MKM 503E - Mechatronic System Components Week-1

Prof. Dr. Volkan Sezer

Objective of Course

- (1) Obtaining a general understanding of sensors, actuators and integrated systems
- (2) Obtain practical knowledge in selecting the right component for mechatronics system design
- (3) Obtaining an insight for design of efficient mechatronic systems

Content of Lecture

Week	Topics
1	Overview of Mechatronics , Introduction.
2	Measurement Systems (Transducer/Sensor) and Their Principles – Part 1
3	Measurement Systems (Transducer/Sensor) and Their Principles – Part 2
4	Fundamentals of Electricity (KCL, KVL, Voltage Dividers, Wheatstone bridge, Strain Gauge..)
5	AC Circuit Analysis, Signal Conditioning (Active/Passive Filters)
6	Mechanical power transmission components: gears, belt drive, Rack and Pinion, Ball-Screw Mechanism etc.. Part1
7	**MIDTERM1 12.11.2025**
8	Mechanical power transmission components: gears, belt drive, Rack and Pinion, Ball-Screw Mechanism etc.. Part2
9	Electric Machines (Principle of Operation, System Modeling, Drivers, Speed/Position Measurement etc.) Part1
10	Electric Machines (Principle of Operation, System Modeling, Drivers, Speed/Position Measurement etc.) Part2
11	Processing Systems & Control Systems Part 1
12	**MIDTERM2 17.12.2025**
13	Control Systems Part 2
14	Exercise, Wrap-up, Discussion

MIDTERM1 : November 12

MIDTERM2 : December 17

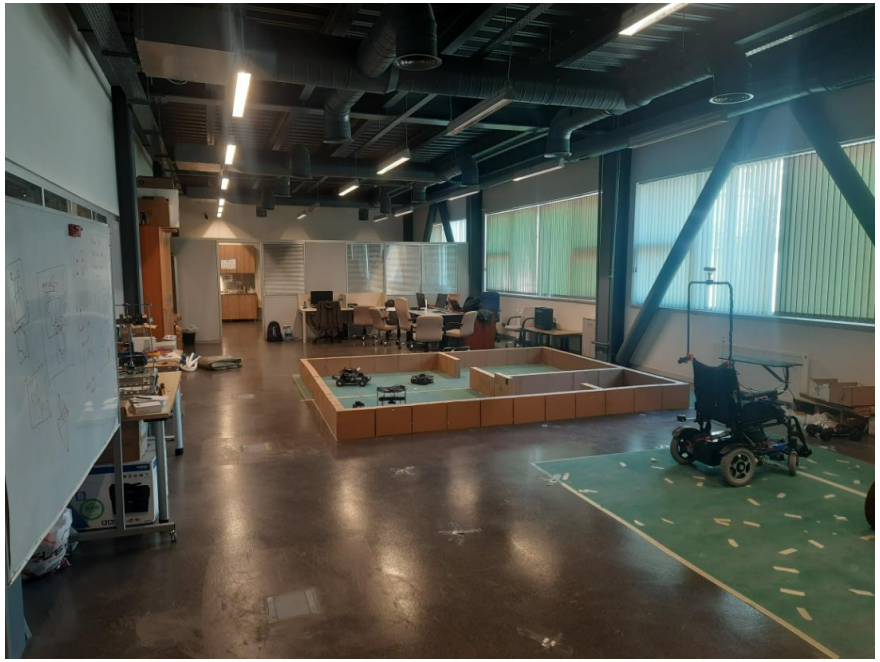
References

- Histand M.B., Introduction to Mechatronics and Measurement Systems, Mcgraw-Hill Series in Mechanical Engineering, 2002
- De Silva,C.W., Mechatronics: An Integrated Approach, 2005.
- Dan Necsulescu, Mechatronics, Prentice Hall, New Jersey, 2002.
- W. Bolton, Mechatronics: Electronics Control Systems in Mechanical and Electrical Engineering, Addison Wesley, 2nd edition, 1999.

Office Hours

- Monday 08.30-09.30 (SASlab, 8105)

Smart and Autonomous System Laboratory (SASlab, 8105)



Evaluation

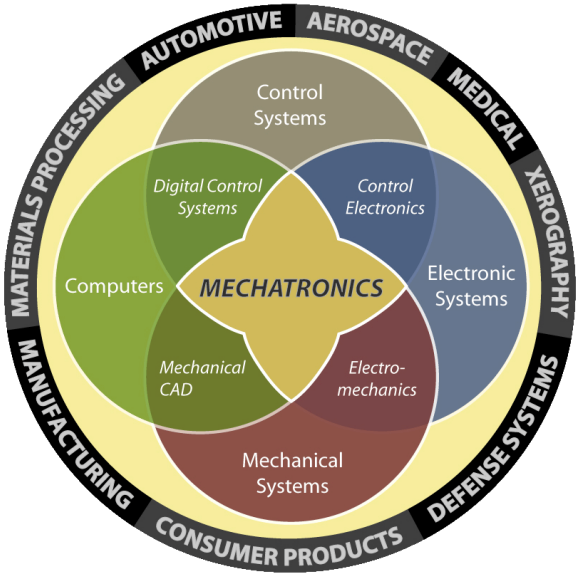
- %25 Midterm1
- %30 Midterm2
- %45 Final Exam

In order to take the final exam, weighted average of midterms must be at least 30. Otherwise your grade will be VF

$$\frac{25 * Midterm1 + 30 * Midterm2}{55} \geq 30$$

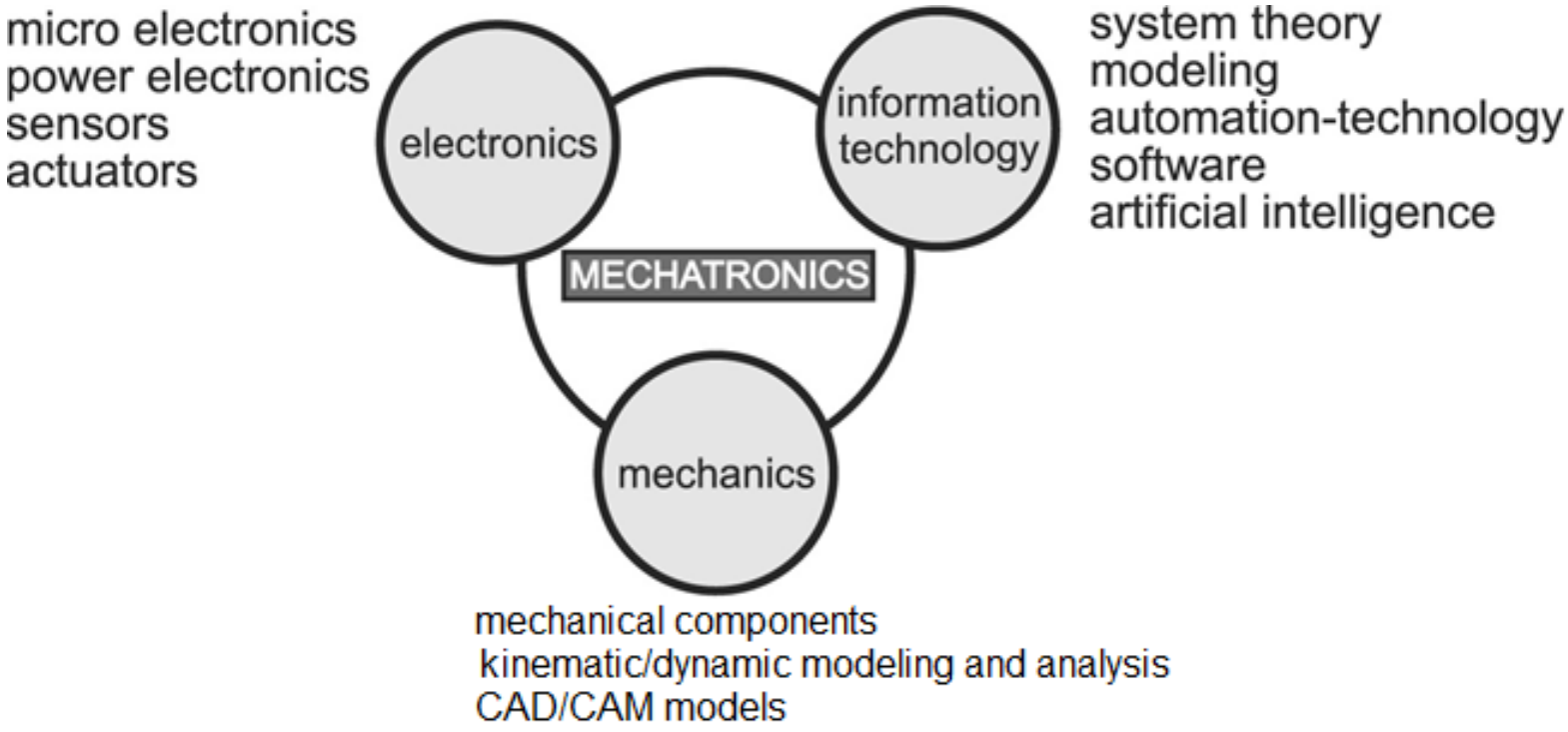
What is Mechatronics?

