HANDS-ON INTERVENTION:
Vehicle-Manipulator Systems

Universitat de Girona

IFRoS

MIRS

The Project
Conceptual design phase

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Introduction

In this phase of the project students will design the solution based on the presented specification. It is also a time for deep understanding of the functioning of the robot's software and hardware architecture, to be able to discover the possibilities and the necessary developments. The following outputs are expected from each group:

	Task description	Pts
A	A high level block diagram of robot hardware architecture, including: the mechanical structure, the actuators, the sensors, and the compute unit.	2
B	A detailed block diagram of the software architecture used in the robot simulation setup.	4
C	A detailed functional block diagram of the designed kinematic control system, including: all necessary components of the control system, interfacing with robot architecture, inputs, outputs, message types.	8
D	Symbolic derivation of the forward and inverse kinematics of the experimental system.	6

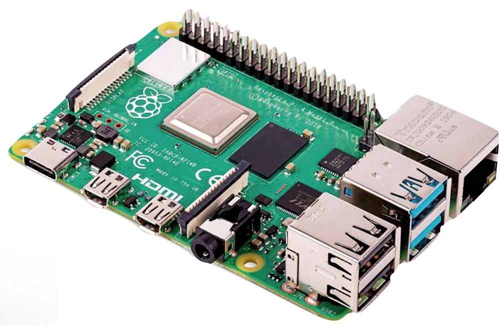
All of the block diagrams have to be prepared in an easily editable form to allow for discussion and correction by the teacher, e.g., using diagrams.net or gitmind.com. The symbolic derivations have to be documented using word processor's formula editor or LaTeX.

A. Hardware architecture

The students are required to provide a block diagram presenting the hardware architecture of the robot at the component level (see list below). Each of the components have to be properly connected (communication interfaces and power supplies) with other components and their crucial specification has to be included in the block diagram. The Turtlebot 2 internal component structure should also be included, i.e., motors, compute units, batteries etc. The aforementioned device specifications can be discovered on the manufacturers' websites, following the model numbers. Depending on the device type the students have to decide what can be considered as the most important parameters.

The following table lists the devices used to build the robot, their power requirements and the communication interfaces. The students should check the specifications of the Turtlebot 2, to discover the available power resources and how they can be utilised to supply the rest of the devices. The embedded computer (RPI) is used to run the Ubuntu Server operating system as well as control all other devices.

	Component
1	Kobuki Turtlebot 2
2	Raspberry Pi 4B
3	uFactory uArm SwiftPro
4	Intel RealSense D435i
5	RPLidar A2
6	Wireless router GL iNet GL-AR300M16
7	DC/DC switching voltage regulator: input: 12VDC -> output: 5VDC, 3A
8	Battery Lithium-Ion (Li-Ion) 4S4P



B. Software architecture (simulation)

The students are required to provide a block diagram presenting the software architecture of the simulation setup prepared for the robotic platform, including the utilised tools, nodes. Moreover, the diagram should include all the ROS interconnections and services available. To discover the structure of the system it is suggested to use standard ROS tools, i.e., rostopic, rosservice, rqt_graph.

Packages necessary for simulation (not including dependencies):
- kobuki_description
- swiftpro_description
- turtlebot_description
- turtlebot_simulation
- stonefish_ros

The software architecture has to be analysed when the simulation is started using:
roslaunch turtlebot_simulation turtlebot_hoi.launch

C. Control architecture (design)

The students are required to present a block diagram presenting the concept of the control system designed to complete the tasks required in the implementation phase. All of the functional blocks, with respective inputs and outputs should be included. This schematic will be used in the implementation phase to structure the code into nodes, classes and functions.

D. Forward and inverse kinematics

The students are required to prepare a symbolic derivation of the kinematics of the utilised mobile manipulator followed by the symbolic derivation of its Jacobian matrix. This step is necessary to implement the kinematic control algorithms. Dimensions of the base of the robot and the manipulator structure are presented below. Both systems are presented in the "zero" state (joint angles equal to 0).