Praktikum:

Robot Practical Course

Lecturers

Houxiang Zhang
Manfred Grove

TAMS, Department of Informatics
University of Hamburg, Germany

@Tams group

Lecture information

- **Class Schedule:**
  - **Praktikum: Robot Practical Course**
  - **Location: F304**
- **Instructors:**

Houxiang Zhang	**Manfred Grove**
Office: F307	**Office: F332**
Phone: 2565	**Phone: 2511**
Office Hours: Friday 11:00 am.	**Monday 10:00am.**

- **http://tams-www.informatik.uni-hamburg.de/lectures/index.php**

Description of our practical course

- Description of our practical course
  - This summer semester

Art	Ba/Ma-Studiengang: Modulkürzel	Verwendbarkeit in Diplomstudiengängen	Veranstaltungstitel	SWS	Anzahl Gruppen	VeranstalterInnen (SWS)
VL	Binf: IAF Robotik	DInf: SP:BV,SV,WV,ES;	Introduction to Robotics	2	1	Zhang
Üb	Binf: IAF Robotik	DInf: SP:BV,SV,WV,ES;	Exercises: Introduction to Robotics	1	1	Klimentjew
Prak	Binf: IAF Robotik		Praktikum: Robot Practical Course	3	1	H. Zhang, Grove , J. Zhang

  - Other issues

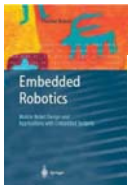
Content of this course

- Introduction to our practical course
  - Motivation, schedule, information, and possible topics
- Telebot system
  - Build the mechanical structure, program and test the robot, improvement.
- Modular robot
  - Build your own inspired robotic systems
- Other open topics
  - Sony Aibo, pioneer robot
- Final evaluation

Acknowledgments

- ***"Introduction to Autonomous Mobile Robots"*** by Roland Siegwart and IIIah R. Nourbakhsh, and pertinent slides with the book are available on: http://www.mobilerobots.org

- ***"Embedded Robotics"*** by Thomas Braeunl, Springer-Verlag Berlin Heidelberg ISBN: 3-540-34318-0, 2006.[2nd Edition]



Acknowledgments

- Thanks for online information from
  - Dr. Alaa Khamis
  - http://gucdiggers.com/robodig/
- Other great work and related information on the internet

Acknowledgments

- Special thanks to the E-Learning-Consortium Hamburg (ELCH) for supporting "Telebot" , an educational robotic system.

- Also, thanks for the ARMS Group at Beijing University of Aeronautics and Astronautics (BUAA) for the technical cooperating on educational robotic projects.

- Modular robot project is developed in cooperation with my colleague Juan Gonzalez-Gomez from the School of Engineering, Universidad Autonoma de Madrid in Spain.

Content of this course

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Introduction to our lecture

- Motivation
- Our schedule
- Other useful information
- Introduction to possible robotic systems

Introduction to our lecture

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Motivation

- Apply the theory and models learned in the robotics course to real robot systems.
- Gain experience in working with physical sensors, actuators and robot programming.
- First step towards creating useful robot systems for non-industrial applications.

Motivation

- In this practical course, the students will work with educational robots and modular robots to learn the following aspects:
  - Building educational robots;
  - Integrating sensors;
  - Programming elementary robot skills and behaviors;
  - Testing the possibilities of cooperation;
  - Building modular mobile robots and simple kinematic chains;
  - Testing inspired behaviors.

Robotic technology

- What is a robot?
- Why should you know something on robots?

Robotics technology

- What is a robot?
- Why should you know something on robots?

- A robot is a mechanical or virtual, artificial agent. It is usually an electromechanical system, which, by its appearance or movements, conveys a sense that it has intent or agency of its own. The word robot can refer to both physical robots and virtual software agents, but the latter are usually referred to as bots to differentiate.[1]

  ***[1]** Telecom glossary "bot". Alliance for Telecommunications Solutions (2001-02-28). Retrieved on 2007-09-05.*

Robot means what?

