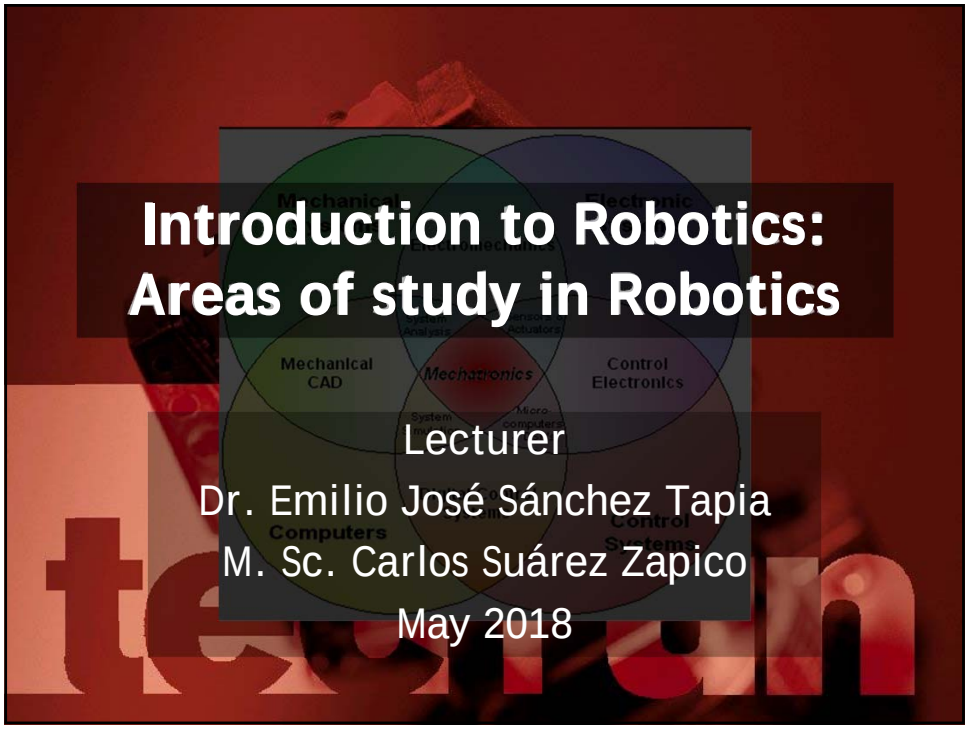
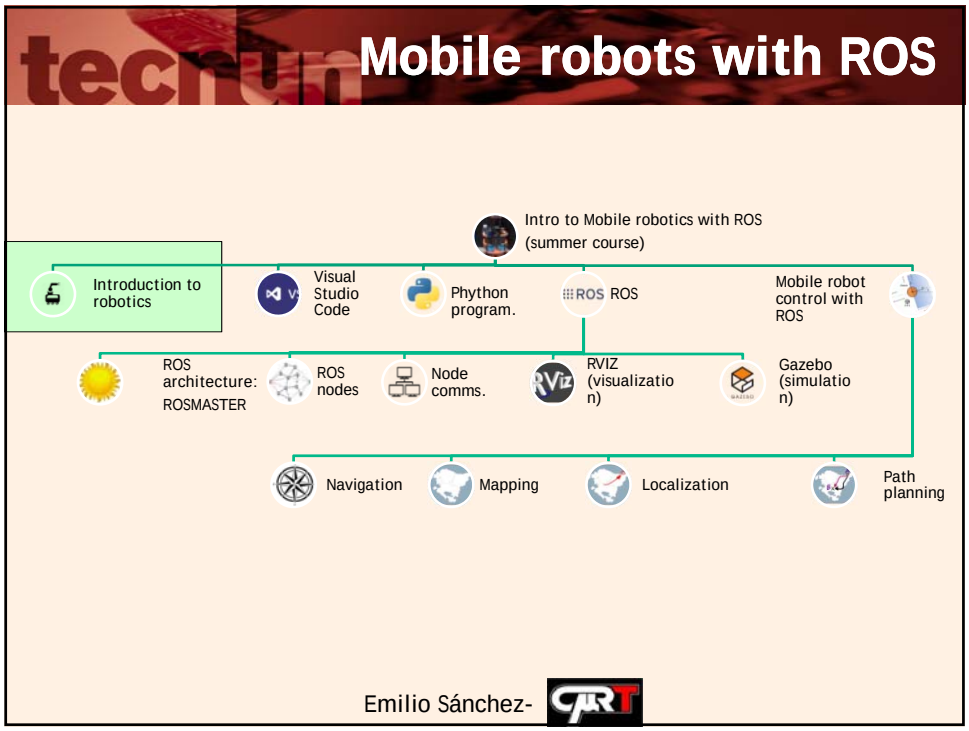
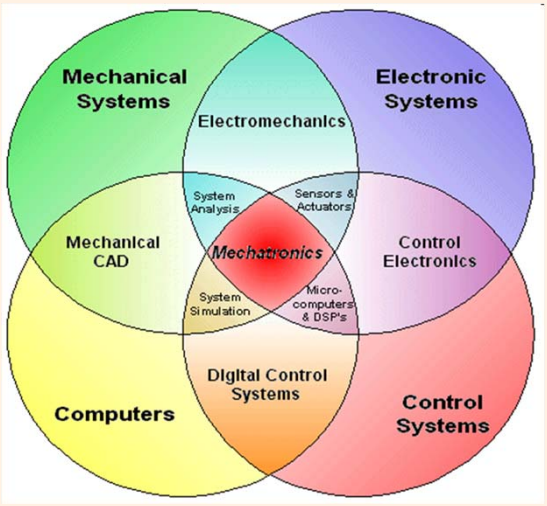

