

## Furniture technology – Robotics and Mechatronics

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### 1 Industrial robotics

#### Part I

- Give some examples of situations where robotics might help. Which would be the advantages?
- What is a robot? What can it do? What are the advantages/disadvantages?
- What are the main constituents of an industrial robot?
- What is a robotic system made of?
- What are the parameters that describe the performance of an industrial robot?
- Main types of industrial robotic manipulators?

#### Part II

- What is a mechanism?
- What is a kinematic pair?
- What is a degree of freedom?
- Class of a kinematic pair? Examples?
- Mobility formula and what is its purpose?
- Examples of mechanisms and their mobility.
- Special cases (hidden joints and redundant constraints)
- What is a Gough-Stewart platform?

#### Part III

- What is kinematics, kinematic analysis?
- What is the loop closure equation?
- Difference between direct and inverse kinematics and an example each.
- Set-up of the problem of solving an open-chain direct kinematics.
- Same thing for closed-chain.
- Inverse kinematics problem setup in open-chain and closed-chain. Example with a Cartesian robot.
- Orientation in the 2D and 3D spaces.
- What is the pose of a robot?
- What is workspace, joint space and are other kinds of workspaces?
- What is a redundant robotic system?
- What is a singular configuration?

#### Part IV

- What is path-planning and what are the main types?
- Point-to-point motions.
- Difference between a trajectory or path in the workspace and in joint-space.
- Speed profile in industrial robots.
- Open and closed loop controls.
- Control at actuator level.
- Admittance and impedance control.
- Path teaching and hand-guiding, characteristics and applications.

## Part V

- Give the description of a robotic system in terms of the machine and its controller.
- What is an actuator? What are its main components?
- How does backlash affect a robotic joint?
- Operating principle of a harmonic drive.
- What is a robot controller?
- How can the hierarchy of a controller be described? In terms of modules and levels.
- How would you program a robot to perform a simple pick and place operation?
- What is the end-effector? What are the main tools?
- How can we classify grippers?
- How would you pick up a wood panel? And a dowel pin?
- Give some examples of tools other than grippers.
- What does a painting robot consist of?

## 2 Collaborative robotics

- What is a collaborative robot?
- How do we define risk? How can we calculate it, in broad terms?
- What are the main contributors to risk?
- What are the general strategies to risk reduction in industrial robotics?
- What are safeguards? Examples and issues?
- How do we reduce the hazard associated with an industrial robot? What steps can we make?
- Is force limitation by itself a good approach with respect to safety? Why?
- What is the most important aspect for safety?
- What is intent signaling?

## 3 Mobile robotics

### Part I

- How would you describe a mobile robot?
- Give some examples of fields of application of a mobile robot, AGV or rover.
- What is the difference between an industrial AGV and a rover?
- How can we summarize the problem of mobile robotics and what are the main constraints?
- What are the main types of motion for mobile robots?
- What are the main wheel types?
- Give some examples of wheels' configurations for mobile robots.
- How is the kinematics of a fixed/steered wheel modeled?
- What is the center of instantaneous rotation for a mobile robot?
- What are the main constraints for a differential drive/bicycle/4-wheel/etc. mobile robot? Which of these are redundant?
- How is the configuration space of a robot defined?
- What is a holonomic constraint (in broad terms) and what relation does it have with a mobile robot?
- How is the accessibility of the configuration space of a non-holonomic system?
- How do omniwheels and mecanum wheels work?

- What is the main constraint we use to determine the model for a wheeled system?
- Control strategies for heading in case of a bicycle, a differential steering and an omnidirectional robot.

## **Part II**

- What type of sensors does a mobile robot employ, in the most general classification?
- What does a proprioceptive sensor measure? And an exteroceptive?
- What are distance sensors and how are they used for mobile robots? What are the main advantages?
- What is a laser scanner and how does mapping with a LiDAR work?
- In which case would you choose a vision system sensing approach vs. laser scanning?
- What is environment mapping and what are the main characteristics?
- What is the definition of the problem of navigation?
- How do we classify the sources used for position determination?
- What is odometry, in broad terms? How is it related to sensing and what is its main drawback?
- What is SLAM?
- What are the main approaches in path planning in mobile robotics?
- How can the possible paths be described in an efficient way?
- What is a grid-based search approach? And an edge visibility graph?
- What is the main principle behind potential fields path-planning and what are the main issues?
- How does terrain geometry affect mobile robots?