Webster Dictionary

An automatic apparatus or device that performs functions ordinarily ascribed to humans or operates with what appears to be almost human intelligence.

Robot Institute of America

A reprogrammable multifunctional manipulator designed to move material, parts, tools or specialized devices through variable programmed motions for the performance of a variety of tasks.

Japanese Industrial Robot Association (JIRA)

A device with degrees of freedom that can be controlled.

International Federation of Robotics (IFR)

An automatically controlled, reprogrammable multipurpose manipulator programmable in three or more axes.

Difference between a machine and a robot

- Two Volkswagen Touareg

Original Volkswagen Touareg

Stanley, Stanford Racing Team
The winner of the 2005 DARPA Grand Challenge

Difference between a machine and a robot

- My definition of “robot”:
  - A robot is an artificial, intelligent, autonomous system with a physical electro-mechanical platform.
  - It is a combined device with enough perception, manipulation capability or mobility to implement typical tasks.
  - Its purpose is to release human beings of laborious tasks, and of working in a critical environment, or to provide services to improve the our living standard.

Dr. Houxiang Zhang

Robot classification

- Mobile robots
- Edutainment robot
- Underwater robots
- Medical robots
- ……

http://www.euron.org/resources/robotgallery.html

Introduction to our lecture

- Motivation
- Our schedule
- Other useful information
- Introduction to possible robotic systems

Our schedule

- Introduction to our practical course
- First section: 5-7 times lessons on the Telebot project including an evaluation
- Second section: 5-7 times lessons on modular robots including an evaluation
- Final summary

What we require of you

- At the beginning of every lesson, the lecturer will give an introduction. Then the students will work in groups of around three persons.
- The group will complete a list of given tasks one by one.
- At the end of section, every group should present the results of their work together. A short working report is required and can be written together.
- You should attend the course regularly. Low attendance or absence will affect your grade.
- German or English is available. English is encouraged

Introduction to our lecture

- Motivation
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Related material

- ***Introduction to Autonomous Mobile Robots,*** R. Siegwart and I. Nourbakhsh, The MIT Press, Cambridge, Massachusetts 02142, ISBN: 0-262-19502-X, 2004.
- ***Evolutionary Robotics: The Biology, Intelligence, and Technology of Self-Organizing Machines,*** Stefano Nolfi and Dario Floreano, ISBN: 0-262-14070-5, 2000.
- ***Designing Autonomous Mobile Robots: Inside the Mind of an Intelligent Machine,*** John M. Holland, Newnes is an imprint of Elsevier, ISBN: 0-7506-7683-3, 2004
- ***Embedded Robotics***, Thomas Braeunl, Springer-Verlag Berlin Heidelberg ISBN: 3-540-34318-0, 2006.[2nd Edition]
- Other references:
  - http://tams-www.informatik.uni-hamburg.de/lectures/2008ss/

Web links on robotics

- International Federation of Robots
  - http://www.ifr.org/
- IEEE Robotics and Automation Society(RAS)
  - http://www.ncsu.edu/IEEE-RAS
- European Robotics research Network (EURON)
  - http://www.euron.org/
- Robotics Trends, news and information
  - http://www.roboticstrends.com/index.php
- Robotics Online
  - http://www.roboticsonline.com/

How to find information for your tasks

- Our library: numerous journals and proceedings
- Internet
- Other information pre-selected by us

Contact information:

Available time: 10:00 am on

Available time: 11:00 am on Friday.