Introduction to Robotics:
Areas of study in Robotics
Mechanical CAD
Mechatronics
Control Electronics
Computers
Lecturer
Dr. Emilio José Sánchez Tapia
M. Sc. Carlos Suárez Zapico
May 2018

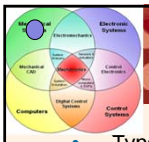

Mobile robots with ROS
Intro to Mobile robotics with ROS (summer course)
Introduction to robotics
Visual Studio Code
Phython program.
ROS
Mobile robot control with ROS
ROS architecture: ROSMASTER
ROS nodes
Node comms.
RVIZ (visualizatio n)
Gazebo (simulatio n)
Navigation
Mapping
Localization
Path planning
Emilio Sánchez-

Areas

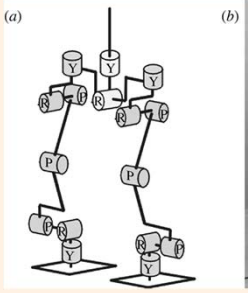


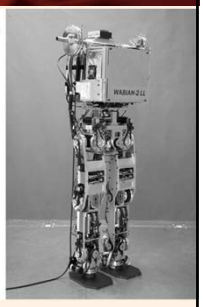
Areas of Robotics Emilio Sánchez- 3

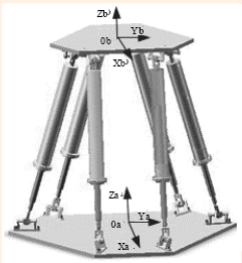
Mechanical Systems

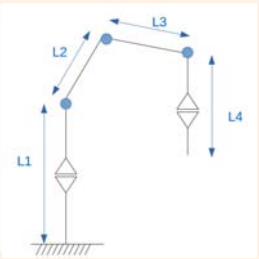


- Type of kinematic chain
- Type of joints (prismatic, articulated…)
- Joint limits
- Link geometry between adjacent joints

