Examination Robotics and Manufacturing Automation MPR213, 2021-05-31

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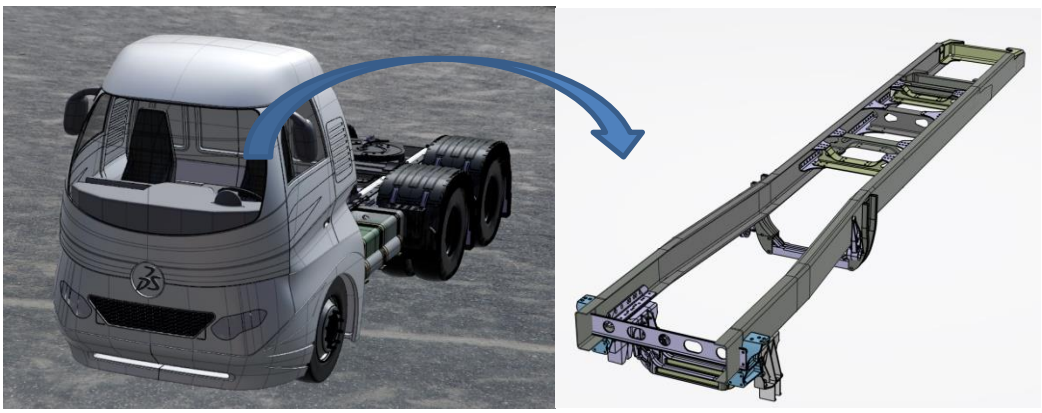
Special rules about auxiliary means, proctoring etc are applied which all students should be aware of.

Evaluation of the examination will be carried out as normal but remotely/digitally.

Grades: 30-39p = 3 40-49p = 4 50-60p = 5

1. You are a tooling designer at a Heavy Duty Trucks Company. They are about to launch a new generation of trucks. They will produce 300 prototypes before launching full production. You have been assigned the mission to design fixtures for the framing structure (see picture) of a prototype series of the truck.



   a) What is important to consider when designing fixtures according to Herman Pollack? What will probably happen if you do not consider the rules from Pollack? A detailed description is required.
   b) Given the rather low number of products to build, what tooling strategy would you choose in selecting a solution based on this scenario. Explain in detail your reasoning. Keywords: Conventional Tooling, Modular Tooling, Flexible Tooling. Elaborate your answer. 6p

2. You are responsible for automation of a ship building company. You have been given the responsibility to deploy industrial robots in a new ship building project.

   a) What type of robots are most likely to be used in such industry and why? Elaborate your answer.
   b) Ships are produced from many steel plates. Each assembly is unique. This will require a lot of programming hours to use robots. Have you any suggestions how to increase the abstraction level? Elaborate your answer. 6p

3. What was the name of the first industrial robot that hit the market? Who were the first customer and why did they deploy industrial robots in their production? 3p

4. What is the purpose of the wrist in an industrial robot? 1p

5. Dr. Robert Bohlin talked about IMMA. What is that? 1p

6. Bertil Thorvaldsson talked about the Gartner Hype Cycle. What is that? 1p

7. Bertil Thorvaldsson talked about the Google Glass. Why wasn't that a hit? 1p

8. What is Motoman and what is Yaskawa? 1p

9. What is field of mechatronics according to Robin Lindor? 1p

10. What was their purpose of using lasers with robots at Prodtex AS according to Vegar Kobbevik? 1p

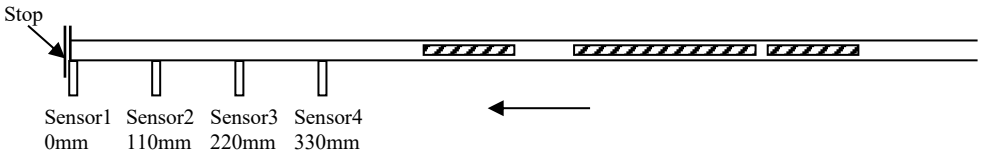
11. From what you have learned in MPR213, what are the most difficult challanges to deploy industrial robots and where are the major areas for further development the next 10 years? 4p

12. Explain in detail the different levels of collaboration? 2p

13. Why should one use collaborative robot applications over traditional robots in final assembly, explain in detail advantages and risks? 2p

14 You and the IBM robot in Chalmers Robotics Laboratory has been employed by a manufacturer from Gränna in order to sort peppermint rocks (candy bars). There are 4 different kinds and the only thing that makes them differ is the length of the bars: 100, 200, 300 and 400 mm.

The bars are transported to the robot on a narrow conveyor with a stop at the end (see figure and I/O below). They arrive randomly and in order to detect the different lengths there are 4 sensors positioned at certain distances from the stop of the conveyor: 0, 110, 220 and 330 mm according to the figure – note that the gap between the bars could be very small (zero).