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  - Telebot system
  - Modular robot
  - Preparation for the next lecture

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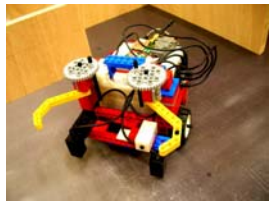
First section:
Telebot system

Lecturer

Dr. Houxiang Zhang

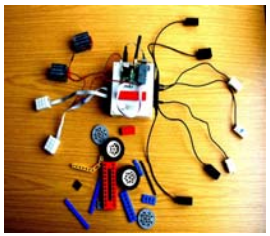
TAMS, Department of Informatics
University of Hamburg, Germany



@Tams/hzhang/project

Outline of the first part

- Brief introduction to the Telebot project
- Telebot system
  - Specification
  - Components
  - Applications
- Possible tasks



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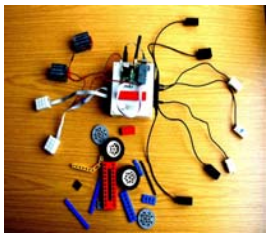
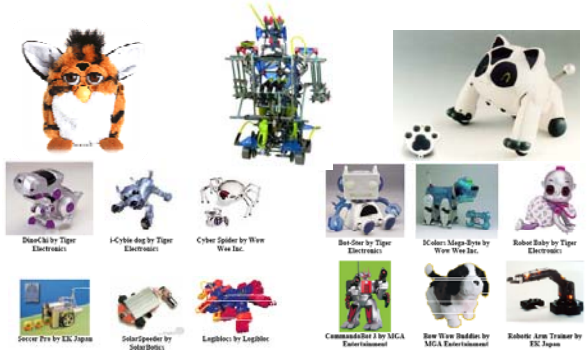


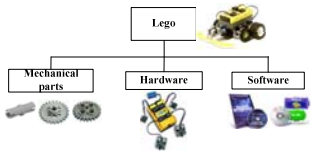
Education and entertainment robots

Edutainment robots- other toys



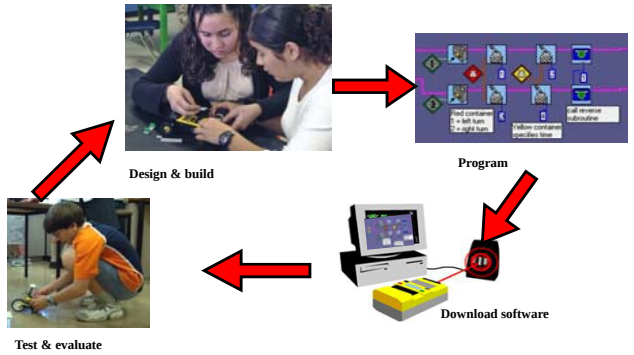
Edutainment robots –Lego

- Lego mindstorms
  - Developed in cooperation with MIT Media Lab researchers in 1998.
  - RCX
    - 3 sensory inputs and 3 motor outputs.
    - includes a display and buttons for selecting programs and viewing status of in/outputs
    - includes an IR serial port, through which it is programmed
  - Robotics Invention System (RIS) and easy-to-use GUI



http://mindstorms.lego.com/

Edutainment robots –Lego



Edutainment robots–Fischertechnik

- Fischertechnik (Arthur Fischer in 1965)
  - Contains a great amount of educational aspects, both with respect to programming and especially with respect to the construction of the robots.
  - Contains a central processing unit, two motors, six switches, two light sensors and one light source.
  - A programming interface for the Fischertechnik robots is also quite similar to that of LEGO Mindstorms
  - A little bit expensive

http://www.fischertechnik.de/en/index.aspx

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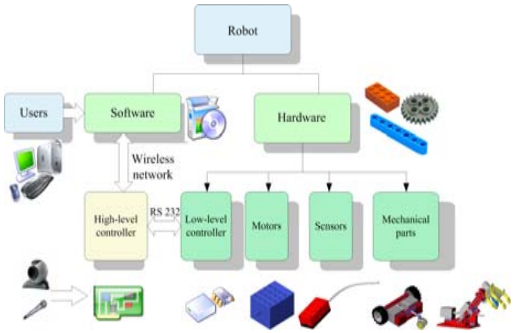
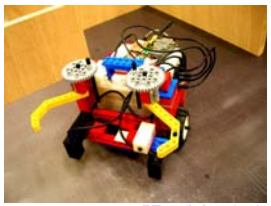
Overview of the Telebot