- Mechatronics is a multidisciplinary field of science that includes a combination of mechanical engineering, electronics, computer engineering, telecommunications engineering, systems engineering and control engineering.



www.wikipedia.org

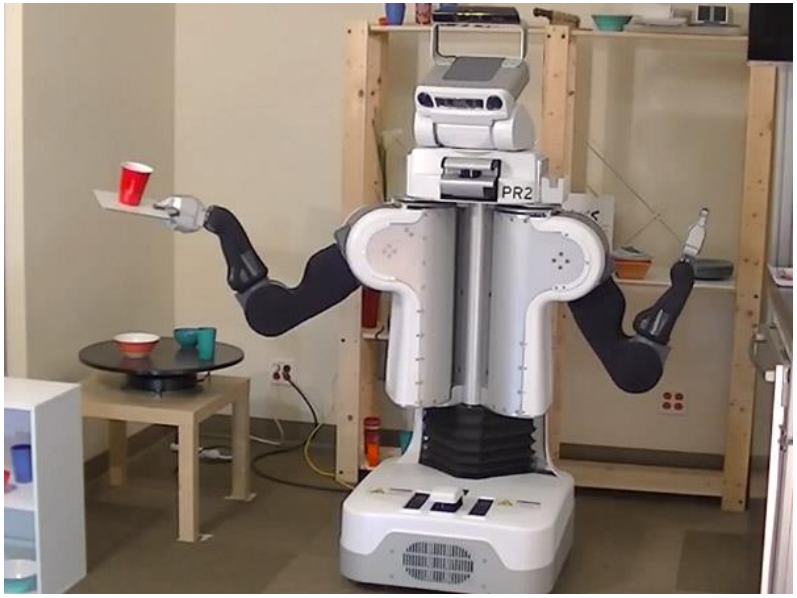
Mechatronics



What is Mechatronics?

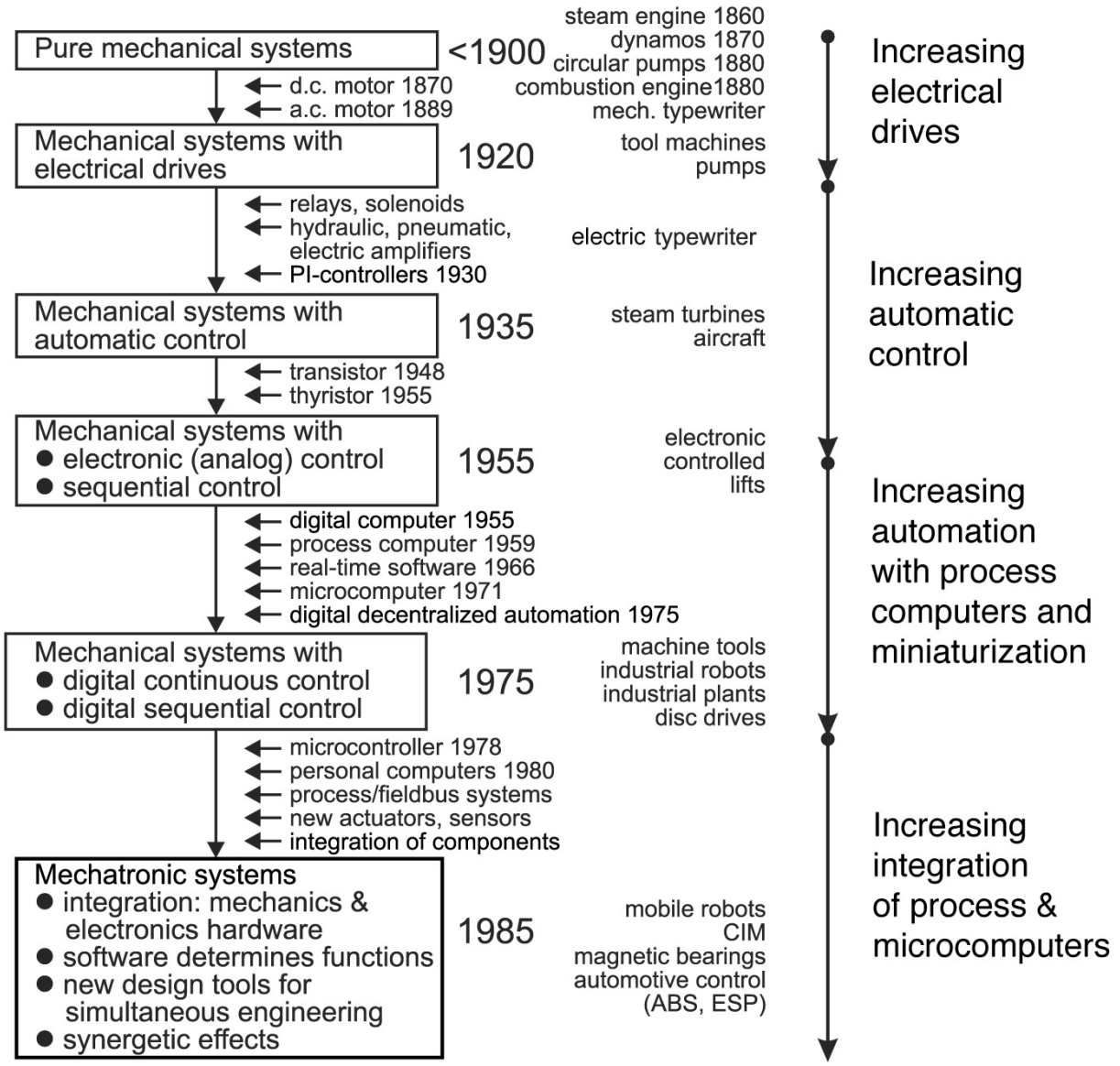
A mechatronics engineer combines the principles of mechanics, electronics, and computing to generate a simpler, more economical and reliable system.

The term "mechatronics" was coined by Tetsuro Mori, the senior engineer of the Japanese company Yaskawa in 1969.



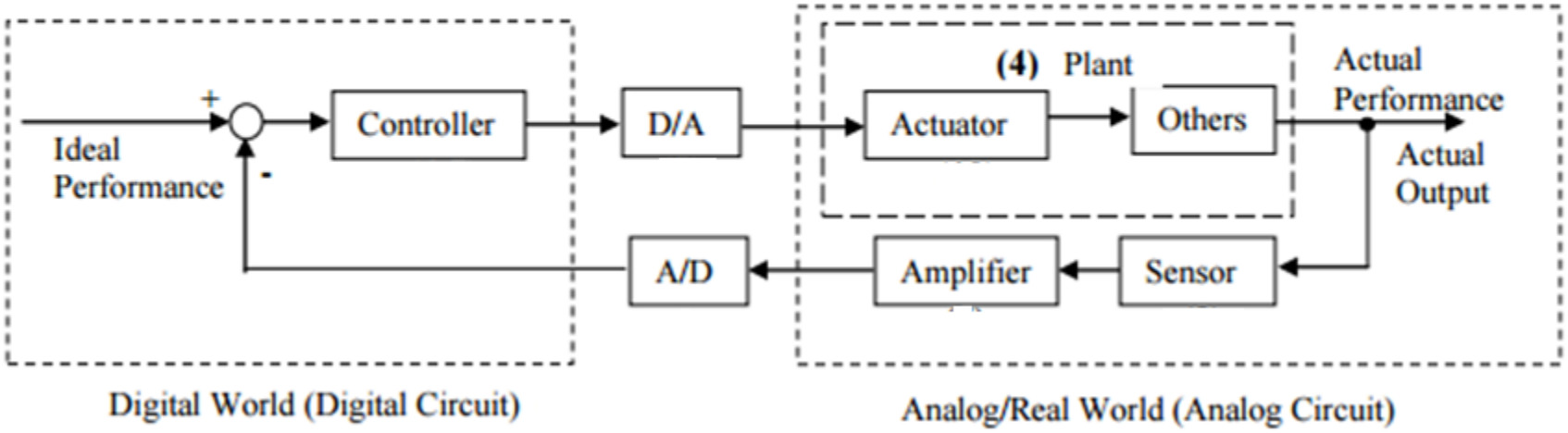
An example of a Mechatronics System-PR2 from Willow Garage