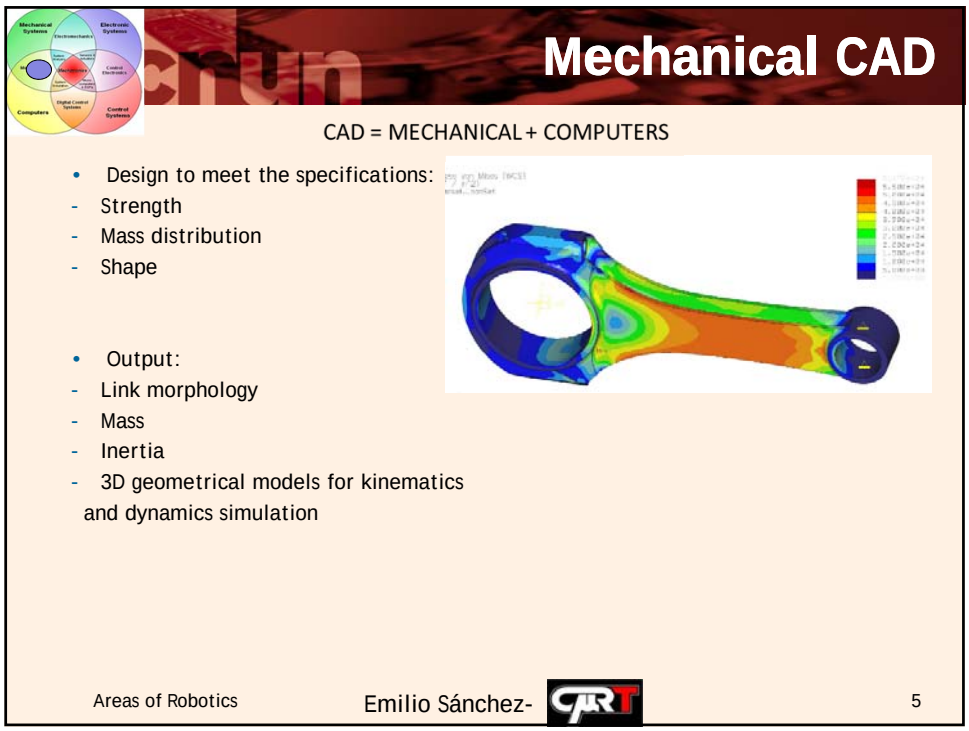


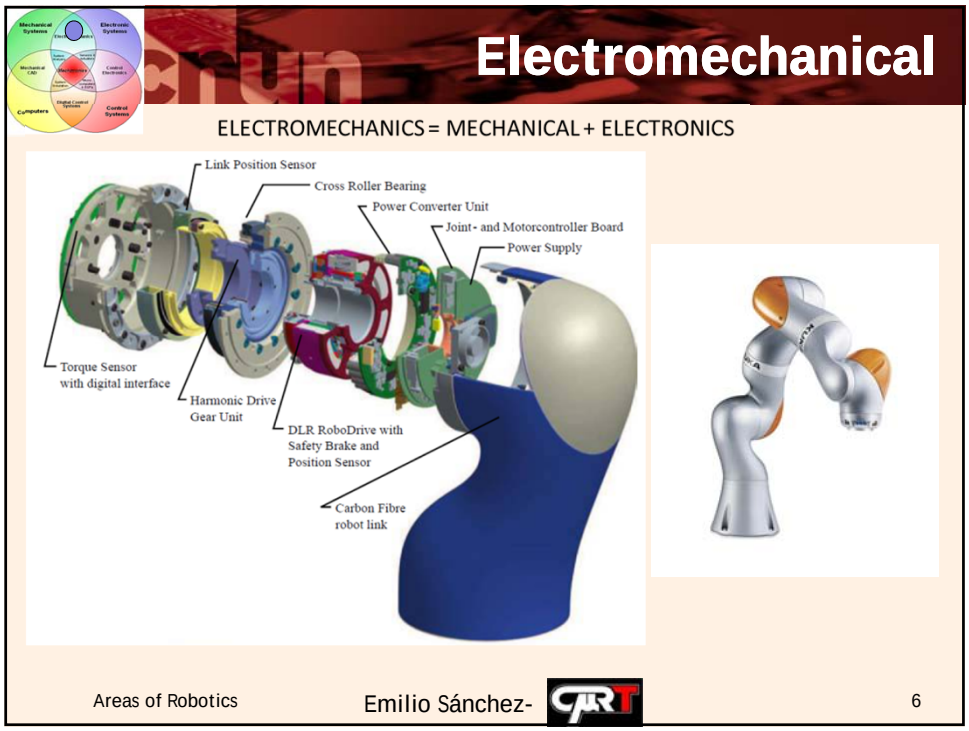






Areas of Robotics Emilio Sánchez- 4


Mechanical CAD
CAD = MECHANICAL + COMPUTERS
• Design to meet the specifications:
- Strength
- Mass distribution
- Shape
• Output:
- Link morphology
- Mass
- Inertia
- 3D geometrical models for kinematics and dynamics simulation
Areas of Robotics
Emilio Sánchez-
5


Electromechanical
ELECTROMECHANICS = MECHANICAL + ELECTRONICS
Link Position Sensor
Cross Roller Bearing
Power Converter Unit
Joint- and Motorcontroller Board
Power Supply
Torque Sensor with digital interface
Harmonic Drive Gear Unit
DLR RoboDrive with Safety Brake and Position Sensor
Carbon Fibre robot link
Areas of Robotics
Emilio Sánchez-
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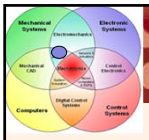
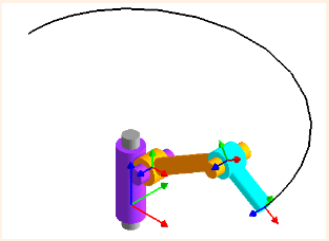
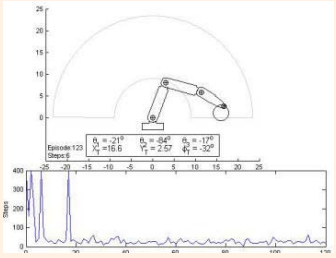


System Analysis

SYSTEM ANALYSIS = MECHANICAL CAD + ELECTROMECHANICS

- Extract kinematic mathematical models (Forward Kinematics, Inverse Kinematics…)
- Analyze the workspace and reachability of a mechanism
- Extract dynamic mathematical model
- Obtain joint actuator features (power, speed, acceleration…)

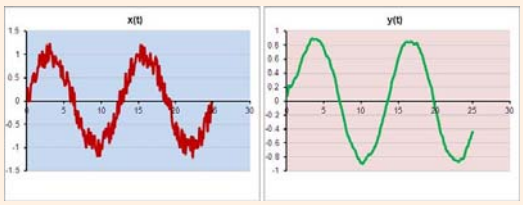




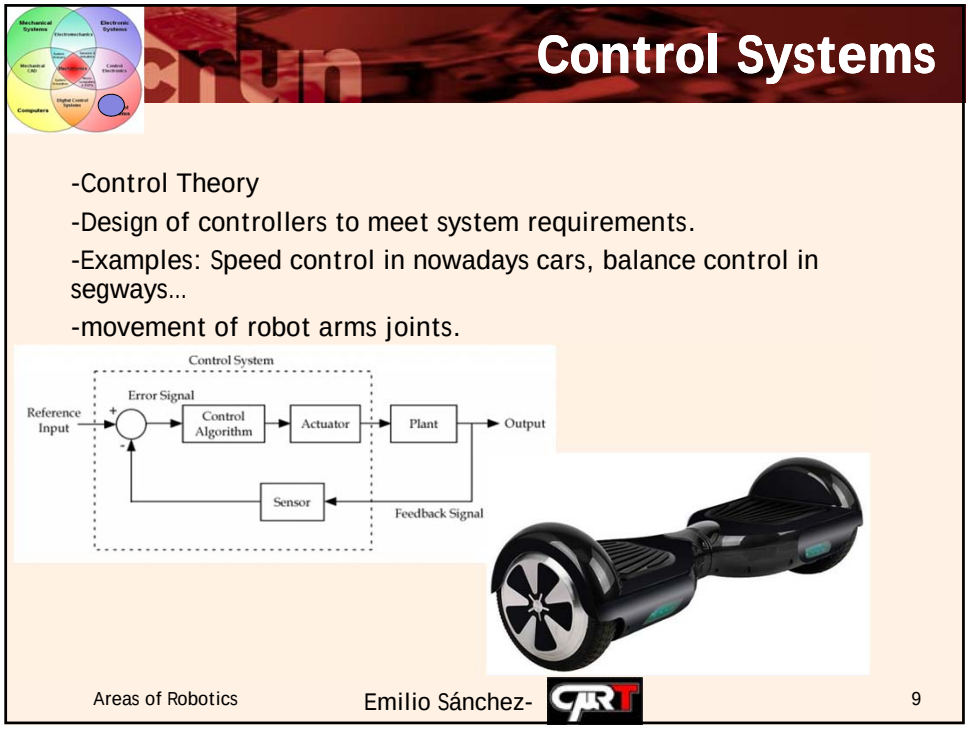
Areas of Robotics Emilio Sánchez- 7

Electronic Systems

- Power electronics (voltage conversions, AC/DC…)
- Signal filtering
- Motor drivers
- Sensor signal treatment (amplified, linearize…)