Telebot system introduction

- Telebot (TAMS group based on cooperation with BUAA, 2006)
  - 9 channels for sensor inputs; 4 outputs for actuators
  - Communication interface
  - Java and C++ programming easy
  - More flexible and extended functions



@Tams/hzhang/project

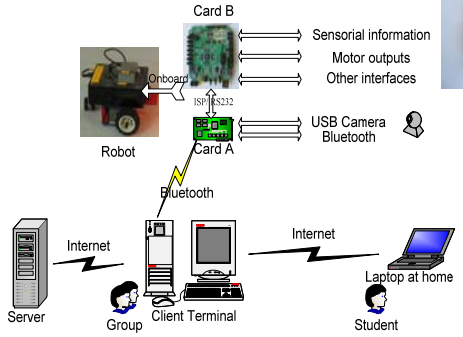
Telebot system

- A new kind of education robotic system for practical courses whose object is to offer a chance to different levels of students to acquire knowledge about robotics;
- More flexible mechanical parts based on LEGO bricks and our newly designed output and input bricks;
- Embedded software hierarchy;
- Easy-to-use programming environment in Java or C language, depending on the students' standard of knowledge.

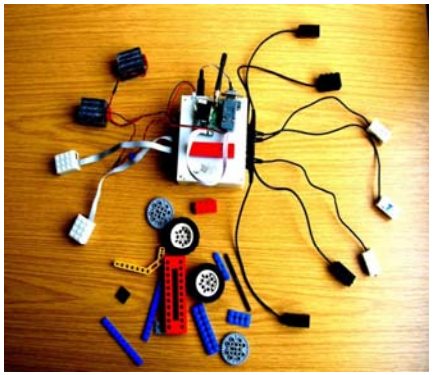
Specifications of the hardware

- Enough I/O resources
  - inputs: switches and analog sensors
  - outputs: 2 motors (PWM), 2 motors (on-off)
- CCD input
- Remote operation
- Wireless communication
- Online debugging

Hardware realization

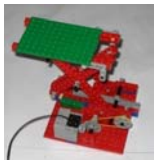


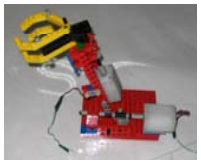
Components of the Telebot system



Mechanical system

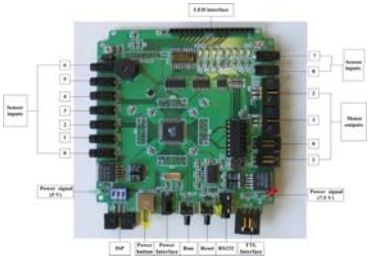
- Functionality
- Extensibility
- Easy handling
- Low cost





Hardware realization- controller B

- ATmega16 microprocessor.
- The sensor channels from 0 to 6 can be used as digital or analog inputs; 7 and 8 can only be used in a digital way.
- Power supply should be 8.4V-24V
- Two communication interfaces on board: RS232 and TTL
- ISP for downloading the drivers
- Motor outputs 0 and 1 can be controlled by PWM signals; 2 and 3 are only under the on-off mode.