History


Pure mechanical systems
<1900
steam engine 1860
dynamos 1870
circular pumps 1880
combustion engine1880
mech. typewriter
d.c. motor 1870
a.c. motor 1889
Mechanical systems with electrical drives
1920
tool machines
pumps
relays, solenoids
hydraulic, pneumatic, electric amplifiers
PI-controllers 1930
electric typewriter
Mechanical systems with automatic control
1935
steam turbines
aircraft
transistor 1948
thyristor 1955
Mechanical systems with
● electronic (analog) control
● sequential control
1955
electronic controlled lifts
digital computer 1955
process computer 1959
real-time software 1966
microcomputer 1971
digital decentralized automation 1975
Mechanical systems with
● digital continuous control
● digital sequential control
1975
machine tools
industrial robots
industrial plants
disc drives
microcontroller 1978
personal computers 1980
process/fieldbus systems
new actuators, sensors
integration of components
Mechatronic systems
● integration: mechanics & electronics hardware
● software determines functions
● new design tools for simultaneous engineering
● synergetic effects
1985
mobile robots
CIM
magnetic bearings
automotive control
(ABS, ESP)
Increasing electrical drives
Increasing automatic control
Increasing automation with process computers and miniaturization
Increasing integration of process & microcomputers

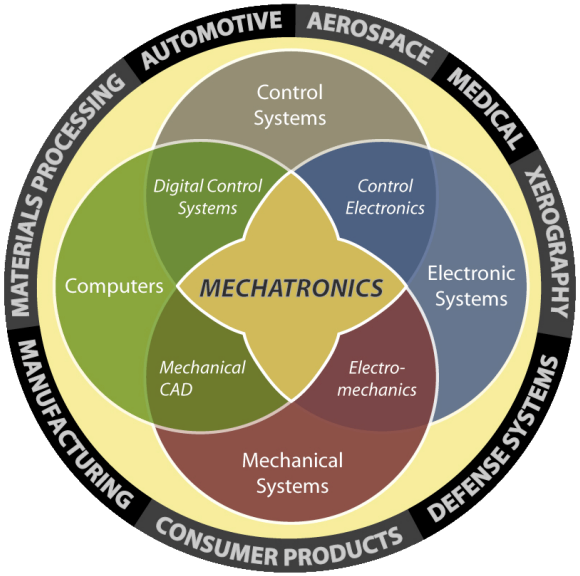
A Typical Mechatronic System

A Mechatronic system can do things that we want it to do (e.g., a copy machine, a refrigerator, an air-conditioner, etc.)

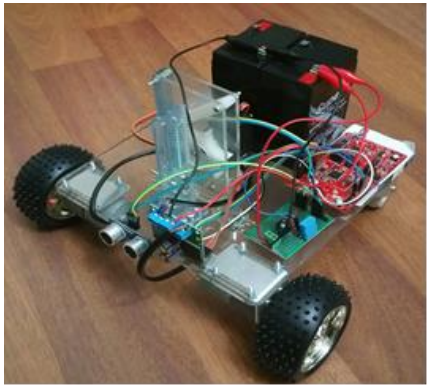


http://www.engr.sjsu.edu/wdu/ME106Spring2010/LectureNotes/Lecture1Summary.pdf

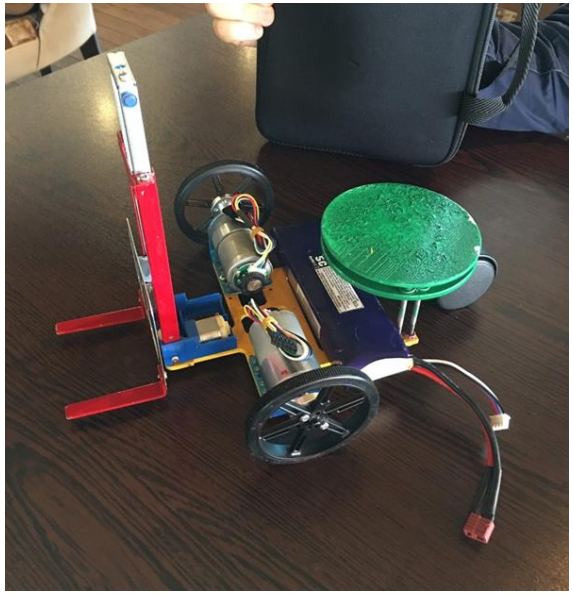
Micro to Macro Applications of Mechatronics



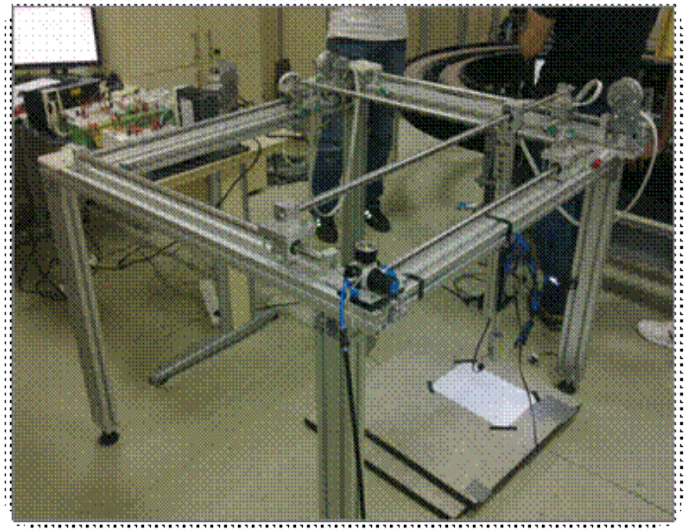
A Few Mechatronic System Examples from MKM512 (Mekatronik Sistem Tasarımı) Lecture



Autonomous Agriculture Robot

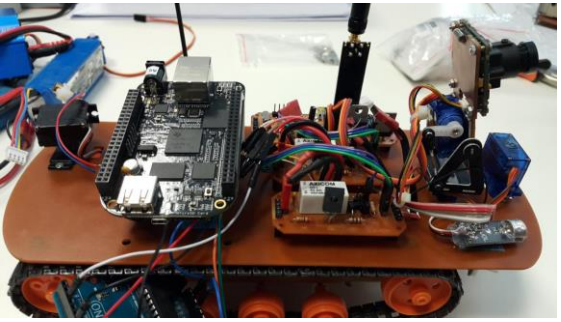


Autonomous Forklift

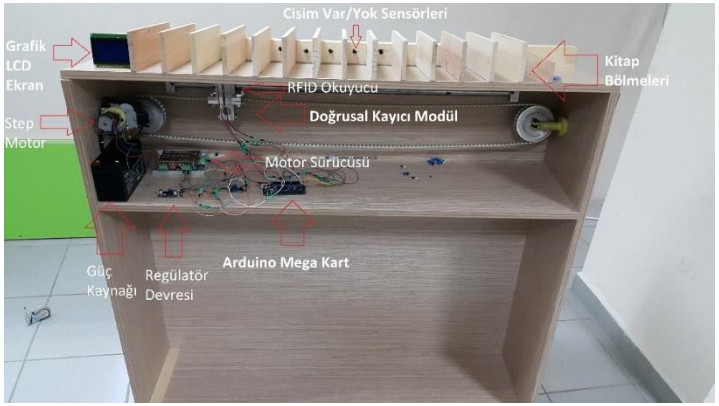


3-Axis Cartesian Robot

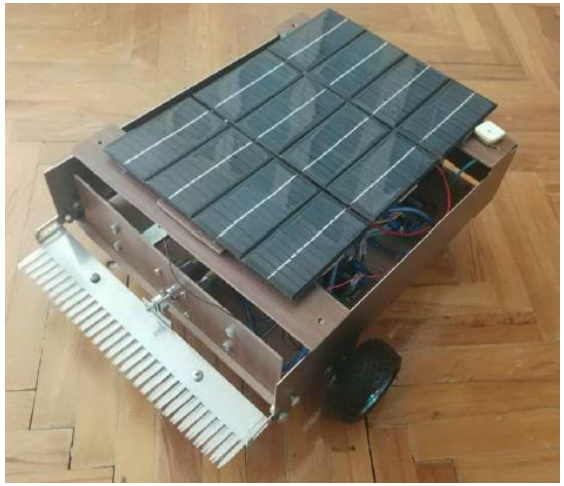
A Few Mechatronic System Examples from MKM512 (Mekatronik Sistem Tasarımı) Lecture



