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 Technical Aspects of Multimodal System
 Dept. Informatics, Faculty of Mathematics, Informatics and Natural Sciences
 University of Hamburg

Praktikum: 10

Single module control

Lecturers

Houxiang Zhang
Manfred Grove

TAMS, Department of Informatics
 University of Hamburg, Germany



@Tams/hzhang

TAMS Ph.D. ZHANG, Houxiang hzhang@informatik.uni-hamburg.de
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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

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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.

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Outline of today's lecture

- Build the first module
- Control the single module to pitch
 - Serial communication program
 - Control model
 - Let it pitch up and down
- Pitching-pitching movement realization




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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




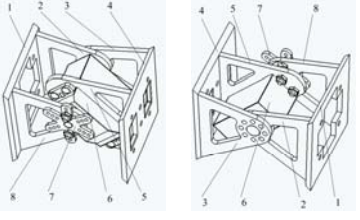
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Build your first module

- Step 1
 - Find all six mechanical parts, some blots and blot caps;

(a) Front view
 (b) Back view

1. Left connecting face; 2. Inboard mechanical ear for rotation output; 3. Outboard mechanical ear for rotation output; 4. Right connecting face;
 5. Mechanical bracket for RC servo; 6. RC servo;
 7. Rotating plate of RC servo; 8. Mechanical ear for rotating plate

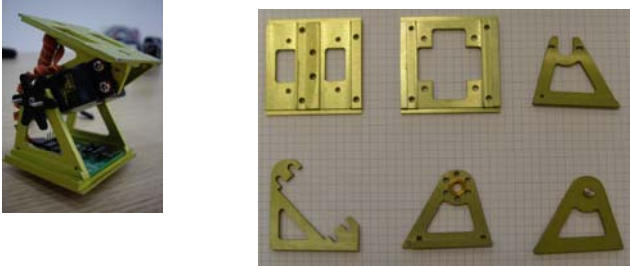
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Build your first module

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Build your first module

- Step 2
 - Firstly the driving RC servo is fixed to the mechanical ear 5 using bolts through four holes while the rotating plate of the servo is fixed to the mechanical ear 8.



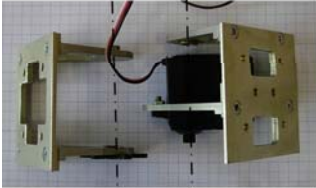
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Build your first module

- Step 3
 - Then we fix the mechanical ears 2 and 8 with the rotating plate to the left connecting face by blots respectively. Now the left part of the GZ-1 module is finished.
 - In the same way, the mechanical ears 3 and 5 with RC servo will be fixed to the right connecting face, as shown below.



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Build your first module

- Step 4
 - The left part and right part approach each other, superimposing axes 1 and 2.

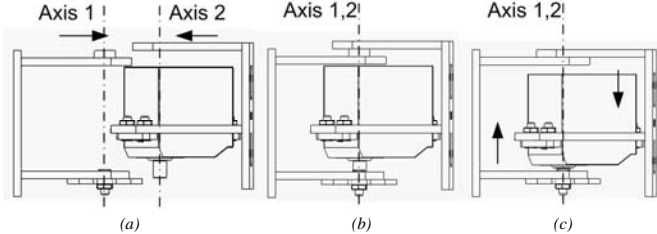


Fig. Assemble procedure (From the top view)

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Build your first module

- Step 5
 - Firstly power on the servo, let the servo rotate to “0” degree position.
 - then the two modules will connect automatically as soon as the rotating plate is fixed to the servo again.

Fig. Assemble procedure (From the top view)

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Build your first module

- Step 6
 - Test the middle position, improve your building.

- Good luck!!

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The Class CSnake (1)


- The same as the class TeleRobot for the TELEBOT
- Written to be used under WINDOWS


- Public methods:
- Csnake() constructor
- Connect() Opens the Connection to the Controller
- Disconnect Closes the Connection to the Controller



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The Class CSnake (2)


- Public methods (cont)
- write_FE() sends the FE-Command to the Controller
- write_FF() sends the FF-Command to the Controller
- write_SO() turn servos ON
- write_SF() turn servos OFF
- write_SE(int chan) enable servo chan (0 <= chan <= 9)
- write_SD(int chan) disable servo chan (0 <= chan <= 9)
- write_SC() set all servos to middle position



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The Class CSnake (3)

- Public methods (cont)


- write_SW(int chan, int wert)
 - sends a SW-Command to the Controller
 - 0 <= chan <= 9, 500 <= wert <= 2500
- write_YT(int wert1, int wert2) start loop-test
 - 0 <= wert <= 255


- write_YF() stop loop-test



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The Class CSnake (4)

- public methods (cont)


- get_obuff(char *buff)
 - returns in *buff* the last command sent to the controller (for debugging only)

- get_response(char *buff)
 - returns in *buff* the last response from the controller.
 - In the moment calling this method only makes sense after issuing a FE-command, when all commands are echoed from the controller.



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20



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Simple Script-Language (1)

- Commands
 - SO
 - SE n: where n is the number of the servo to be enabled
 - SC
 - SW n value: where n is the number of the servo and value is the laue to be transmitted, $500 \leq \text{value} \leq 2500$
 - SF
 - SD
 - "Command" +Chr\$(13)



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Simple Script-Language (2)

- Pseudo commands:
 - loop n*
 where *n* is the number of times the commands
 inside the loop are executed
 - od*
 end of loop
 - timer n*
 sets the timer to *n* milliseconds ($n \geq 20$),
 e.g. every *n* milliseconds one command is executed
 in Auto-Mode



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Simple Script-Language (3)

- An example:
 - ; ----- a rather senseless example -----
 - SO ; Servos on
 - SE 0 ; Enable servo 0
 - SE 1 ; Enable servo 1
 - SE 2 ; Enable servo 2
 - timer 40
 - DO 2 ; loop 2 times
 - SW 0 1000
 - SW 2 1000
 - SW 1 2400
 - SW 0 1500
 - SW 1 1500
 - SW 2 1500
 - OD ; End of loop



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Control model

- 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 .

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

- 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.

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Control model

- Compute y_i according to the following equation .

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

- Compute the real PPM signal according to the following relationship

-90°	0°	+90°
↓	↓	↓
500 μ s	1500 μ s	2500 μ s

- Build the commands


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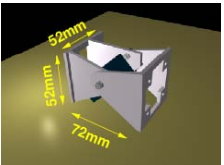
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Let it pitch up and down

- Basic movement
 - Single module



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It is time for you...

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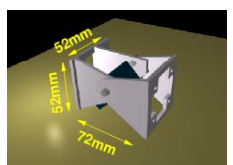
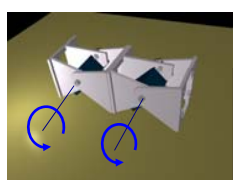


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Pitching-pitching movement realization

- Basic movement
 - Single module
 - Pitching-pitching movement

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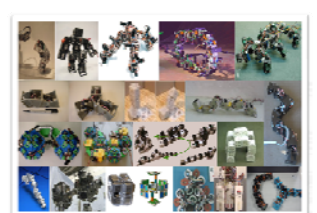
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Caterpillar-like robot realization

Lecturer

Houxiang Zhang
Manfred Grove

TAMS, Department of Informatics
University of Hamburg, Germany



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Thanks for your attention!

Any questions?