Write an AML/E-program for the robot in order to carry out the described task - use CAPITAL letters and only the listed commands! 6p

Predefined subroutines (don't need to be declared):

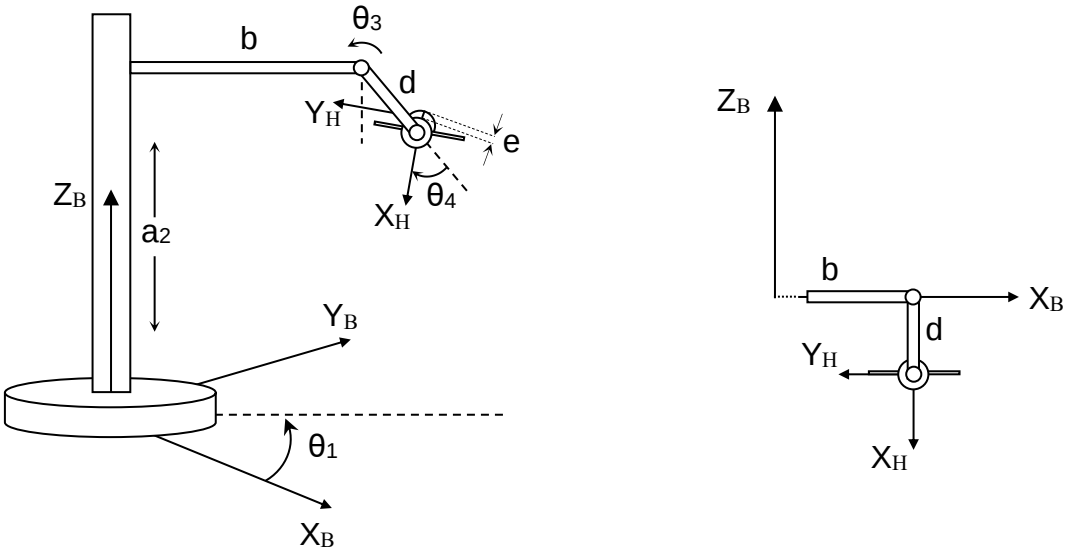
Routine call	Description
SORTROCK(LE);	The robot delivers the peppermint rock in the right package station. The parameter LE has to be an integer with the value 1-4, which corresponds to the length without zeros. The call SORTROCK(3) means that the robot delivers the peppermint rock in the package station for bars with the length 300mm.
PICKROCK;	The robot moves to a position "A" above the conveyor somewhere between Sensor1 and Sensor2. Then it moves straight down, grasps the bar and moves straight up to "A".

I/O

Signal	Description
Input 1	=1 if a peppermint rock covers Sensor1, =0 otherwise.
Input 2	=1 if a peppermint rock covers Sensor2, =0 otherwise.
Input 3	=1 if a peppermint rock covers Sensor3, =0 otherwise.
Input 4	=1 if a peppermint rock covers Sensor4, =0 otherwise.
Output 9	=1 starts the conveyor, =0 stops the conveyor

Available instructions and their syntax:

Command	Description
WRITEO(DO,VAL);	The output DO is set to the value VAL
TESTI(DI,VAL,HOPP);	Checks if an input (DI) has the value VAL, which results in a branch to HOPP. If the input does not have the value VAL, the next instruction is executed
WAITI(DI,VAL,TIMELIMIT);	The program waits for a digital input (**DI**) to equal a binary value. If the time limit is exceeded, the program execution will be terminated. Valid values: DI: 1-16 VAL: 0 or 1 TIMELIMIT: max 25.5 seconds Setting the TIMELIMIT to zero means infinite delay until the input equals the value
HOPP:;	Marks a branch label. It is only allowed to branch inside a subroutine
BRANCH(HOPP);	Unconditional branch to the label HOPP
NAME: SUBR(VAR,VAR1..);	Defines a subroutine with the name NAME and the variables with the names VAR,VAR1.. become local
END;	Marks the end of a subroutine



15 An entertainment park attraction ("AeroSpin", https://www.liseberg.com/rides-attractions/aerospin/) is slightly modified to become a robot and is described kinematically in the left figure above.

When the 4 joint variables $\theta_1 = a_2 = \theta_3 = \theta_4 = 0$ we have the situation in the right figure above. Link lengths are b, d and e which means that in the zero position TCP is located in (b, e, -d). The rotational joints positive rotation direction is indicated by the corresponding arrow.

a) Determine the homogeneous transformation matrix for the robot. 6p

b) Calculate the joint values for the TCS position: x = -e, y = $(b + \frac{d}{2})$, z = $(30 - \frac{\sqrt{3}}{2}d)$ with orientation EulerZYZ = (180°, 90°, -60°). 5p

Workspace: $0° \le \theta_1 < 360°$, $0m \le a_2 \le 30m$, $-45° \le \theta_3 \le 180°$, $-90° \le \theta_4 \le 90°$

16 The well known IBM7545 robot has the following Jacobian:

$$J = \begin{bmatrix} -(as_1 + bs_{12}) & -bs_{12} & 0 & 0 \\ ac_1 + bc_{12} & bc_{12} & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 1 & 1 & 0 & -1 \end{bmatrix}$$

$s_1 = \sin\theta_1$, $c_1 = \cos\theta_1$, $s_{12} = \sin(\theta_1+\theta_2)$, $c_{12} = \cos(\theta_1+\theta_2)$

θ_1 = value joint 1, θ_2 = value joint 2, **a** and **b** are the lengths of link 1 and 2 respectively.

a) Explain the details and purpose of the fourth row in the Jacobian above. Also explain why the values for the third prismatic joint $\mathbf{d_3}$ and the last rotational joint $\boldsymbol{\theta_4}$ are not present in the Jacobian 4p

b) Invert the Jacobian above and check if there are any singularities. 5p

----------Rotation matrices----------

$$\textbf{Rot}(x,\theta) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta \\ 0 & \sin\theta & \cos\theta \end{bmatrix} \quad \textbf{Rot}(y,\theta) = \begin{bmatrix} \cos\theta & 0 & \sin\theta \\ 0 & 1 & 0 \\ -\sin\theta & 0 & \cos\theta \end{bmatrix} \quad \textbf{Rot}(z,\theta) = \begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

17 NO QUESTION. Optional third lab exercise “Pathplanner”. Depending if you passed this lab exercise you will get additional points here. 4p