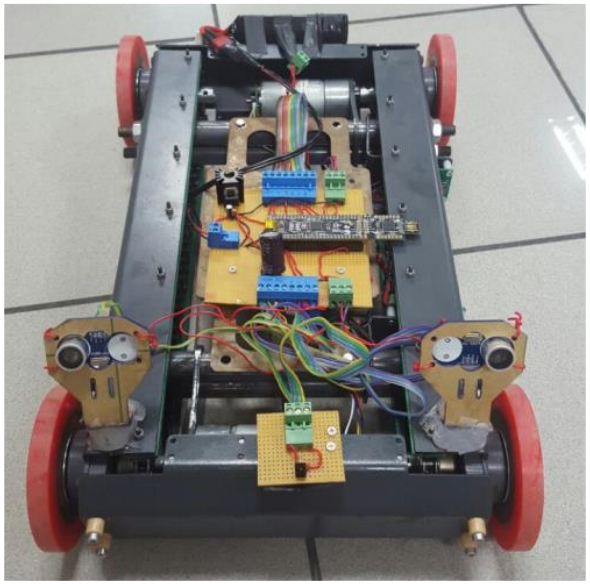
Semi Autonomous Tank



Library Assistance Robot

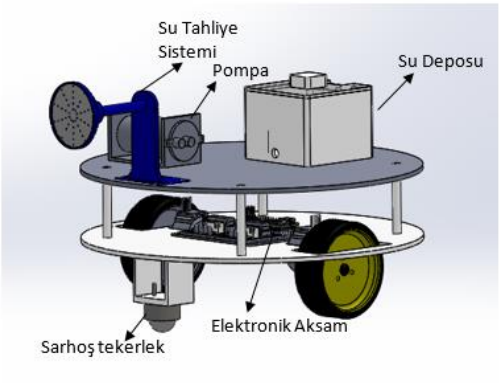


Autonomous Lawnmover

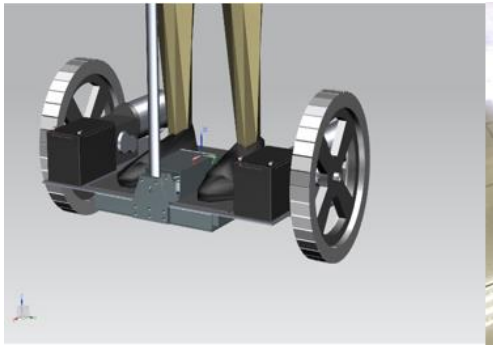


Tracker Robot

A Few Mechatronic System Examples from MKM512 (Mekatronik Sistem Tasarımı) Lecture



Autonomous fire fighting robot



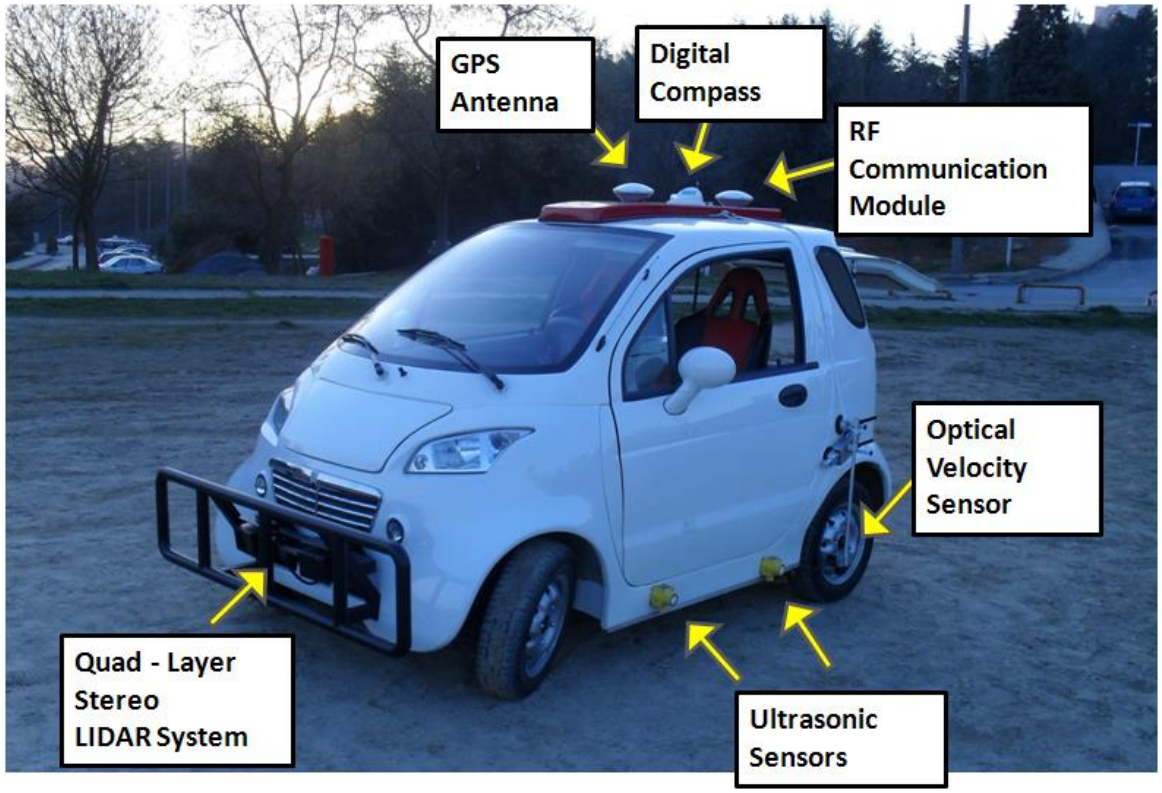
Segway

Autonomous Perfume Producer

A Few Mechatronic System Examples from MKM512 (Mekatronik Sistem Tasarımı) Lecture

https://youtu.be/xMmQwWaBua8

Components of ITU's Autonomous Vehicle (Otonobil)



Components of ITU's Autonomous Vehicle (Otonobil)

Sensors

Measurement of vehicle states (speed, acceleration, position, heading..) and surrounding features (obstacles, road properties ..).

Processing System

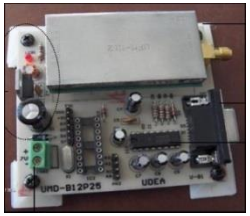
•Processing of the data that come from sensors for localization and mapping.
•Planning the trajectory in order to achieve the goal position for the vehicle.
• Controlling the vehicle for trajectory tracking.

Actuators –Controllers

•Actuating the vehicle inputs such as steering wheel and pedals. These actuators have also their own controllers for communication and driving the motors.

Communication

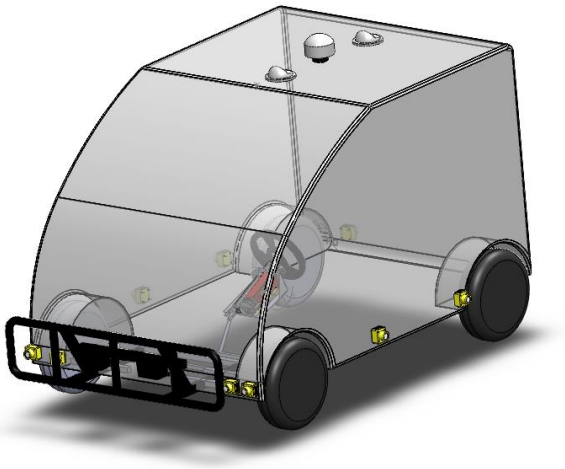
•Out Vehicle: Receiving the commands (goal coordinates, emergency stop..) from a remote computer. Sending the important data (speed, position, state of battery..) from vehicle
•In Vehicle: Different information sources (sensors, computers..) must communicate in vehicle.

