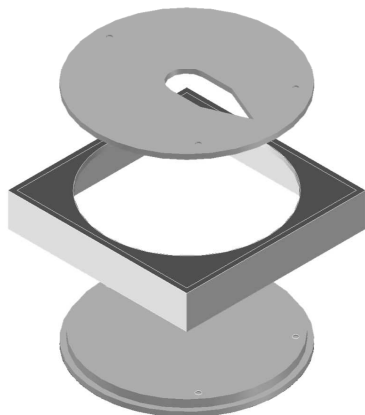
- ▶ Base plate
- ▶ Central frame
- ▶ Top cover

Design



- ▶ Base plate
- ▶ Central frame
- ▶ Top cover

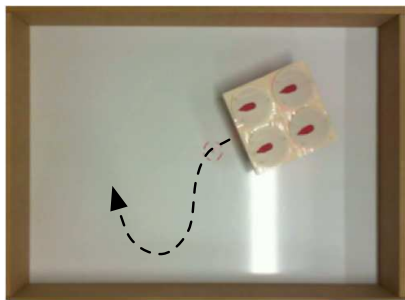
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- ▶ Central frame
- ▶ Top cover

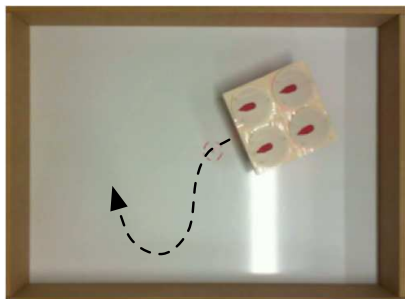
Proof of concept

- ▶ As a proof of concept we present an algorithm for controlling the motion of a group of physically connected modules
- ▶ Alignment based upon the example of Campo et al. (2007)
- ▶ Adapted following analysis of the epuck's infrared sensors
- ▶ Extended to include forward motion and obstacle avoidance



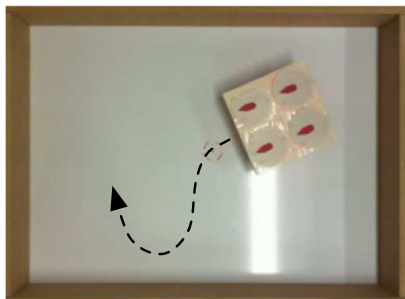
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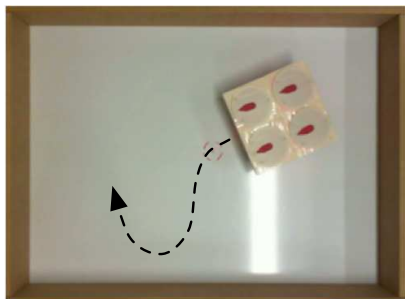
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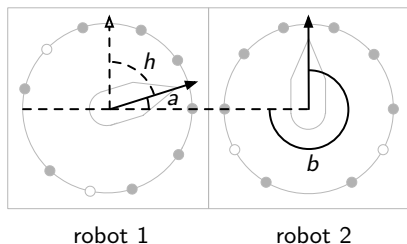
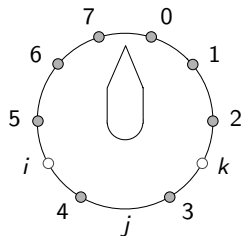


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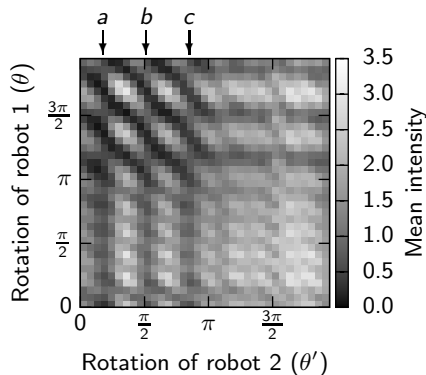


Stationary Alignment



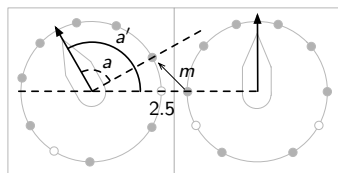
- ▶ Robots use IR comms. to determine their neighbours headings
- ▶ Each robot broadcasts its own ID and listens for its neighbours
- ▶ Messages are sent to every identified neighbour, notifying them of the angle at which they were detected
- ▶ Using this information a robot may calculate the relative heading of its neighbours as $h = a + \pi - b$

Sensor Analysis



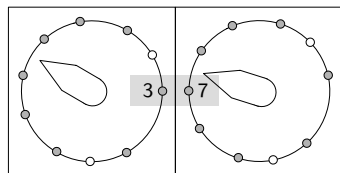
- ▶ Purpose: to examine the sensor coverage problem
- ▶ Data gathered by sending messages between robots at various orientations and measuring the intensity of the signal received
- ▶ Intensity is high when two sensors are closely aligned