Areas of Robotics Emilio Sánchez- 8


Control Systems
-Control Theory
-Design of controllers to meet system requirements.
-Examples: Speed control in nowadays cars, balance control in segways...
-movement of robot arms joints.
Control System
Error Signal
Reference Input
Control Algorithm
Actuator
Plant
Output
Sensor
Feedback Signal
Areas of Robotics
Emilio Sánchez-
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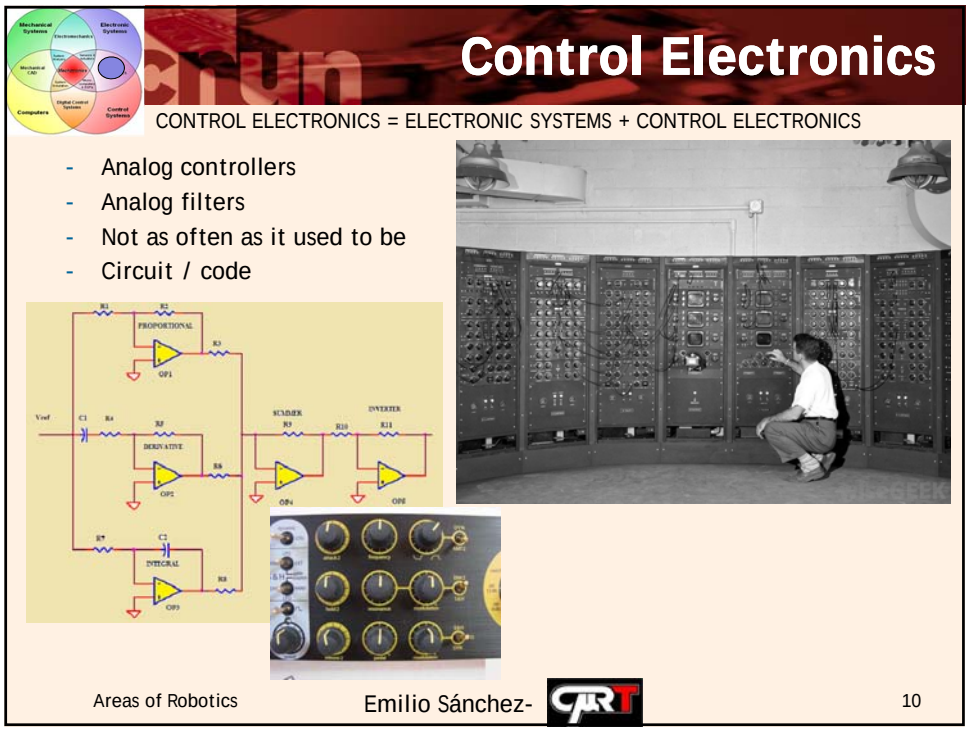
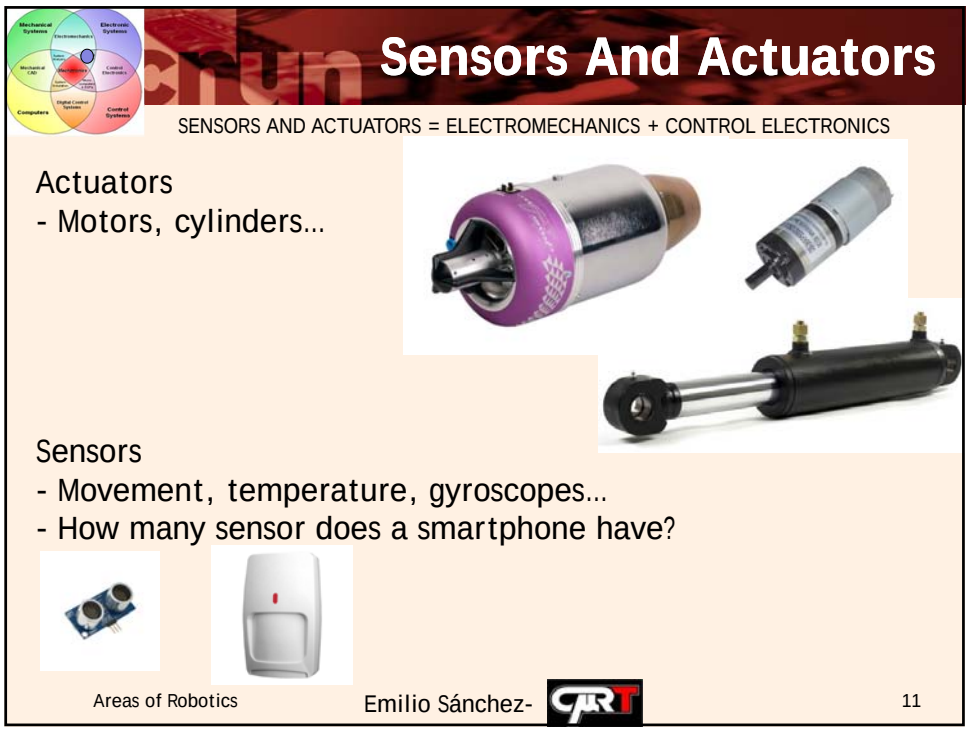
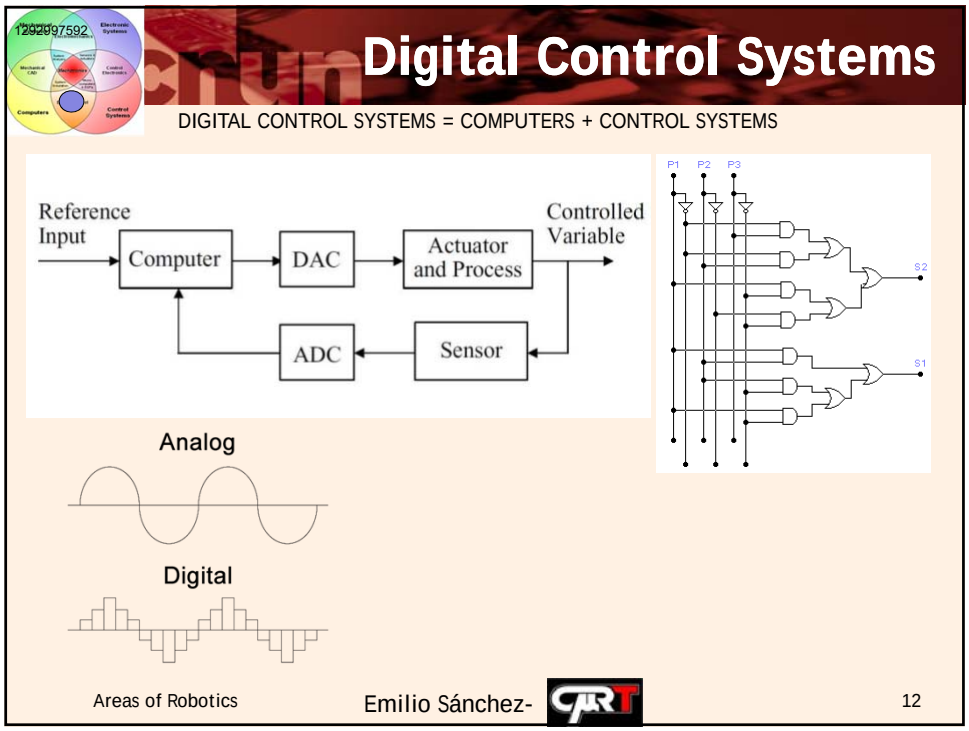
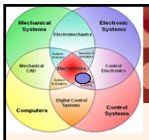