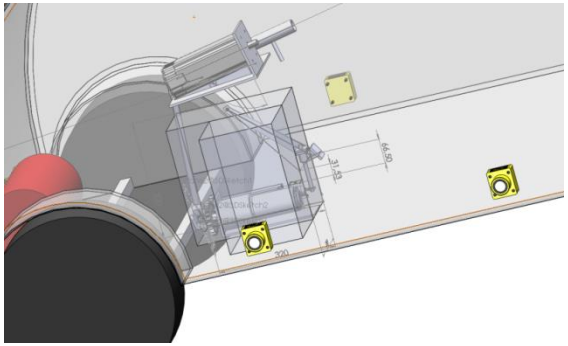


Components of ITU's Autonomous Vehicle (Otonobil)

Using Computer Environment in Mechanical Design Process

Basic measurements, consisting of simple dimensions of the vehicle help to build a CAD model of the vehicle

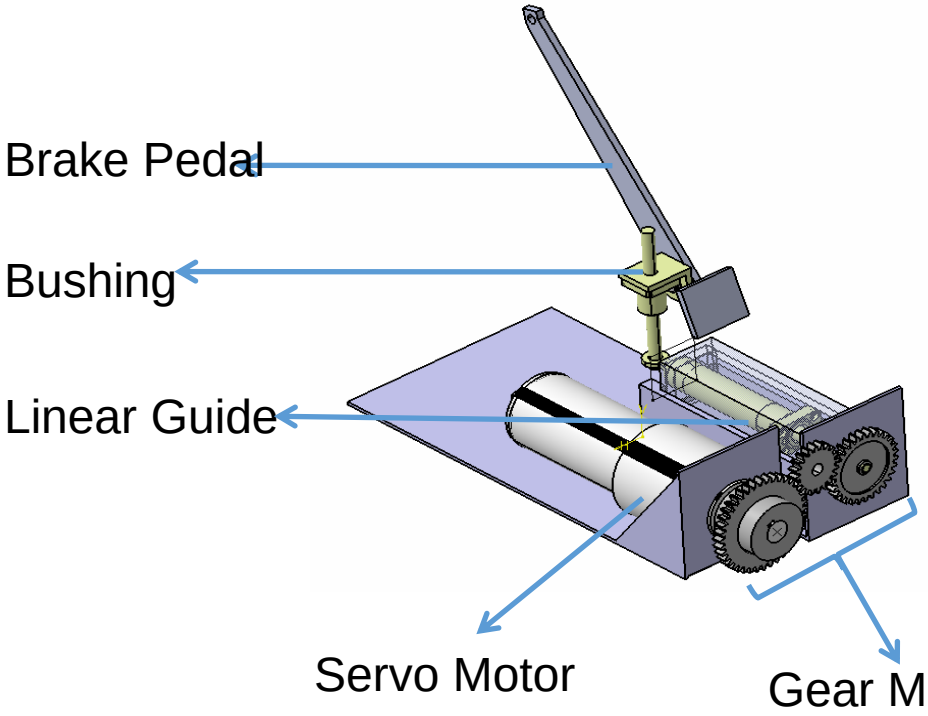


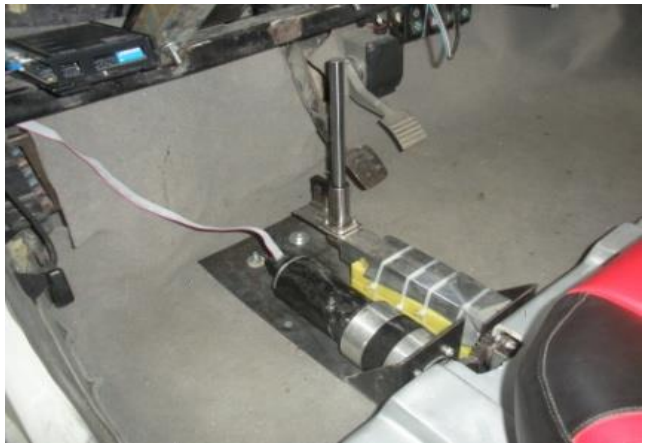


Components of ITU's Autonomous Vehicle (Otonobil)

Braking Mechanism

The system below is designed to actuate brake pedal of the





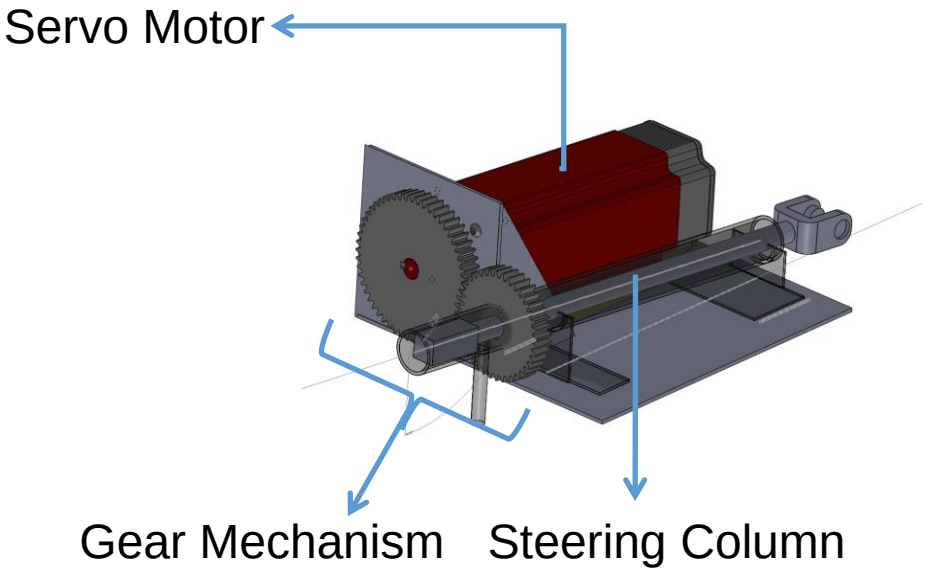
Real System

Vehicle can autonomously brake with this mechanism.

Mechanical Modifications

Steering Mechanism Design

The system below is designed to actuate steering wheel of the vehicle

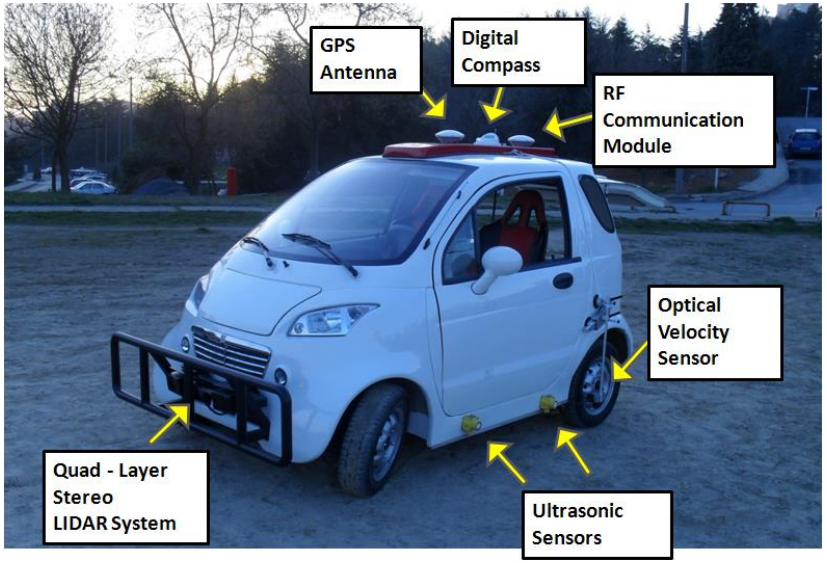


Real System

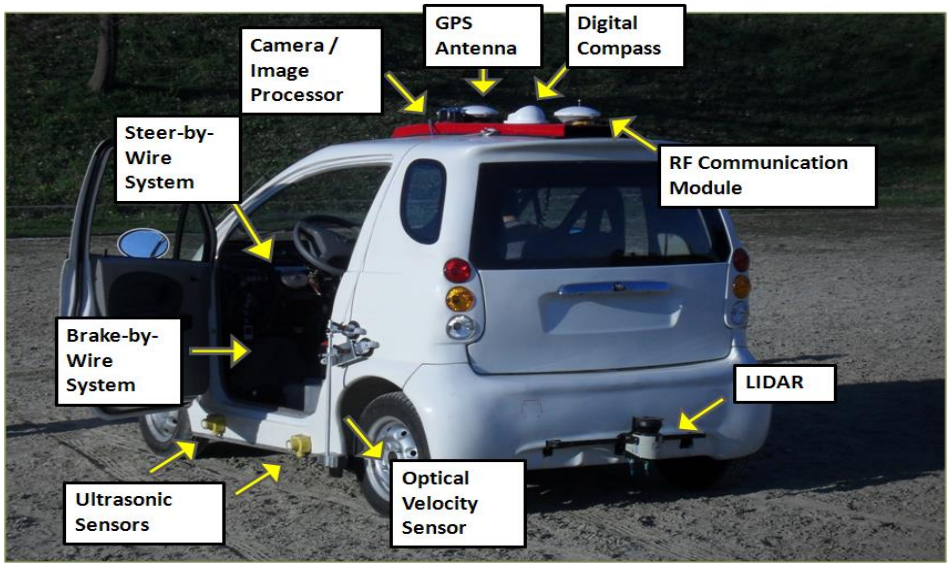
Vehicle can autonomously steer with this mechanism.