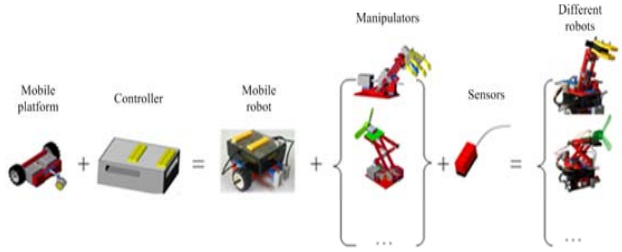


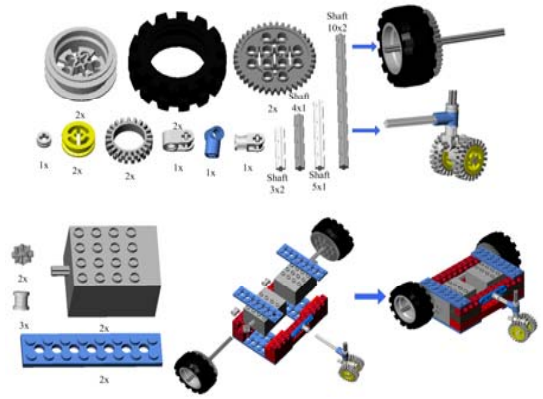
In-System Programming *(abbreviated ISP) is the ability of some programmable logic devices, microcontrollers, and other programmable electronic chips to be programmed while installed in a complete system, rather than requiring the chip to be programmed prior to installing it into the system.*

Sensors

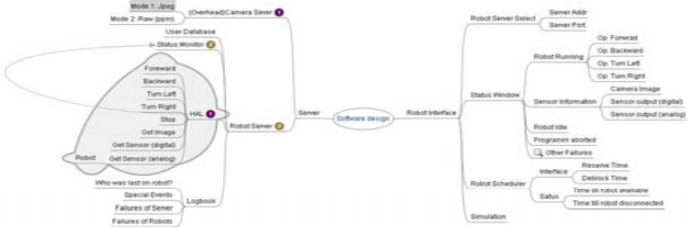
Kinds	Purposes	Number	Photo
Color sensor	Detect black and white	2	
Object sensor	Detect objects in front	2	
Light sensor	Detect an illuminant object such as a candle or a lamp	2	
Touch sensor	Switch	2	

System integration





Software hierarchy



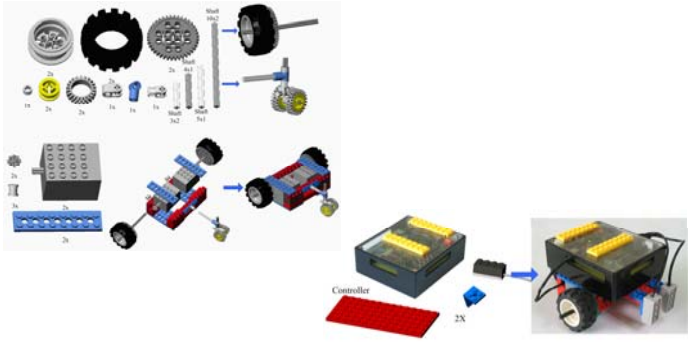
Possible tasks for our practical course

- Moving along a line
- Detecting and moving around an obstacle
- Looking for an object
- Following a moving object
- Mapping the scenario
- …