Control Electronics
CONTROL ELECTRONICS = ELECTRONIC SYSTEMS + CONTROL ELECTRONICS
- Analog controllers
- Analog filters
- Not as often as it used to be
- Circuit / code
PROPORTIONAL
DERIVATIVE
INTEGRAL
SUMMER
INVERTER
Areas of Robotics
Emilio Sánchez-
10


Sensors And Actuators
SENSORS AND ACTUATORS = ELECTROMECHANICS + CONTROL ELECTRONICS
Actuators
- Motors, cylinders…
Sensors
- Movement, temperature, gyroscopes…
- How many sensor does a smartphone have?
Areas of Robotics
Emilio Sánchez-
11

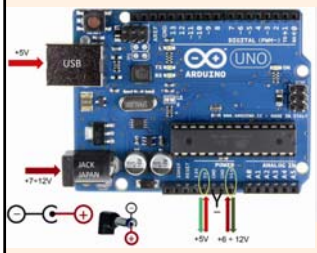

Digital Control Systems
DIGITAL CONTROL SYSTEMS = COMPUTERS + CONTROL SYSTEMS
Reference Input
Computer
DAC
Actuator and Process
Controlled Variable
ADC
Sensor
Analog
Digital
Areas of Robotics
Emilio Sánchez-
12



MicroComputers and DSP

MICROCOMPUTERS and DSP= DIGITAL CONTROL SYSTEMS + CONTROL ELECTRONICS

Control theory applied on digital controllers, which is characterized by been discrete system.

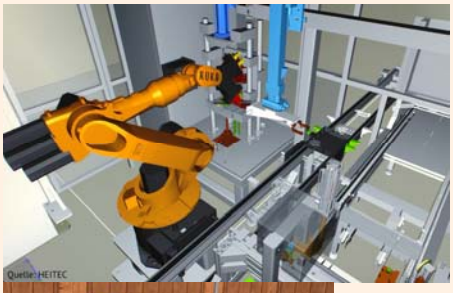


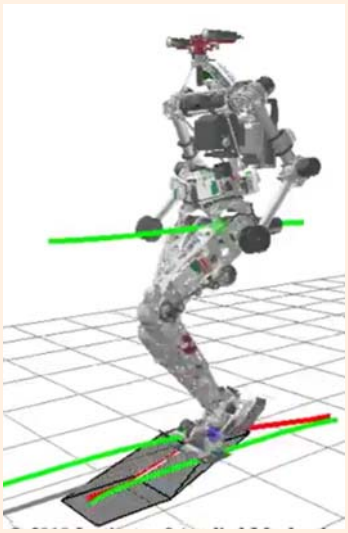
A controller, to be robust and reliable, needs to work under a real-time system. A computer with Windows does not meet this requirement because Windows, as well as MAC and Linux are not real-time OS.