Components of ITU's Autonomous Vehicle (Otonobil)

Sensors and Computers



Otonobil-Front View



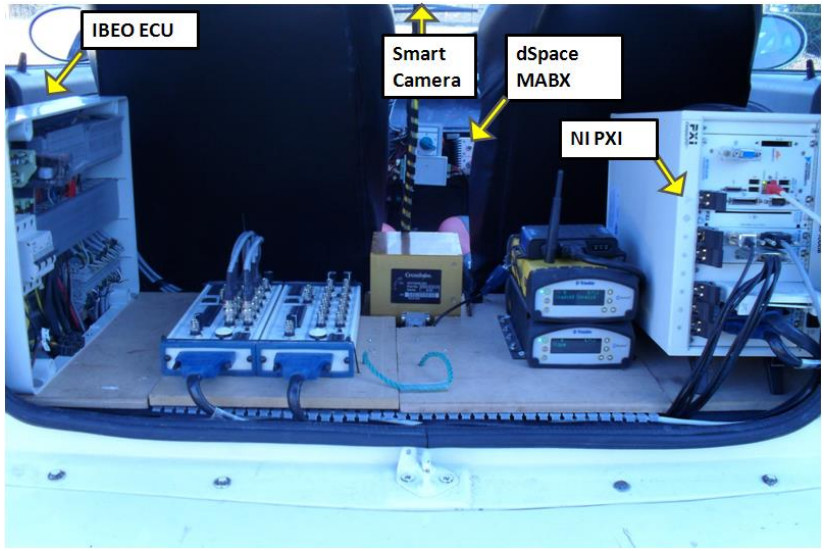
Otonobil-Rear View

Sensor Type	Quantity	Brand/Model
Laser Scanner	2	IBEO-LUX
Laser Scanner	1	SICK LMS 151
Camera	1	SONY-XCI-SX100
Ultrasonic Sensor	6	Banner-QT50ULB
Differential GPS	1	Trimble SPS851-SPS551H
Digital Compass	1	KVH Azimuth1000
IMU	1	Crossbow VG700AB-201
Optic Speed Sensor	1	Corsys-Datron LF II P
Potentiometer for Steering Wheel Position	1	Spectrol(5 kOhm)

Sensor List of Otonobil for State Estimation and Mapping

Components of ITU's Autonomous Vehicle (Otonobil)

Sensors and Computers



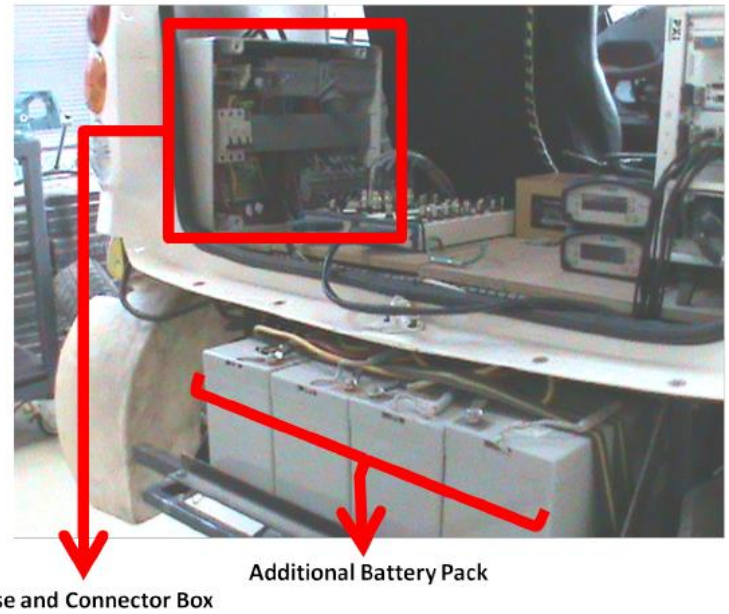
Rear Luggage of the Vehicle

Computer	Description	Duty
NI PXI-8110RT processor PXI-7954R FPGA module on PXI1000B chassis	It has 2.26Ghz quad-core processor and a powerful FPGA module with several I/O cards.	Localization, mapping and global path planning
Dspace Microautobox (MABX) 1401 /1501 /1507	It has 800Mhz processor and several I/O interfaces.	Local Trajectory Planning and tracking, low level control (throttle, steering, brake), wireless communication
SONY-XCI-SX100	It is a smart camera, which can process images with its own processor and sends processed data via UDP/IP.	Image Processing
IBEO ECU	It can give both object and raw data. It has tracking algorithms inside and can classify the objects around it.	LIDAR Data Processing

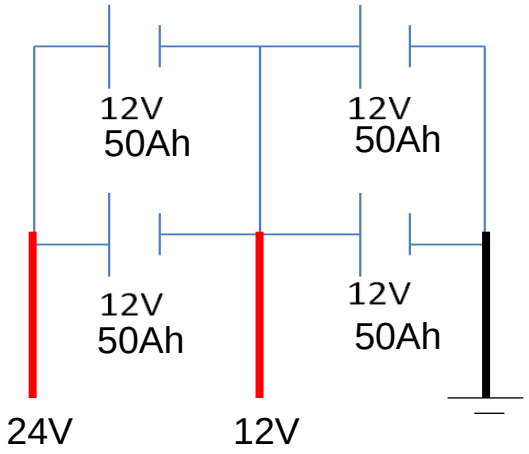
Computational Components of Otonobil

Components of ITU's Autonomous Vehicle (Otonobil)

Additional Power System



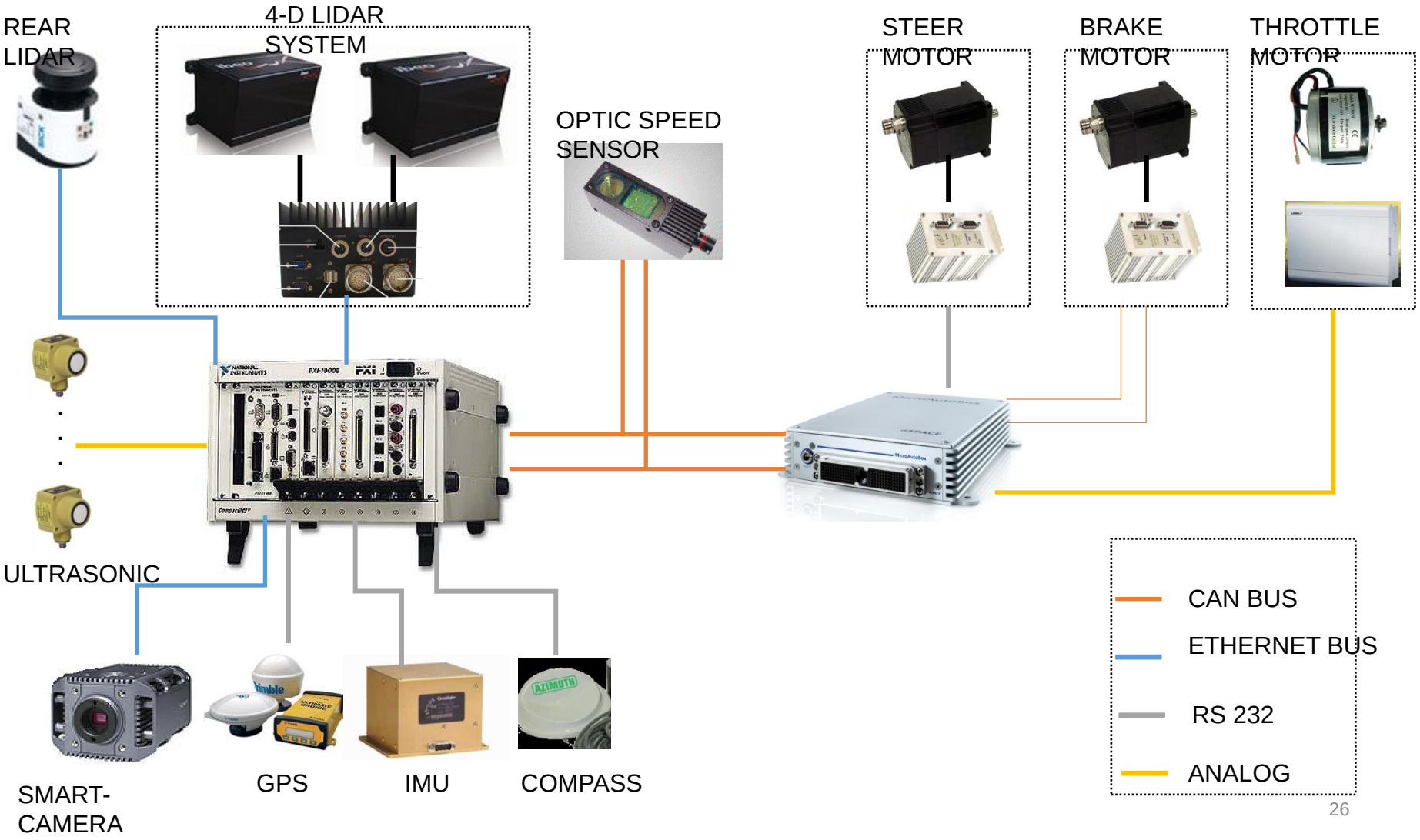
4 piece of 12V/50Ah lead-acid batteries are used by connecting them serial and parallel



