Praktikum: 12

Snake-like robot realization

Lecturers

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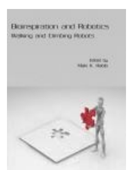
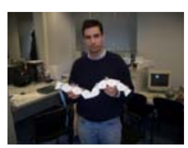
Acknowledgments

- ***"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 snake-like modular robot
- Realization different locomotion gaits
  - Linear gait
  - Turning gait
  - Rolling gait
  - Lateral shift
  - Rotation

1D Topology:

Locomotion in 1D:

Pitch-Pitch

8 pitch-connecting modules

Locomotion in 2D:

Pitch-Yaw-Pitch

8 pitch-yaw-connecting modules

2D Topology:

Locomotion in 2D:

Star of 3 modules

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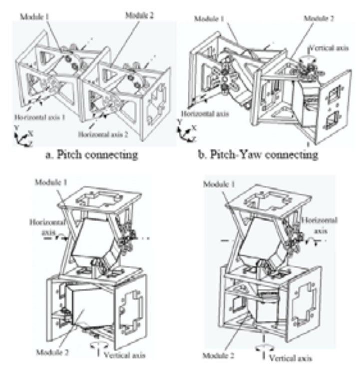
GZ-I with four connecting faces



a. Pitch connecting b. Pitch-Yaw connecting

c. and d. Lateral connecting

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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Your tasks

- Caterpillar-like movement
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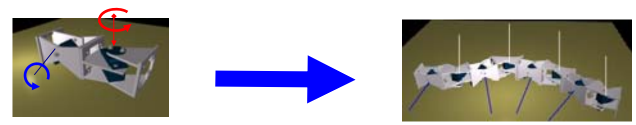

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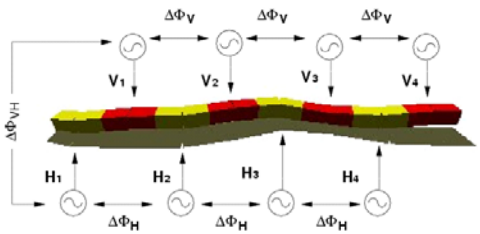
Locomotion controlling method

- 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.

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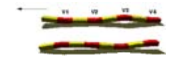
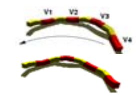
Locomotion capabilities

- Linear gait
  - Forward and backward movement



- Turning gait
  - Turn left and right; or the robot moves along an arc



- Rolling gait
  - The robot rolls around its body axis

- Lateral shift
  - The robot moves parallel

- Rotation
  - The robot rotates around its body axis

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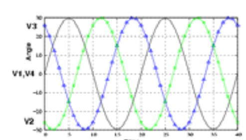
Locomotion capabilities-linear gait

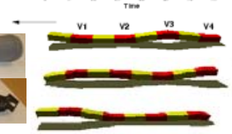
- **Parameters**:

$A_V \neq 0$ $A_H = 0$

$O_V = 0$ $O_H = 0$

$\Delta\Phi_V = 120$





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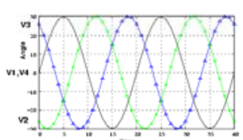
Locomotion capabilities-turning gait

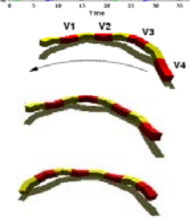
- **Parameters**:

$A_V \neq 0$ $A_H = 0$

$O_V = 0$ $O_H \neq 0$

$\Delta\Phi_V = 120$





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Locomotion capabilities-rolling gait

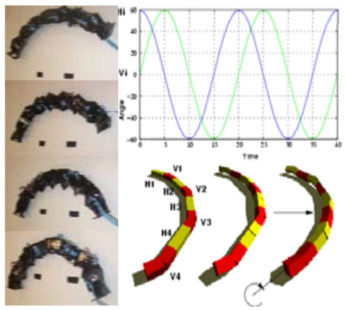
- **Parameters**:

$A_V \neq 0$ $A_H \neq 0$

$O_V = 0$ $O_H = 0$

$\Delta\Phi_V = 0$ $\Delta\Phi_H = 0$

$\Delta\Phi_{VH} = 90$



Locomotion capabilities-lateral shift

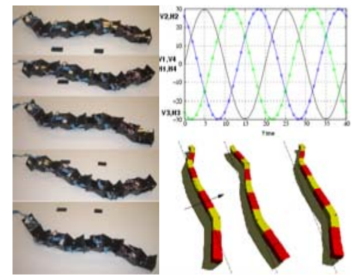
- **Parameters**:

$A_V \neq 0$ $A_H \neq 0$

$O_V = 0$ $O_H = 0$

$\Delta\Phi_V = 100$ $\Delta\Phi_H = 100$

$\Delta\Phi_{VH} = 0$



Locomotion capabilities-rotating gait

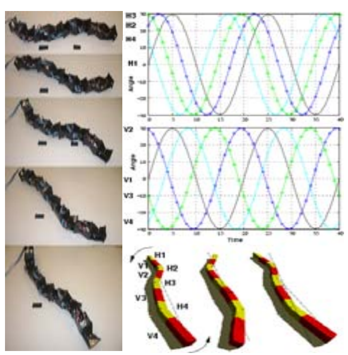
- **Parameters**:

$A_V \neq 0$ $A_H \neq 0$

$O_V = 0$ $O_H = 0$

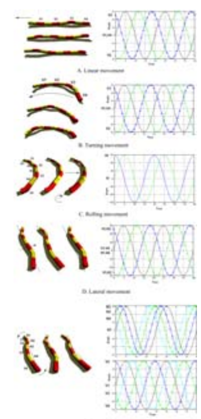
$\Delta\Phi_V = 120$ $\Delta\Phi_H = 50$

$\Delta\Phi_{VH} = 0$

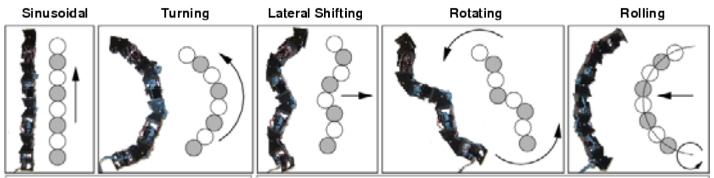


Summary

Gate types	Parameters for sinusoidal generators	
Linear movement	A_{Vi} 0; $A_{Hi}=O_{Vi}=0$	$\Delta\Phi_V$=100-120, O_{Hi} 0
Turning movement		$\Delta\Phi_V$=100-120, $O_{Hi}=0$
Rolling movement	A_{Hi}, A_{Vi} 0; $O_{Hi}=O_{Vi}=0$	$\Delta\Phi_V=\Delta\Phi_H=0$, $\Delta\Phi_{VH}=90$
Lateral movement		$\Delta\Phi_V=\Delta\Phi_H=100$, $\Delta\Phi_{VH}=0$
Rotation movement		$\Delta\Phi_V=120$, $\Delta\Phi_H=0$, $\Delta\Phi_{VH}=50$



Summary



Sinusoidal	Turning	Lateral Shifting	Rotating	Rolling
$A_V \neq 0$ $A_H = 0$ $O_V = 0$ $\Delta\Phi_V = 120$		$A_V \neq 0$ $A_H \neq 0$ $O_H = 0$ $O_V = 0$		
$O_H = 0$	$O_H \neq 0$	$\Delta\Phi_{VH} = 0$ $\Delta\Phi_H = 100$ $\Delta\Phi_V = 100$	$\Delta\Phi_{VH} = 0$ $\Delta\Phi_H = 50$ $\Delta\Phi_V = 120$	$\Delta\Phi_{VH} = 90$ $\Delta\Phi_H = 0$ $\Delta\Phi_V = 0$

It is time for you now…

Praktikum: 13

Open possibilities using GZ-I

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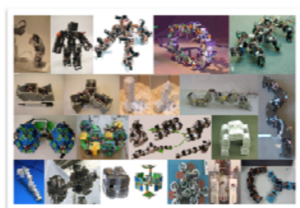

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Thanks for your attention!

Any questions?