Areas of Robotics Emilio Sánchez- 13

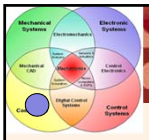
System Simulation

SYSTEM SIMULATION = MECHANICAL CAD + DIGITAL CONTROL SYSTEMS





Areas of Robotics Emilio Sánchez- 14



Computers

- Communications
- Computer Vision
- User Interface (HMI)
- Motion Planning and Obstacle Avoidance
- World Modeling, Mapping Pose Estimation, --
- Manipulation (Grasping, contact modeling, fixtures…)
- Physics simulators
- Machine Learning

Computers - Communications

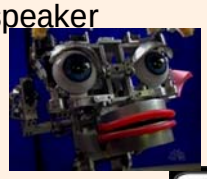
- Swarm or networked robotics

- Access to Internet (database, return state…)
- Distributed Architecture
- Hardware interface

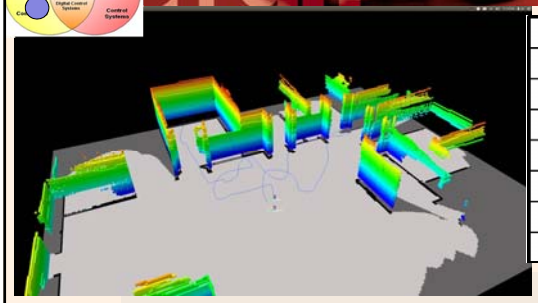
Computers -HMI (Human Machine Interface)

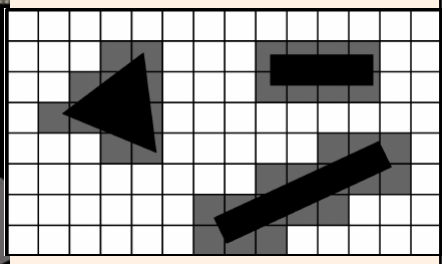
- Console (teachpendant for robot arms)
- Tablet or graphical interface

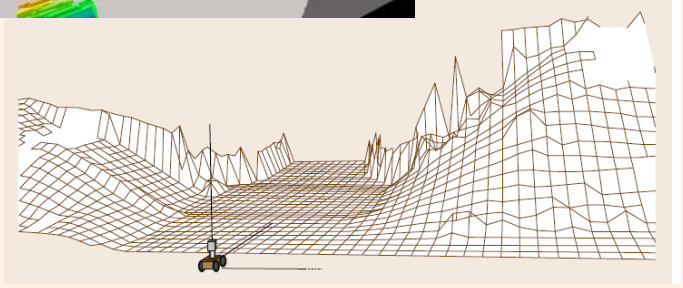
- Voice synthesizer, speaker
- Face expressions