This provides 8 hour uninterruptible operation

Components of ITU's Autonomous Vehicle (Otonobil)

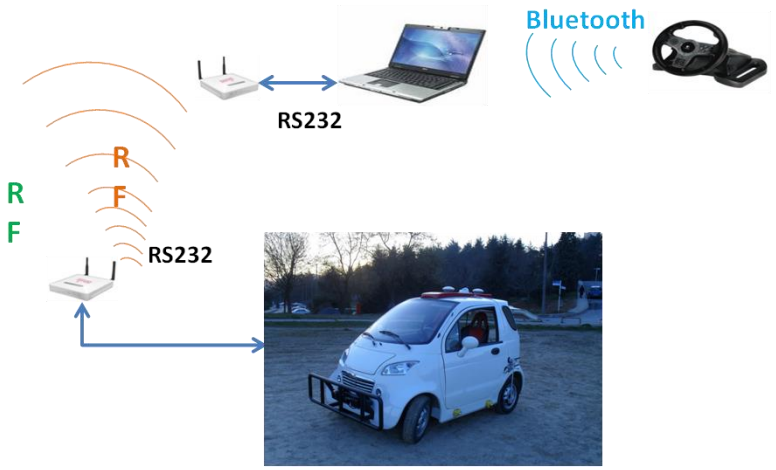
Communication and Interface (In-vehicle)



Components of ITU's Autonomous Vehicle (Otonobil)

Communication and Interface(Out-Vehicle)

Interface Software

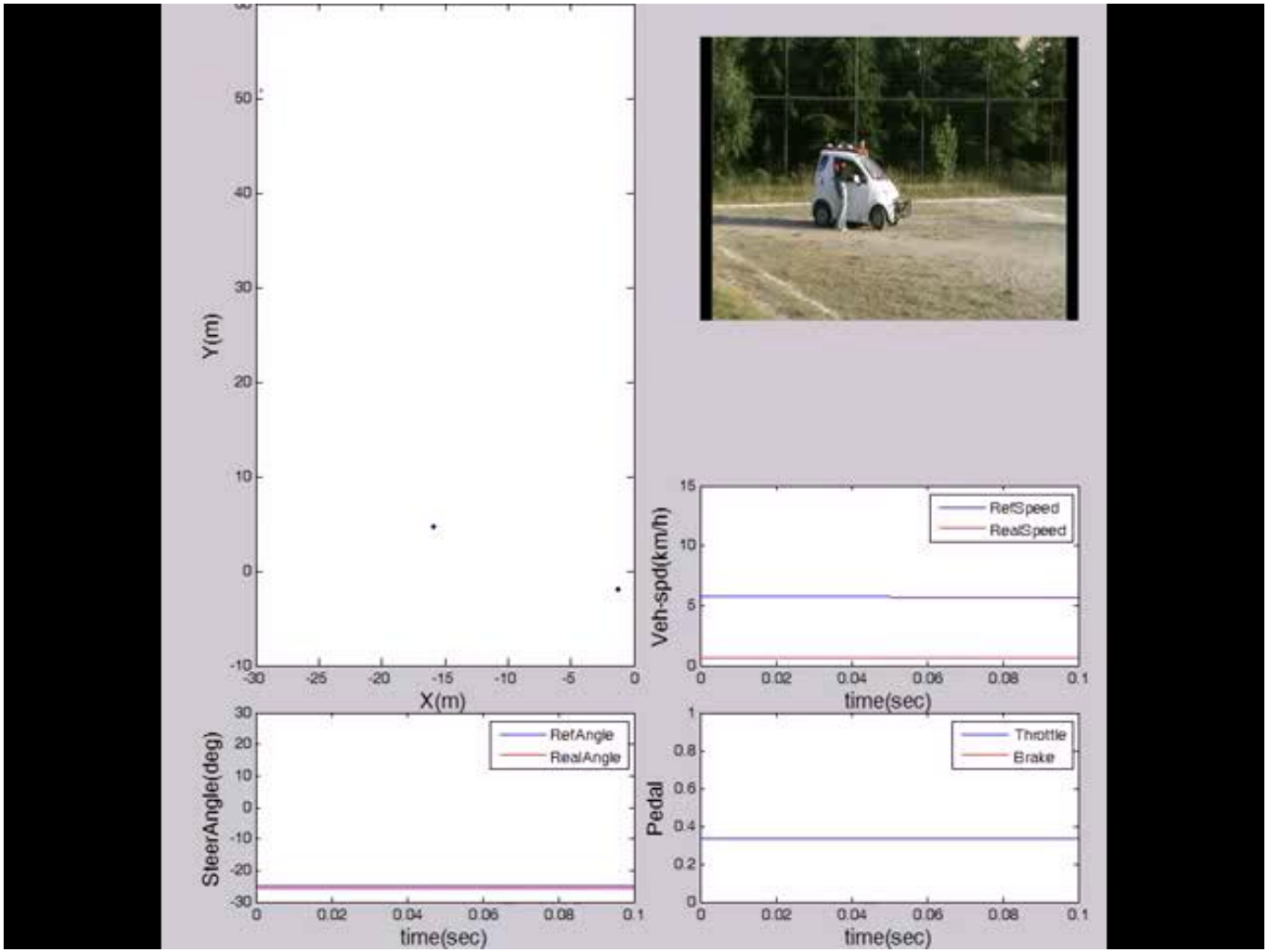


Communication Scheme

Three modes can be selected using software

- Driver Mode
- Remote Control Mode
- Autonomous Mode

Components of ITU's Autonomous Vehicle (Otonobil)



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Components of a Domestic Logistic Robot

Chassis

Specific Gears

Ball Screw Mechanism

Damper

Spring

Wheels

Electrical Motors

Motor Drivers

Wheel Encoders

Embedded Controller

High Level Computer

Camera

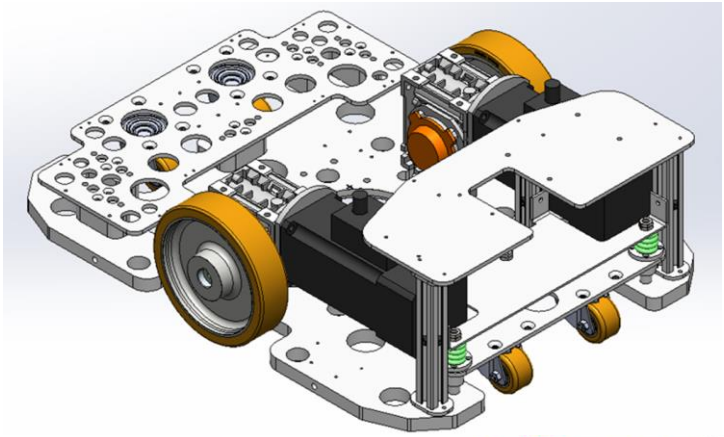
Wi-fi Router

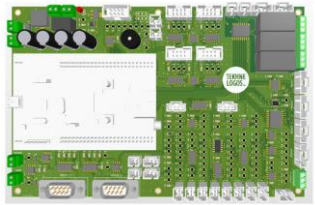
Battery

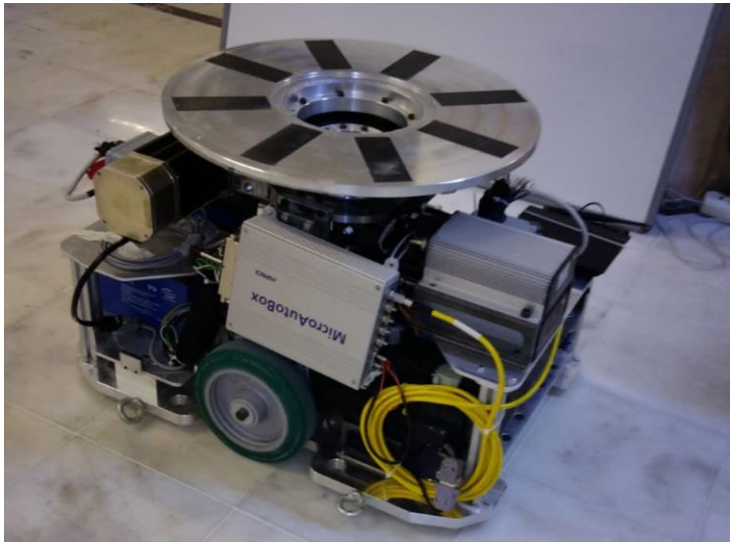
Power Electronics

Infrared/Ultrasound/Lidar Sensors

….