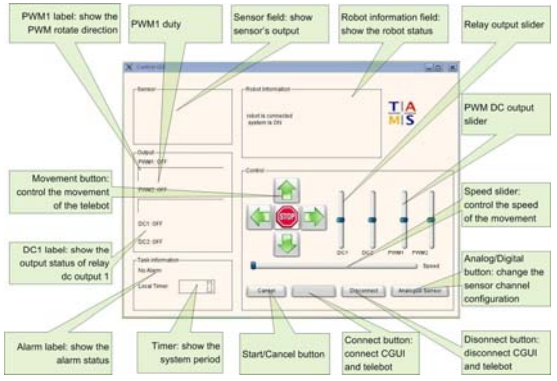
Implementation

- Building mechanical system
- Programming
- Testing

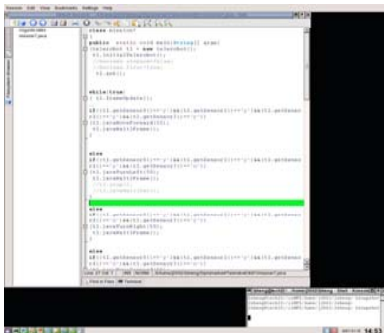
Mechanical building



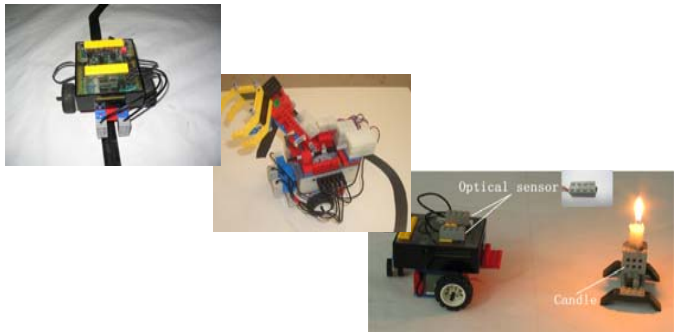
GUI



C and Java programming environments



Testing and demos



Introduction to our lecture

- Motivation
- Our schedule
- Other useful information
- Introduction to possible robotic systems
  - Telebot system
  - Modular robot
  - Preparation for the next lecture

Second section:
GZ-I modular robot

Lecturer

Dr. Houxiang Zhang

TAMS, Department of Informatics
University of Hamburg, Germany

@Tams/hzhang/project

Outline of the second part

- Brief introduction to modular robots
- Introduction to our modular system
- Possible tasks

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Edutainment robots- Modular robot

- Main idea: building robots composed of **modules**
- The design is focused on the module, not on a particular robot
- The different combinations of modules are called **configurations**
- Some advantages:
  - Versatility
  - Fast prototyping
  - Testing new ideas

Edutainment robots- Modular robot

- **POLYBOT** (USA). Palo Alto Research Center (**PARC**)
- **SUPERBOT** (USA)
- **Y1** and **GZ-I** (Spain & GE)
- **M-TRAN** (JAPAN). Advance Industrial Science Technology (**AIST**)
- **YAMOR** (Swiss). Ecole Polytechnique Federale de Lausanne (**EPFL**)

Other examples

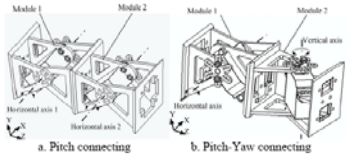
Outline of the second part

- Brief introduction to modular robots
- Introduction to our modular system
- Possible tasks

GZ-I system introduction

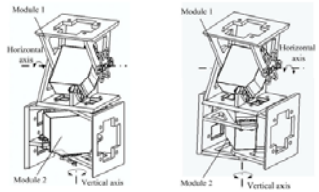
- GZ-I was developed in 2006 in cooperation with my colleague Juan González-Gómez. This system has been developed and is currently still under improvement by our consortium.
  - *Low-cost mechanical design with only six parts in aluminium making up a strong module;*
  - *Simple robust modules assembling manually and in a quick-to-build, easy-to-handle design;*
  - *Four faces for interconnecting modules to implement pitching and yawing movements and two crossed connecting modes so that the system can be extended to build different kinds of inspired robots*
  - *Onboard controller and sensors completing the system and making sensor-servo-based active perception of the environment possible.*

Connecting design



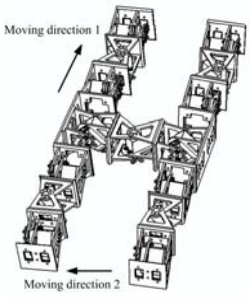
a. Pitch connecting

b. Pitch-Yaw connecting

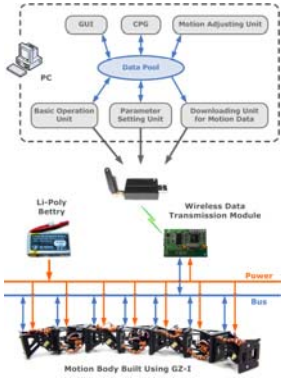


c. and d. Lateral connecting

Robots with various shapes



System integration

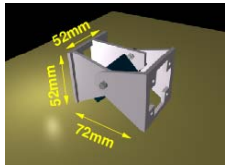


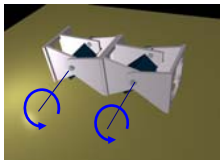
Outline of the second part

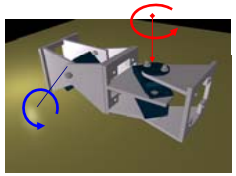
- Brief introduction to modular robots
- Introduction to GZ-I system
- Possible tasks