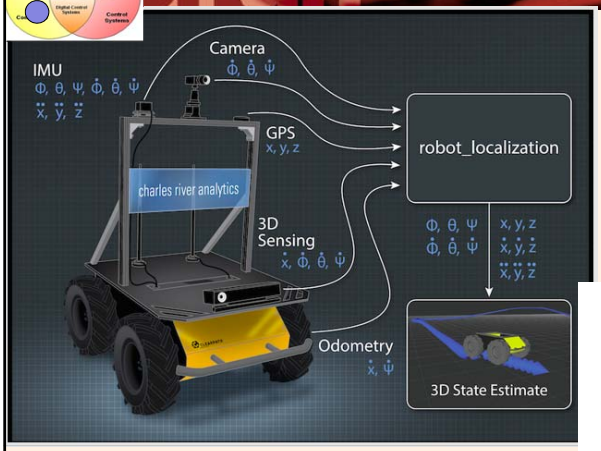
Computers- World Modeling

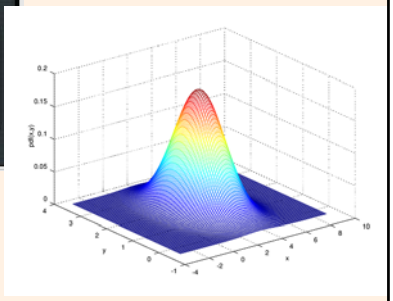






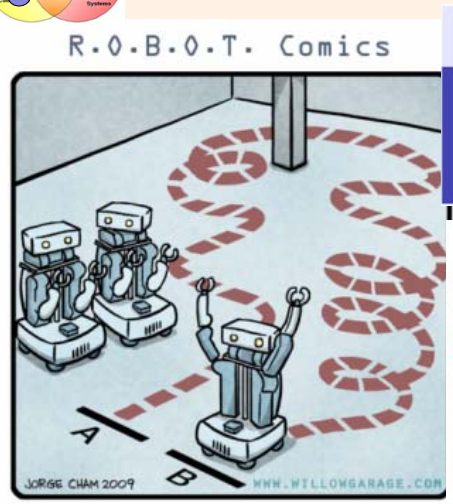
Computers – Pose Estimation



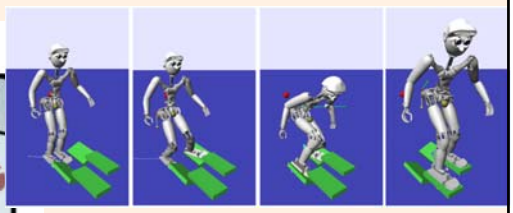


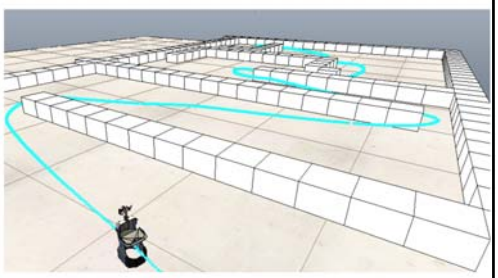
Areas of Robotics Emilio Sánchez- 19

Computers – Motion Planning

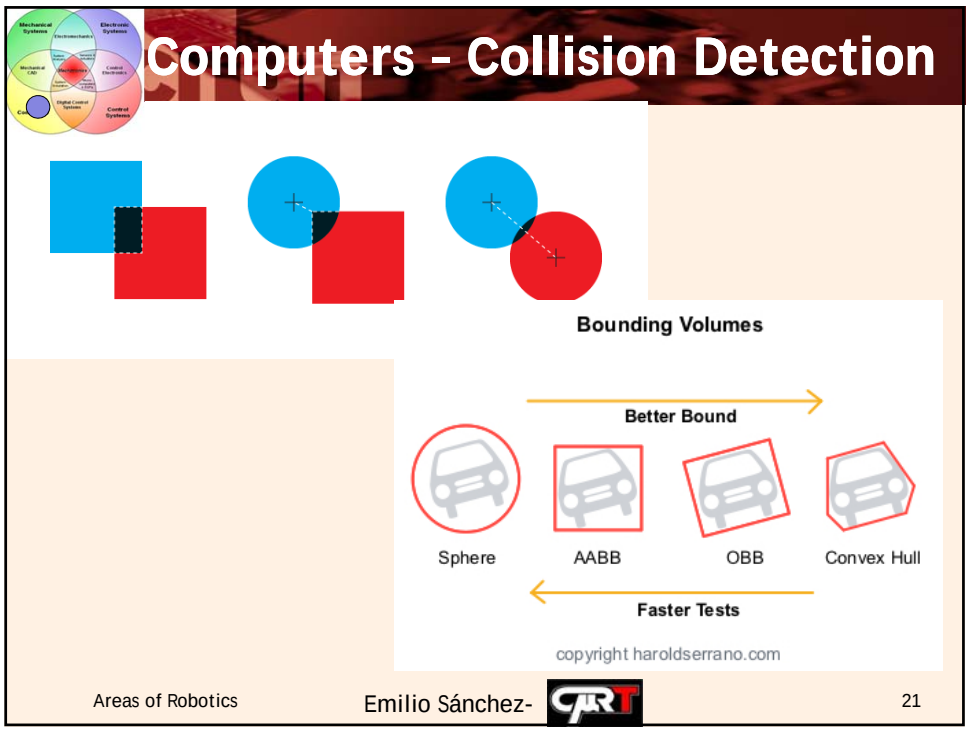


"HIS PATH-PLANNING MAY BE SUB-OPTIMAL, BUT IT'S GOT FLAIR."