Components of a Domestic Logistic Robot

Components of a Domestic Logistic Robot

Components of a Domestic Logistic Robot

Components of a Semi-Autonomous Wheelchair

Chassis

Specific Gears

Spring

Wheels

Electrical Motors

Motor Drivers

Wheel Encoders

Embedded Controller

High Level Computer

Battery

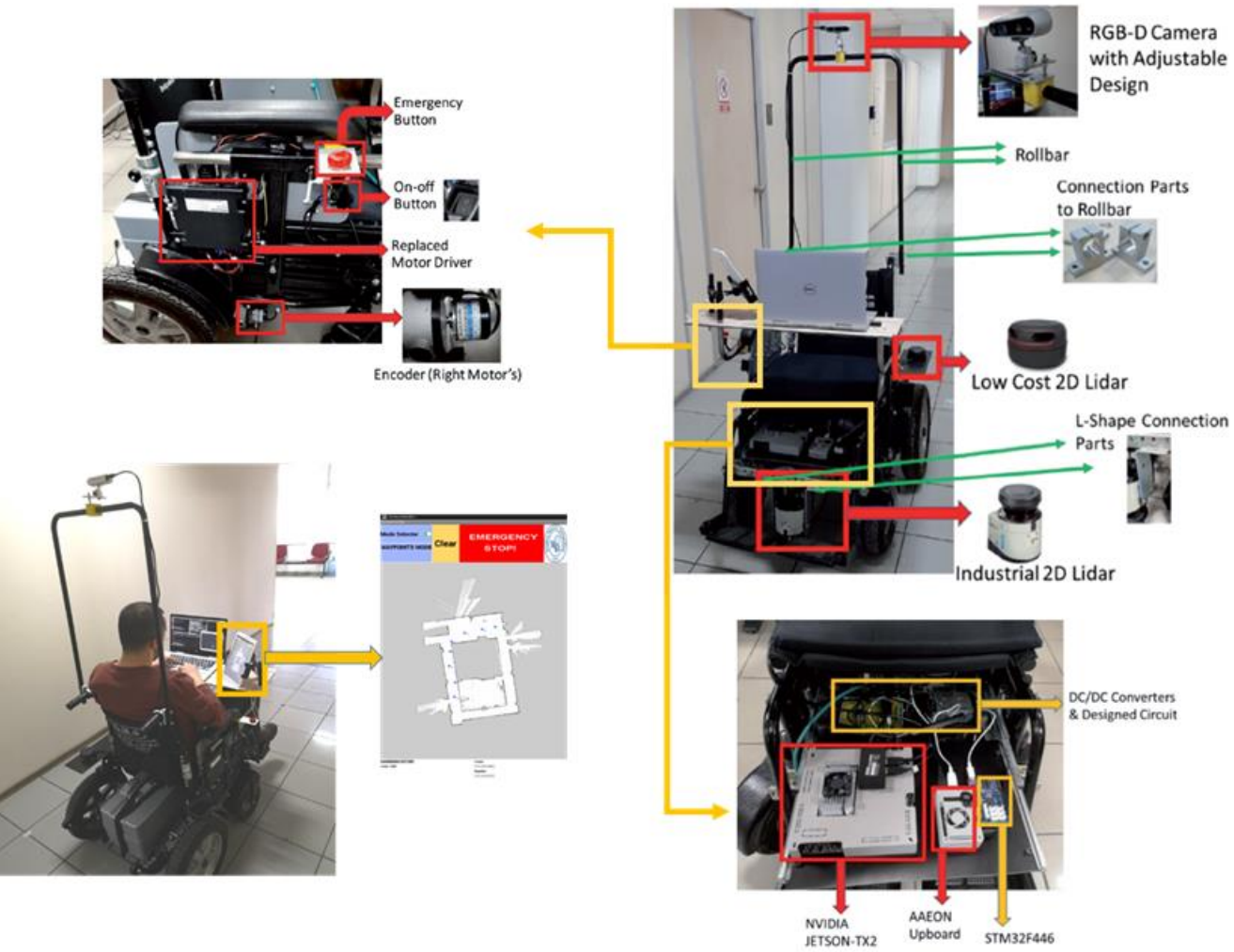
Lidar Sensor

Accelerometer

….

Components of a Semi-Autonomous Wheelchair

Components of a Fully Autonomous Wheelchair



Chassis

Specific Gears

Spring

Wheels

Electrical Motors

Motor Drivers

Wheel Encoders

Embedded Controller

High Level Computer

Battery

DC/DC Converter

Industrial Lidar

Low-Cost Lidar

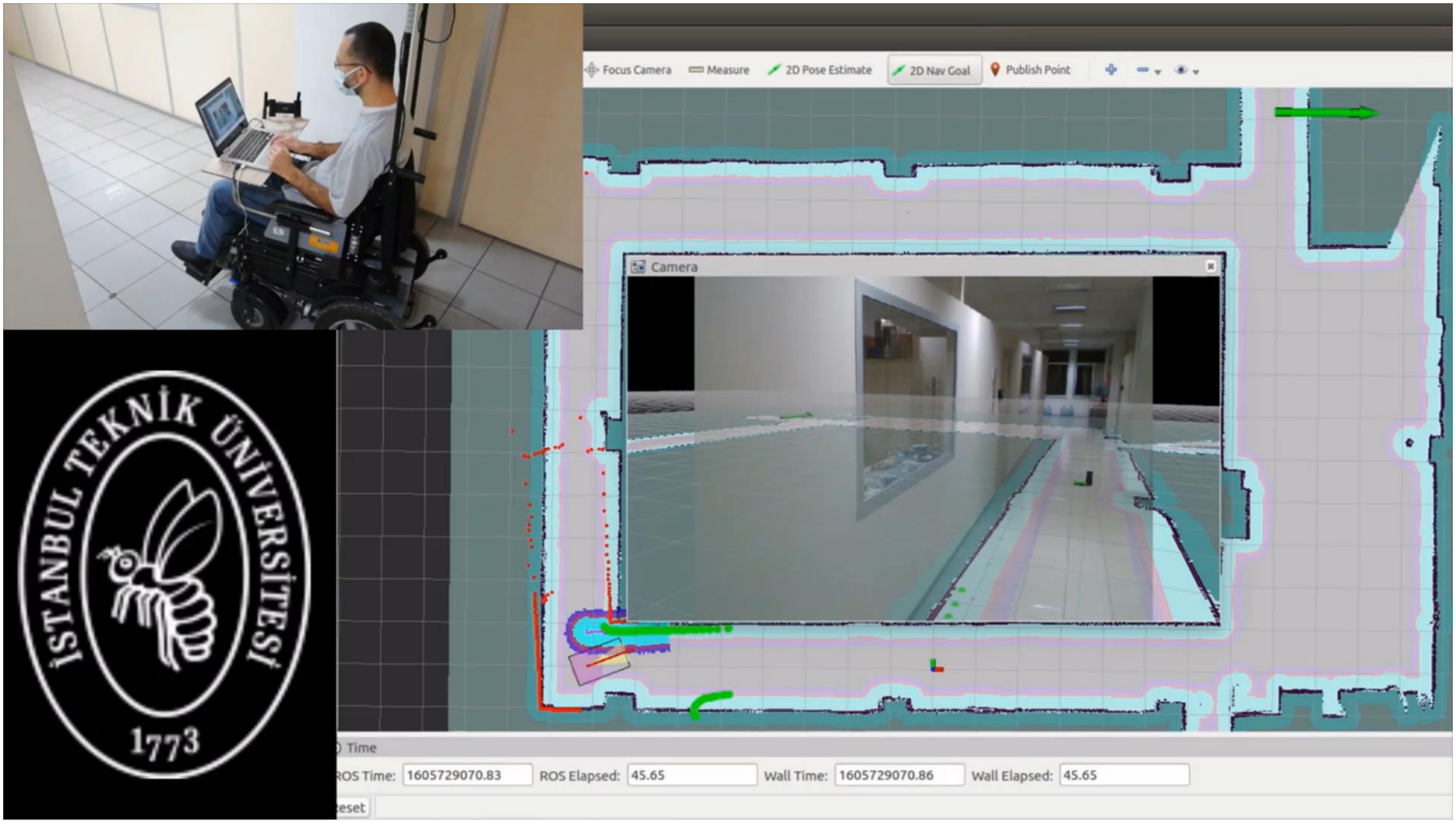
Rollbar

Emergency Button

Tablet

RGB-D Camera….

Components of a Fully Autonomous Wheelchair



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