3H (Three Hours) Written Comprehensive Online Re-Examination

Mr. Adnan Jawed (2018MEZ8581)

April 09, 2021 (Friday, 3-6pm) [Open book with Camera on]

Instructions: Answer Sections A and B separately and upload two different .pdf files

Duration: 3 hours Marks: 100

Section A (Prof. S.K. Saha): 80 marks

Q1. (a) What is SVD decomposition of a matrix? What are the methods to find it?

(b) Draw S-N diagram for steel in fatigue loading. How is it different from stress-strain diagram in static loading?

(c) What is Euler's method of integration? Explain using a sketch.

(d) What is LU decomposition? Outline the steps.

(4×5 = 20)

Q2. (a) Showing the steps find $\mathbf{LL}^T$ (Cholesky) decomposition of the following matrix:

$$\mathbf{A} = \begin{bmatrix} 9 & -1 & 2 \\ -1 & 8 & 5 \\ 2 & 5 & 7 \end{bmatrix}$$

(b) Find the solution for the 2nd order differential equation using Runga-Kutta method for the value of $x = 2$.

$y'' - 3y' + 2y = 0$ with initial conditions $y(0) = 4$, $y'(0) = 5$

(2×10 = 20)

Q3. (a) Using sketches, define holonomic and non-holonomic constraints of a mechanical system.

(b) Using DH parameters find out the final Homogeneous Transformation Matrix (HTM) of the end-effector for the revolute-prismatic manipulator. Find out its equations of motion using the DeNOC matrices.

(c) Derive the Jacobian matrix of a UAV with six rotors (Hexa-Copter). How can you solve inverse kinematics in velocity level?

(5+10+5=20)

Q4. (a) What are the major differences between Stiffness control, Impedance control, Admittance control, and hybrid control.

(b) Suppose the unforced equations of motion of a system in state space is given by

$$\dot{\mathbf{x}} = \begin{bmatrix} 0 & 0 & -2 \\ 0 & 1 & 0 \\ 1 & 0 & 3 \end{bmatrix} \dot{\mathbf{x}}$$

Find out the State Transition Matrix and find the response if the initial value (at time t = 0) is given by $\dot{\mathbf{x}}_0 = \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix}$. (2×10 = 20)

Section B (Prof. Sumantra Dutta Roy): 20 marks

(*This is a test of mathematical and concept understanding. Please use consistent notation across questions, and state what practical assumptions are used, and where. The test seeks to check the depth of one's understanding, not how well one can search for a topic in Google, or otherwise*).

1. Give a proper mathematical formulation of bundle adjustment in terms of the inputs, outputs and the basic mathematics involved.

2. Give a mathematical formulation of 3-D projective structure, and how one can upgrade projective structure to Euclidean.

3. Read up about `Building Rome in a Day', and SLAM. How are the two different in terms of the problems, the mathematical descriptions, the algorithmic principles, and the solutions?
4. How can one get correspondence across images: what are common practical assumptions, in practically important scenarios? Consider the practical scenarios from `Building Rome in a Day' and getting structure from motion.

(4×5=20)

3D (Three days) Written Comprehensive of Mr. Adnan Jawed
Submission: April 12, 3pm

Instructions: Answer Sections A and B separately and upload two different .pdf files

Marks: 100

Section A (Prof. S.K. Saha): 70 marks

1. (a) Write MATLAB programs to solve HTM/
   (b) Perform inverse and forward dynamics of Question Q4 (b) of Section A numerically
   (c) Verify its results using RoboAnalyzer or ReDySim or any other software.

   (10+30+10=50)

2. For the Hexa-Copter, solve the problem of Question 4(c) of Section A.

(20)

Submit a handwritten report in .pdf file describing the methodologies followed and the results obtained. Add the plots saved in .pdf as a part of the report.

Section B (Prof. Sumantra Dutta Roy): 30 marks

1. Survey the state-of-the-art in terms of the concepts behind `Building Rome in a Day', and write the entire engineering effort needed in terms of the basic input and output, in your own words.

2. Survey the state-of-the-art in terms of SLAM with a single moving camera, and write the entire engineering effort needed in terms of the basic input and output, in your own words.

3. Read up about Monocular SLAM from http://www.cse.iitd.ac.in/~chetan and summarize the basic math and engineering needed to build a system from scratch. The camera is on a person. One needs to find the 3-D structure of the world around, from the views of the camera.

(3×10=30)