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THE OPEN UNIVERSITY OF SRI LANKA

FACULTY OF ENGINEERING TECHNOLOGY

BACHELOR OF TECHNOLOGY – LEVEL 06

FINAL EXAMINATION – 2009

MEX6271 – ROBOTICS

DATE : *30 MARCH 2010*
TIME : *1400HRS -1700HRS*
DURATION : *THREE HOURS*

PLEASE READ THE FOLLOWING INSTRUCTIONS BEFORE ANSWERING THE PAPER

INSTRUCTIONS:

1. *This paper consists of eight questions. Answer any **five questions only.***
2. *Each question carries equal marks.*
3. *Answers should be written on the answer books provided by the Examinations Division.*

Question 01

(1.1) Write down a definition for a Robot. What makes a robot different from other forms of automated devices?

(1.2) What distinguishes anthropomorphic robots from other forms of robots? Give examples and applications of the above-mentioned type of robots.

(1.3) Explain briefly, the main types of movement necessary for obtaining the desired motion in an industrial robot

(1.4) Briefly explain the main components of a robot manipulator system.

Question 02

(2.1) What are the main types of robot configurations found in robotics based on physical configuration? Briefly explain any two of the mentioned configurations.

(2.2) Taking suitable examples, distinguish between 'Effort Variables' and 'Flow Variables'.

(2.3) What are the three (03) types of variants in a revolute joint? Explain each of these variants by using a neat sketch.

(2.4) Describe TRL and TRR types of robots in the context of physical configuration of robotic manipulators. Discuss the advantages and disadvantages of each of the above-mentioned configurations

Question 03

(3.1) *Lead-through mode and Walk-through mode are two different methods commonly used in programming a robot.* Explain these two methods of programming.

(3.2) *Redundant manipulators are not commonly used in industrial applications.* Explain what is meant by a 'redundant manipulator' and elaborate on the above statement.

(3.3) Explain the term 'payload' with respect to a robots load carrying capacity. Why is the payload very much less than the robot's maximum load carrying capacity?

(3.4) Define the term 'dexterity' in the context of robot movement.

Question 04

(4.1) Using the standard notations find the representation of a point P described in frame {2}, with respect to a frame {1}. Note that frame {2} has been rotated about a fixed origin with respect to frame {1}.

(4.2) Explain the mathematical meaning of the term 'rotation matrix'.

(4.3) Using the answer obtained in (4.1) or otherwise, deduce the following relationships with regard to the rotation matrix $\mathbf{R}$

(a) $^{2}\mathbf{R}_{1} = \left[{}^{1}\mathbf{R}_{2}\right]^{T}$

(b) $^{2}\mathbf{R}_{1} = \left[{}^{1}\mathbf{R}_{2}\right]^{-1}$

Question 05

(5.1) A homogeneous coordinate vector is given by $\mathbf{A} = \begin{bmatrix}10 & -4 & 6 & 2\end{bmatrix}^{T}$. Find the Cartesian coordinate vector for the homogenous coordinate vector $\mathbf{A}$.

(5.2) Explain the mathematical meaning of the term 'basic homogenous matrix.

(5.3) Frame {2} is rotated with respect to frame {1} about the X-axis by an angle of 30^{0}. The position of the origin of frame {2} as seen from frame {1} is $^{1}\mathbf{D}_{2} = \begin{bmatrix}7.0 & 5.0 & 7.0\end{bmatrix}^{T}$.

(a) Obtain the transformation matrix $^{1}\mathbf{T}_{2}$

(b) Find the description of a point **P** in frame {1} if $^{2}\mathbf{P} = \begin{bmatrix}2.0 & 4.0 & 6.0\end{bmatrix}^{T}$

Question 06

(6.1) 'The rotational matrix $\mathbf{R}(\theta)$ which rotates a vector through some angle θ about a *k*-axis, is the same as the rotational transformation matrix, which describes any frame rotated by θ relative to the reference frame'. Comment on the statement using your knowledge in frame transformations.

(6.2) Consider the following transformations of a point **P** in 3-D space. The point P is rotated by an angle 45^0 about *z*-axis and then translated it by -1 unit along *x*-axis and -2 units along *z*-axis.

(a) Determine the new location of the point **P** after the transformations.

(b) Show the transformation of the vector pictorially.

Question 07

(7.1) Using first principles and standard notations prove the following relationship with regard to homogeneous transformations.

$$^2\mathbf{T}_1 = \left[{}^1\mathbf{T}_2\right]^{-1} = \left[\begin{array}{ccc|c} & {}^1\mathbf{R}^{\mathrm{T}}{}_2 & & -{}^1\mathbf{R}^{\mathrm{T}}{}_2\,{}^1\mathbf{D}_2 \\ \hline 0 & 0 & 0 & 1 \end{array}\right]$$

(7.2) Frame {2} is rotated with respect to frame {1} about the X-axis by an angle of 60^0. The position of the origin of frame {2} as seen from frame {1} is,

$^1\mathbf{D}_2 = \left[7.0 \quad 5.0 \quad 7.0\right]^{\mathrm{T}}$.

(a) Find the homogeneous transformation matrix which describes the position and orientation frame {2} relative to frame {1}.

(b) Using the relationship in (7.1) find the transformation matrix which describes the position and orientation of frame {1} relative to frame {2}

Question 08

(8.1) A frame is given two rotations, one about x-axis by 60^0 and one about y-axis by 45^0. Show that $\mathbf{R}_x\mathbf{R}_y \neq \mathbf{R}_y\mathbf{R}_x$ and explain the reasons for the result.

(8.2) Determine the orientation matrix for,

(a) ZXZ fixed angle rotations.

(b) ZXZ Euler angle rotations.

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