Adaptations



robot 1

robot 2



robot 1

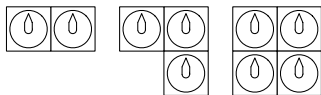
robot 2

- ▶ We define two *virtual* sensors '2.5' and '4.5'
 - ▶ If a message m is received on sensor 2 (5) and its *intensity* $< \tau$ we assume that the message arrived at virtual sensor 2.5 (4.5)
- ▶ We define five sensor pairings and assume that high intensity messages sent between them are indicative of close alignment
- ▶ For every message received a new 'desired heading' is created

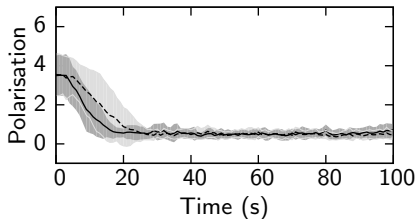
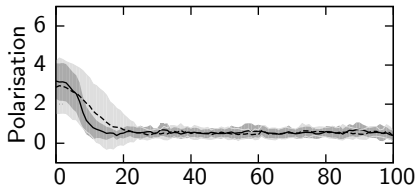
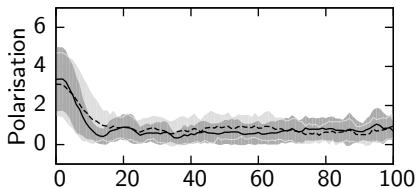
(Video not included)

Stationary Alignment Results

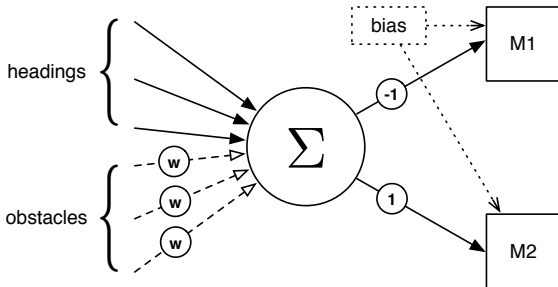
- ▶ 3 different configurations:



- ▶ Mean polarisation plotted
 - ▶ Dashed line: 'synchronize'
 - ▶ Solid line: new approach
- ▶ No significant difference in terms of final alignment
- ▶ Time to converge faster with the new approach

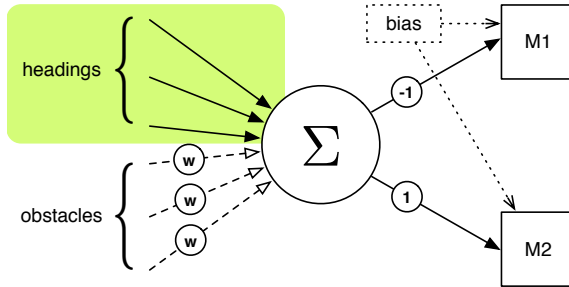


Collective Locomotion



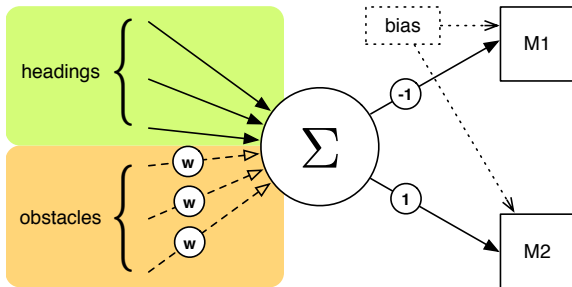
- ▶ For every obstacle detected a new desired heading is created with a weight proportional to the distance to the obstacle
- ▶ All of the desired headings are summed and a forward bias is applied to determine the speed of the robot's motors

Collective Locomotion



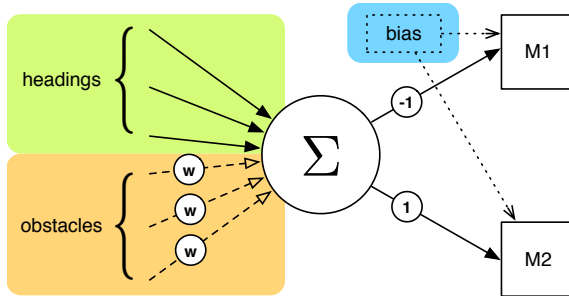
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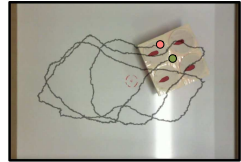
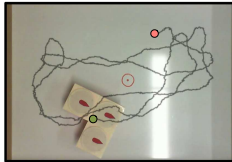
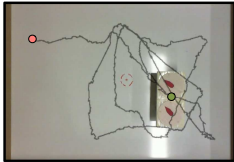
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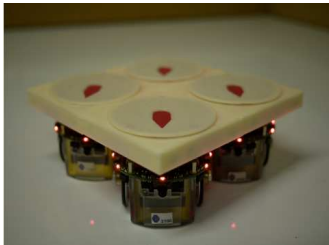


- ▶ A single 30 minute run was conducted for each configuration
- ▶ In every case the robots successfully navigated the arena without colliding with the arena walls
- ▶ In the 3 module configuration, one robot broke away from the group, only to rejoin shortly after

(Video not included)

(Video not included)

Thanks!



Lachlan Murray

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www-users.york.ac.uk/~ljm505/modular_epucks.html