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Robotic Technology for Port and Maritime Automation

Presenter:
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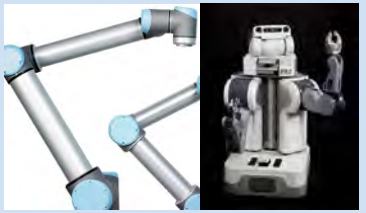
SMI Automation and Autonomy Seminar
11 April 2014

Industrial/Service Robots



Field Robots

Factory Automation

Outdoor Automation

Outline

- Introduction of Robotics Research Centre, NTU
- Competencies in robotics and automation
- Focus research areas in robotics
- Track records
- Research related to port and maritime automation

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Robotics Research Center

- Established in May 1994
- Key faculty researchers: 20
- Research Staffs: 35
- Graduate students: 40 (80 PhD, 70 MEng graduated)
- Collaborators:
  - ASTAR RIs, NRF, NMRC, Nat'l Health Group (TTSH, IMH), SGH, NUH, PUB, LTA, Mindef, ENV, HDB, SPRING, AVA, SMF, SHF
  - ST Engineering, SATS-SFI, Rolls-Royce, Aldebaran
- International reputations:
  - medical robots, rehabilitation robots, biomimic robots, reconfigurable robots, humanoid robots, precision mechatronics/actuators
  - Hosting flagship robotics conference – IEEE International Conference on Robotics and Automation 2017 (2000+ delegates)

Competency in Robotics & Automation

Systems Development	• System design, system architecture, system integration
Human Robot Interaction	• Physical interaction through Hardware, Communication Software interfaces, Manipulation, Haptics
Mechatronics	• Mechanical systems, Sensors, Actuators, Power supply and management, Control
Perception, Navigation, Cognition	• Sensing, Interpretation, Localization, Mapping, Motion planning, Machine learning, Natural interaction

Research Focus

- **Medical Robotics**
- **Rehabilitation & Assistive Robotics**
- **Social robotics & Human Robot interaction**
- **Industrial Robotics & Automation**
- **Unmanned Intelligent Systems**

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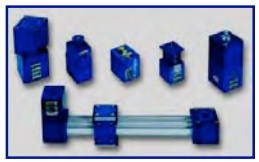
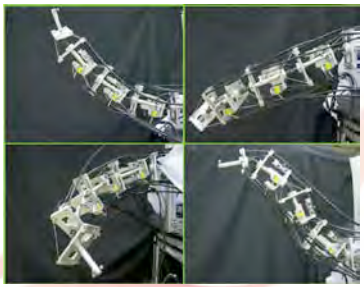
Innovative Robot Design

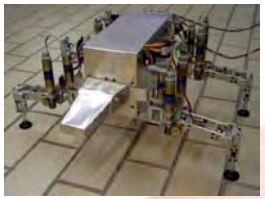


Modular Reconfigurable Robotics

Cable-Driven Robotis



Legged Locomotion Platforms



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Exoskeletons & Humanoid Platforms

Land-Based Mobile Platforms

Tracked Mobile Manipulation System

Autonomous Tractor

Segway Mobile Platform

Autonomous Vehicle

Underwater & Biomimic Platforms

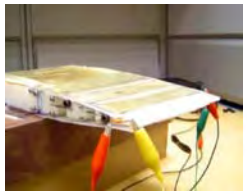
Robotic Ray
Biomimic underwater robot

Water Quality Insp. robot
Lakebed mapping

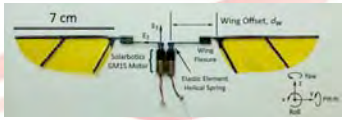
Robotic knife fish
Biomimic underwater robot

AUV
Underwater structure inspection

Unmanned Aerial Vehicles



SMA actuated morphing structure



Research Relevant to Maritime Automation

- Automated lashing, mooring and coning
  - Cable-driven robotic systems
- Autonomous vehicles, cranes or machines
  - Intelligent tractors & vehicles
- Autonomous boats or drones in port waters
  - Distributed USV & UAV
- Other autonomous technology for port, ship and shipyards
  - Configurable robotic platform for maintenance