Areas of Robotics Emilio Sánchez- 20


Computers - Collision Detection
Bounding Volumes
Better Bound
Sphere
AABB
OBB
Convex Hull
Faster Tests
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Areas of Robotics
Emilio Sánchez-
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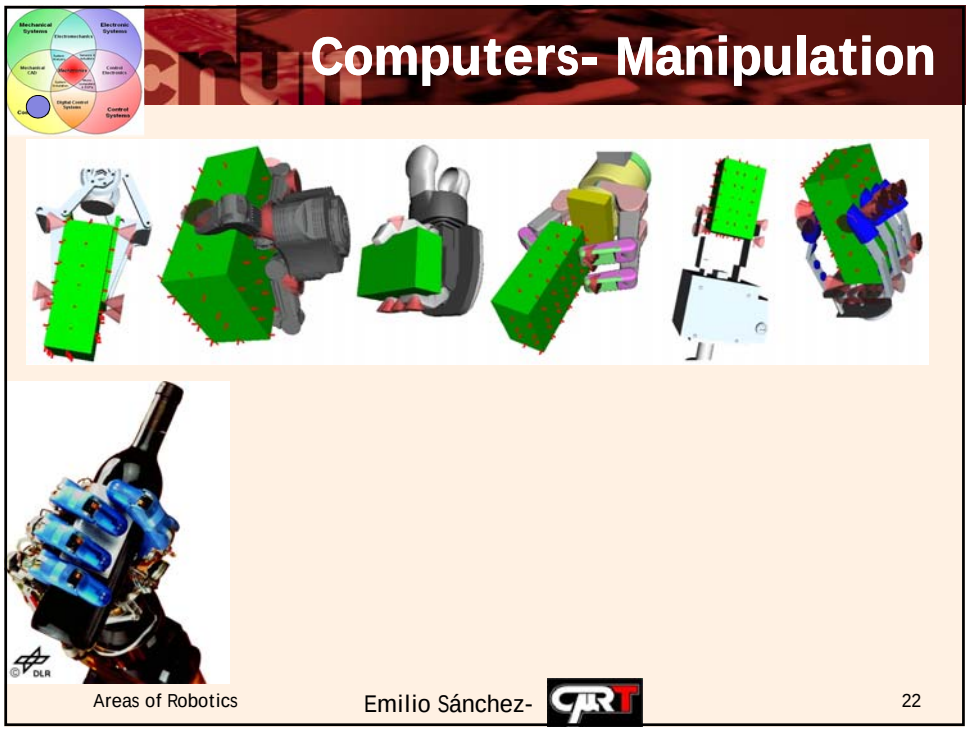
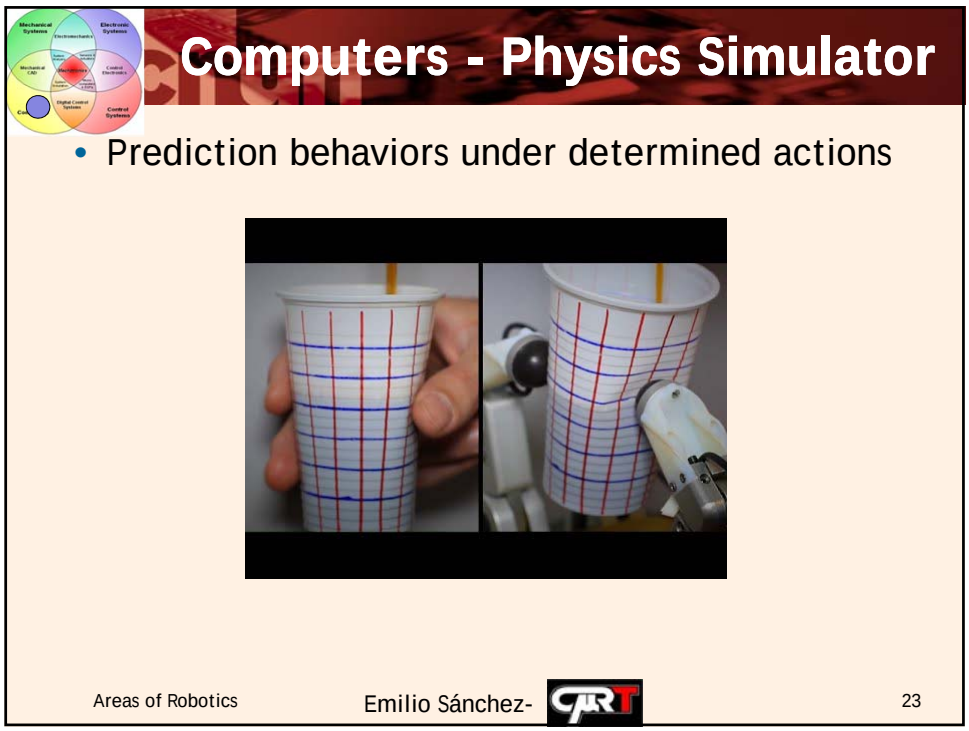
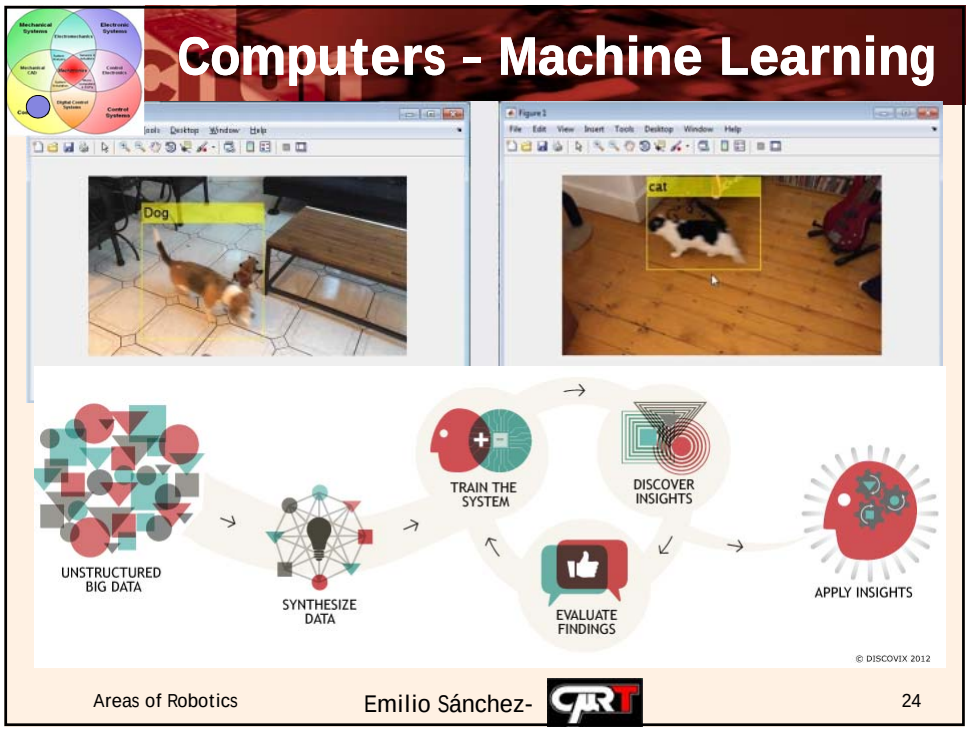

Computers- Manipulation
Areas of Robotics
Emilio Sánchez-
22


Computers - Physics Simulator
• Prediction behaviors under determined actions
Areas of Robotics
Emilio Sánchez-
23


Computers - Machine Learning
Dog
cat
UNSTRUCTURED BIG DATA
SYNTHESIZE DATA
TRAIN THE SYSTEM
DISCOVER INSIGHTS
EVALUATE FINDINGS
APPLY INSIGHTS
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Areas of Robotics
Emilio Sánchez-
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