Praktikum: 11

Caterpillar-like robot realization

Lecturers

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Acknowledgments

- ***"Bioinspiration and Robotics: Walking and Climbing Robots"*** Edited by: Maki K. Habib, Publisher: I-Tech Education and Publishing, Vienna, Austria, ISBN 978-3-902613-15-8.
  - http://s.i-techonline.com/Book/

- My colleague *Juan Gonzalez-Gomez* from the School of Engineering, Universidad Autonoma de Madrid in Spain.

- Other great work and related information on the internet
  - http://en.wikipedia.org/wiki/Self-Reconfiguring_Modular_Robotics

Lecture material

- *Modular Self-Reconfigurable Robot Systems: Challenges and Opportunities for the Future* , by Yim, Shen, Salemi, Rus, Moll, Lipson, Klavins & Chirikjian, published in IEEE Robotics & Automation Magazine March 2007.
- *Self-Reconfigurable Robot: Shape-Changing Cellular Robots Can Exceed Conventional Robot Flexibility*, by Murata & Kurokawa, published in IEEE Robotics & Automation Magazine March 2007.
- *Locomotion Principles of 1D Topology Pitch and Pitch-Yaw-Connecting Modular Robots*, by Juan Gonzalez-Gomez, Houxiang Zhang, Eduardo Boemo, One Chapter in Book of "Bioinspiration and Robotics: Walking and Climbing Robots", 2007, pp.403-428.
- *Locomotion Capabilities of a Modular Robot with Eight Pitch-Yaw-Connecting Modules* , by Juan Gonzalez-Gomez, Houxiang Zhang, Eduardo Boemo, Jianwei Zhang: The 9th International Conference on Climbing and Walking Robots and their Supporting Technologies for Mobile Machines, CLAWAR 2006, Brussels, Belgium, September 12-14, pp.150-156, 2006.

Outline of today's lecture

- Build a caterpillar-like modular robot
- Realization different locomotion gaits
  - Linear gait
  - Turning gait

1D Topology:

Locomotion in 1D:

Locomotion in 2D:

Pitch-Pitch

8 pitch-connecting modules

Pitch-Yaw-Pitch

8 pitch-yaw-connecting modules

2D Topology:

Locomotion in 2D:

Star of 3 modules

Outline of today's lecture

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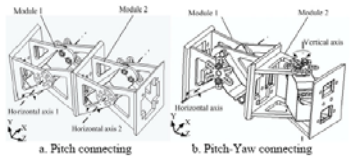
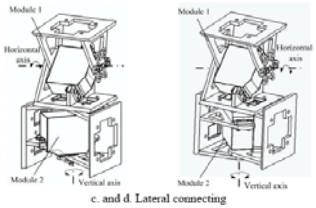
GZ-I with four connecting faces



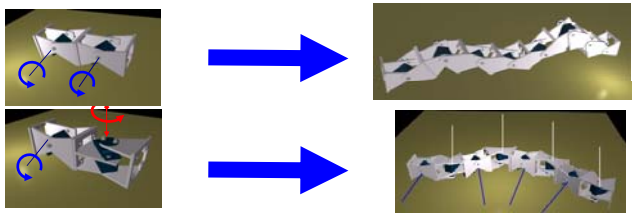
a. Pitch connecting b. Pitch-Yaw connecting



c. and d. Lateral connecting

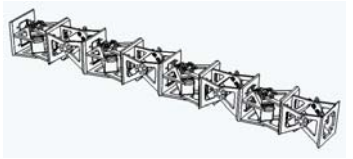
Possible tasks using our module

- 1D Topology
- 8 Pitch-yaw connecting modules
- 4 rotates around the pitch axes
- 4 rotates around the yaw axes
- Based on the Y1 modules



Your tasks

- Caterpillar-like movement
  - minimal configurations
  - Caterpillar with 4 to 8 modules
- Snake-like movement
  - minimal configurations (new question)
  - Snake-like movement



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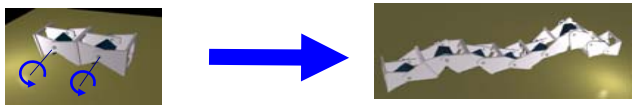


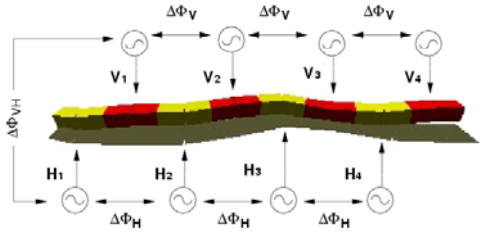
Locomotion controlling method

- The sinusoidal generators produce very smooth movements and have the advantage of making the controller much simpler. Our model is described by the following equation .

$$y_i = A_i \sin(\frac{2\pi}{T} t + \phi_i) + O_i$$

- Where y_i is the rotation angle of the corresponding module; A_i is the amplitude; T is the control period; t is time; Φ_i is the phase; O_i is the initial offset.

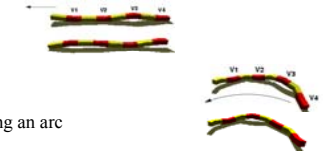
Locomotion controlling method (cont')



- They are divided into horizontal and vertical groups, which are described as H_i and V_i respectively. Where i means the module number;
- $\Delta\Phi_V$ is the phase difference between two adjacent vertical modules;
- $\Delta\Phi_H$ is the phase difference between two adjacent horizontal modules;
- $\Delta\Phi_{HV}$ is the phase difference between two adjacent horizontal and vertical modules.

Locomotion capabilities

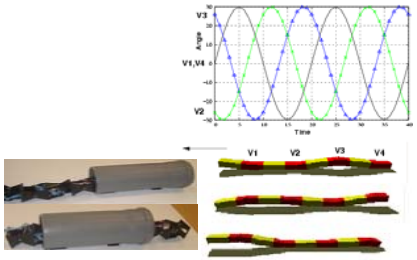
- Linear gait
  - Forward and backward movement
- Turning gait
  - Turn left and right; or the robot moves along an arc



Locomotion capabilities-linear gait

- **Parameters**:

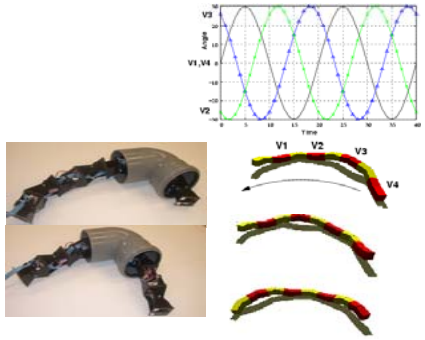
$A_V \neq 0$ $A_H = 0$
$O_V = 0$ $O_H = 0$
$\varphi_V = 120$



Locomotion capabilities-turning gait

- **Parameters**:

$A_V \neq 0$ $A_H = 0$
$O_V = 0$ $O_H \neq 0$
$\varphi_V = 120$



It is time for you now…

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Snake-like robot realization

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Thanks for your attention!

Any questions?