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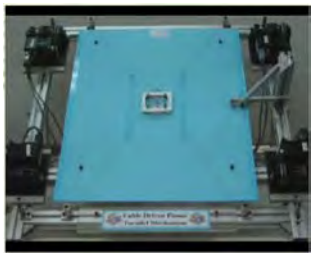
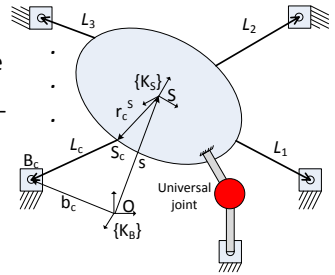
Chen I-Ming/Yeo Song Huat

Cable-driven Robotic Mooring System



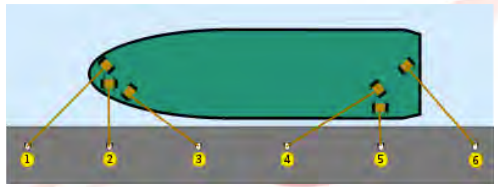
Advantages:

- Intrinsically-safe
- Lightweight
- High payload-to-weight ratio
- Dexterous workspace



Cable-driven parallel manipulator

>>> Robotic mooring



Erdal Kayacan

Autonomous Tractor

Control, **sensing actuation** integrated **intelligent system.**

- GPS-based navigation
- Learning control algorithms
- Sensor fusion
- State and parameter estimation
- System identification and modeling

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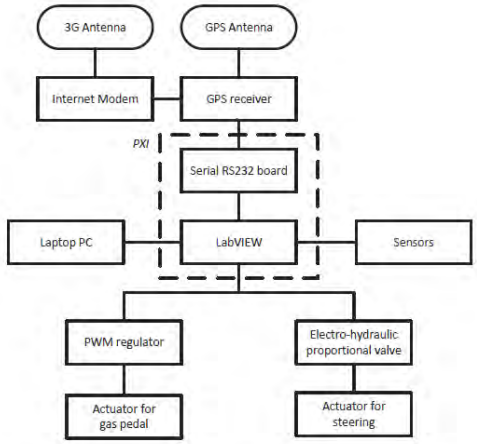
Erdal Kayacan

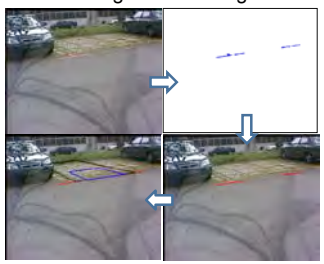
Autonomous Tractor



Autonomous Driving

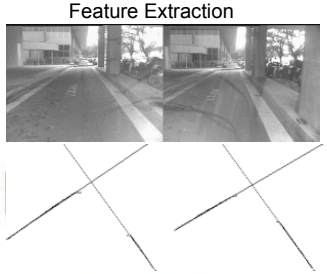
Xie Ming

Vision-guided Parking

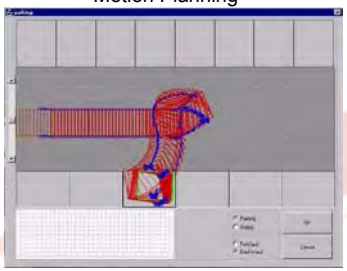


Vision-guided Pursuing

Feature Extraction



Motion Planning



RobotX Challenge: Autonomous Surface Vehicles

Xie Ming

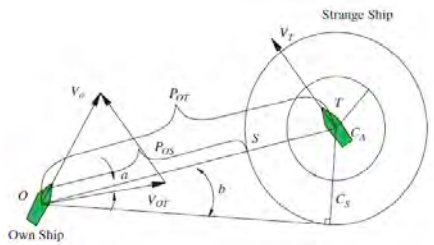
International Competition on 20 Oct 2014 at Marina Bay

Task 1: Autonomous navigation and control
Task 2: Collision Avoidance
Task 3: Docking and Identification
Task 4: Underwater Search
Task 5: Observation