Possible tasks

- Basic movement
  - Single module
  - Pitching-pitching movement
  - Pitching-yawing movement

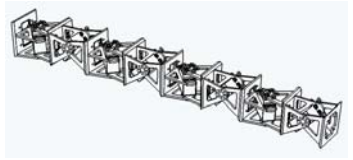






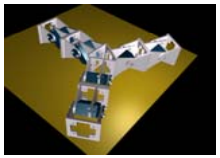
Possible tasks

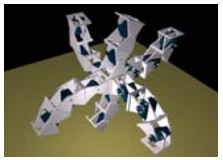
- Caterpillar-like movement
  - minimal configurations
  - Caterpillar with 4 to 8 modules
- Snake-like movement
  - minimal configurations (new question)
  - Snake-like movement



Possible tasks

- Other possibilities
  - Three legged robot
  - Four legged robot
  - Six legged robot
  - Biped robot
- Be creative!





1D Topology:

Locomotion in 1D:

Locomotion in 2D:

Pitch-Pitch

8 pitch-connecting modules

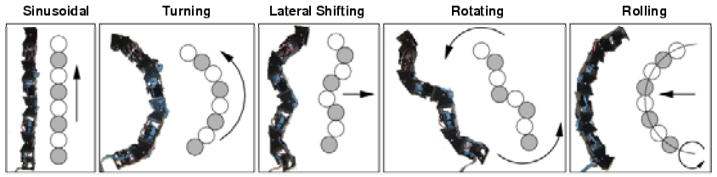
Pitch-Yaw-Pitch

8 pitch-yaw-connecting modules

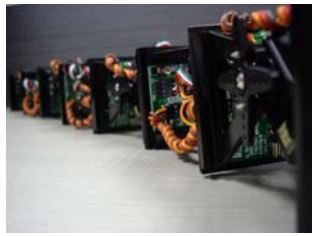
2D Topology:

Star of 3 modules

Locomotion in 2D:



Testing and demos



Introduction to our lecture

- Motivation
- Our schedule
- Other useful information
- Introduction to possible robotic systems
  - Telebot system
  - Modular robot
  - Preparation for the next lecture

Lego mindstorms

- **Lego Mindstorms**

The latest product in the Mindstorms series is Mindstorms NXT, released in August 2006. The kit includes three servo motors, a touch sensor, a light sensor (now with the ability to differentiate between colors based on grayscale readings), a new sound sensor, an ultrasonic sensor and a new NXT 'Intelligent Brick'.
The kit is sold for $249 USD.

Available in GUC Library: Mario Ferrari, Giulio Ferrari, Ralph Hempel, *Building Robots With Lego Mindstorms : The Ultimate Tool for Mindstorms Maniacs*. Syngress Publishing; 1 edition, 2001.

Reading material

- ***Building Robots with LEGO Mindstorms NXT;*** by, Mario Ferrari, Guilio Ferrari, and David Astolfo

- ***The LEGO MINDSTORMS NXT Zoo! - A Kid-Friendly Guide to Building Animals with the NXT Robotics System;*** by Fay Rhodes

- ***LEGO Mindstorms NXT Power Programming: Robotics in C*****;** by, John C. Hansen

http://mindstorms.lego.com/Books/

Web links for next time

- **Lego mindstorms**
  - http://mindstorms.lego.com/default.aspx?domainredir=www.legomindstorms.com
- **Telebot project**
  - http://tams-www.informatik.uni-hamburg.de/people/hzhang/projects/index.php?content=Telerobot

Thanks for your attention!

Let us make the practical course a success together!

Any questions?