Ref. No. : Ex/PG/ETCE/T/128C/2018

M.E. ELECTRONICS AND TELE-COMMUNICATION ENGINEERING FIRST YEAR SECOND SEMESTER - 2018

Subject: **ROBOTICS & COMPUTER VISION** Time: 3 Hours Full Marks: 100

Answer ANY FOUR.

All parts of the same question must be answered at one place only.

1. (a) Find out the transformation matrix representing RPY orientation. 10

(b) Derive the decoupled equations of roll, pitch and yaw angles for a given final desired orientation. 10

(c) The desired final position and orientation of the hand of a Cartesian-RPY robot is given below. Find the necessary roll, pitch and yaw angles and displacements. 5

$$T = \begin{bmatrix} 0.354 & -0.674 & 0.649 & 4.33 \\ 0.505 & 0.722 & 0.475 & 2.50 \\ -0.788 & 0.160 & 0.595 & 8 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

2. (a) Define the rules for selection of axes in Denavit-Hartenberg scheme. 4

(b) Determine the homogeneity matrix to transform one body-attached frame to the next frame following Denavit-Hartenberg scheme. 12

(c) Define Jacobian with respect to differential motion of the hand frame of a robot. 3

(d) The order of multiplication of rotational matrices for differential motion is not important. Justify. 6

3. (a) Explain the difference between a differential operator and a transformation matrix. 6

(b) Derive the equations of motion of a two-link robot with I_i, m_i and l_i as the moment of inertia, mass and length of the i-th link for $i = \{1, 2\}$. 10

(c) For a general multi-axis robot with n links, derive the expression of Lagrangian. 9

4. (a) Prove that 12

$$\frac{d\vec{r}}{dt} = \frac{d^*\vec{r}}{dt} + \vec{\omega} \times \vec{r}$$

and hence derive $\frac{d^2\vec{r}}{dt^2}$ where the parameters have their usual meaning.

(b) For a two-link robot determine $\dot{\vec{v}}_i$ and for link $\dot{\vec{\omega}}_i$ i. 6

(c) The end-point gripper of a six-link robot needs to be moved from an initial angle of 30^0 to a final angle of 75^0 on a plane in 5 seconds. Using a third-order polynomial, calculate the joint angle, velocity, and acceleration at 1, 2, 3 and 4 seconds. 7

5. (a) Define projection of a binary image. 3

(b) How can you determine area and size of an object in an image using its projection? 2

(c) State and define one topographical feature of a binary image 2

(d) What is a connected component? 2

(e) Explain the sequential algorithm for labeling connected components of an image. 7

(f) How peaks and valleys are detected in a histogram to facilitate selection of threshold in mode-based thresholding technique? 6

(g) Explain the principle of adaptive thresholding to handle images of uneven illumination. 3

6. (a) What is primary limitation of histogram based approaches for thresholding? 2

(b) Name and illustrate a non-histogram based thresholding method. 6

(c) Find out the quad tree representation of the following object. 6

0	0	1	1	1	1	0	0
0	0	1	1	1	1	0	0
0	1	1	1	1	1	1	0
0	1	1	1	1	1	1	0
0	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1
1	1	0	0	0	0	1	1
1	1	0	0	0	0	1	1

(d) What is the disadvantage of a mean filter? How the shortcoming can be overcome by a median filter? 4

(e) An 8×8 image $f[i, j]$ has grey levels given by $f[i, j] = |i - j|$ for $i, j = 0, 1, \ldots, 7$. Find out the output image obtained by applying a 3×3 median filter on the image $f[i, j]$. The border pixels are to be kept unchanged. 7

7. (a) Explain the Gaussian separability and cascade property which makes Gaussian filter to be implemented easily. 6

(b) What is the advantage of the Sobel operator over the Robert operator? 4

(c) Derive the expression of the Laplacian operator. 4

(d) Give an example to show how Laplacian operator could be used to detect ramp edge in an image. 3

(e) Draw a City-block distance metric of disc of radius 4. 3

(f) Explain image erosion with appropriate example. 5