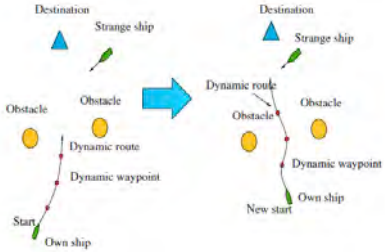
Automatic Simulation of Ship Navigation

D Konovessis

- Automatic simulation programs of ship navigation can be a powerful tool for operational planning and design studies for
  - waterways
  - ports
  - berthing procedures
- The *key* tasks are autonomous route-finding and collision-avoidance done through potential field method



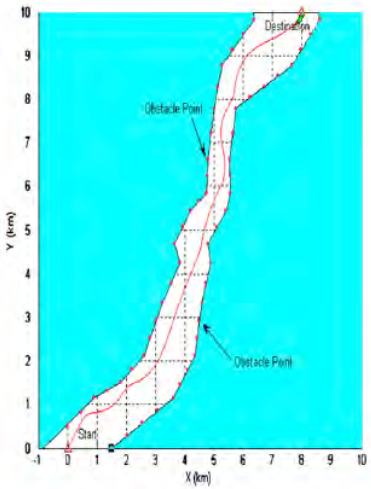
Collision Avoidance Strategy



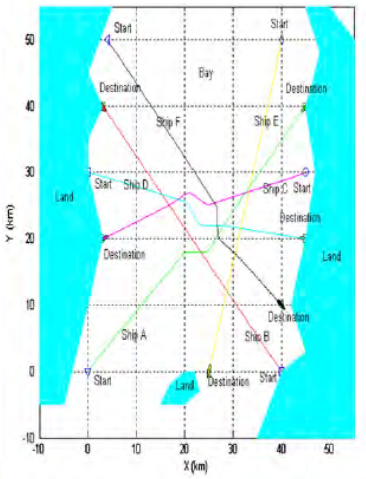
Dynamic Route Generation

Automatic Simulation of Ship Navigation

D Konovessis



Example – Simulation of Canal Passage



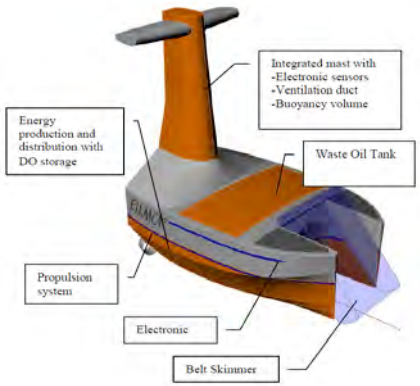
Example – Simulation in a Congested Area

D Konovessis

Distributed Autonomous Boats

Multi-robot Interaction for coordinated tasks

Design Process



A Possible Concept

Chen I-Ming

Shipyard Process Automation

Adaptive/configurable autonomous mobile platform for tank/hull maintenance (grit-blasting, cleaning, painting)

- Intelligent reconfigurable robotic technology to reduce reliance on manual labors
- Robot can change its configuration according to given tasks
- Intelligent peception to scan and build 3D environment, automatic planning of task trajectories
- Mobility and robotic infrastructure to move around large working area

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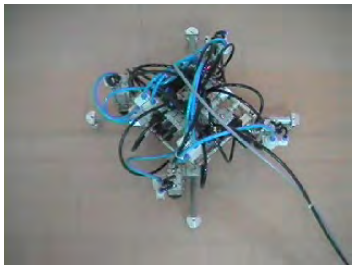
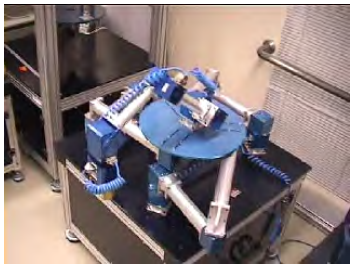
Chen I-Ming

Shipyard Process Automation



Omni-direction 2D climbing robot



Reconfigurable modular robot

Thank You

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