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# MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

*(A constituent unit of MAHE, Manipal)*

**SEVENTH SEMESTER BTECH. (E & C) DEGREE END SEMESTER EXAMINATION**
**JANUARY/FEBRAURY 2021**
**SUBJECT: MOTION AND GEOMETRY BASED METHODS IN COMPUTER VISION**
**(ECE - 4039)**

**TIME: 3 HOURS** **MAX. MARKS: 50**

**Instructions to candidates**

- Answer **ALL** questions.
- Missing data may be suitably assumed.

1A. Compute the intersection of three planes (P1, P2, and P3) defined below in 3D projective space using homogenous representation.

P1: 2X+3Y+4Z+5 = 0

P2: X+2Y+3Z+4= 0

P3: 3X+5Y+7Z+8 = 0

1B. Given two 8-bit grayscale images shown in Figure 1B, compute the joint probability $(x, y)$ of the two images. With the help of these two images as an example, describe the process of image registration using mutual information.

1C. Two consecutive frames $(f(x,y,t), f(x,y,t+\Delta t))$ of a video is shown in Figure 1C. Assuming these frames as 8-bit grayscale image, calculate the following quantities required in computing Horn and Schunk Optical Flow: $\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}, \frac{\partial f}{\partial t}$

(4+3+3)

2A. Compute the first order and second order derivative of the 4-bit grayscale image shown in **Figure. 2A**.

2B. Compare step and roof edges in range images. Explain why the methods used to calculate edges in grayscale images cannot be used in case of range images.

2C. Explain the benefit(s) of utilizing range images in addition to color images for object tracking as compared to using only color images.

(4+3+3)

3A. The two images shown in **Figure. 3A** are to be stitched to create an image mosaic.

i. Suggest an algorithm (in detail) to create the image mosaic,

ii. Discuss the limitation(s) of the above-mentioned algorithm in creating the image mosaic from these two images.

3B. One frame from a CCTV footage of a busy street market is shown in **Figure. 3B**. The objective is to design a robust tracking algorithm to track the motion of ALL the people visible in the scene.

i. Discuss the challenges associated in designing the tracking algorithm

ii. Suggest an algorithm (in details) to track all the persons present in the scene

iii. Describe the limitations of the tracking algorithm presented in (ii).

(5+5)

4A. Two cameras with fixed parameters (Internal and External) are setup to capture the same scene from two viewpoint (stereopsis) as shown in **Figure. 4A**. The objective is to compute the disparity map for this pair of images.

i. Suggest an algorithm(in detail) to compute the disparity map for these two pair of images.

ii. Describe the limitations of the method described above.

4B. Assume that CCTV installed in the AB5, Second floor (MIT campus) corridor is to be used to measure the height (in meters) of a person present in the corridor.

i. Identify the scene reconstruction (metric/affine/projective) required to measure the person's height. Justify your answer.

ii. Suggest an algorithm (in details) to perform the appropriate scene reconstruction for measurement of the person height. Assume that there are more than one CCTV available capturing the same scene, and the camera parameters (internal and external) of the CCTV are unknown. Also, assume that the point correspondence $((x_i \leftrightarrow x_i'))$ is available for all the images (cameras).

(5+5)

5A. Show that fundamental matrix $F$ can be defined as $F = [e']_x P' P^+$ where *P, P'* are two camera matrices and $P^+$ is the pseudo-inverse and *e'* is the epipole for the second camera.

5B. For an internally calibrated perspective camera, explain the data normalization proposed by Hartley in estimating the fundamental matrix. Also, describe its usefulness.

5C. Differentiate between stratified approach and direct approach for upgrading a projective reconstruction to metric reconstruction.

(4+3+3)

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|---|---|---|---|---|---|
| **0** | **0** | **0** | **0** | **0** | **0** |
| **0** | **0** | **0** | **0** | **0** | **0** |
| **0** | **0** | **10** | **10** | **0** | **0** |
| **0** | **0** | **10** | **10** | **0** | **0** |
| **0** | **0** | **10** | **10** | **0** | **0** |
| **0** | **0** | **0** | **0** | **0** | **0** |

**Image 1**

| | | | | | |
|---|---|---|---|---|---|
| **0** | **0** | **0** | **0** | **0** | **0** |
| **0** | **0** | **0** | **0** | **0** | **0** |
| **0** | **0** | **0** | **10** | **10** | **0** |
| **0** | **0** | **0** | **10** | **10** | **0** |
| **0** | **0** | **0** | **10** | **10** | **0** |
| **0** | **0** | **0** | **0** | **0** | **0** |

**Image 2**

**Figure. 1B**

| | | | | | |
|---|---|---|---|---|---|
| **0** | **0** | **0** | **0** | **0** | **0** |
| **0** | **0** | **0** | **0** | **0** | **0** |
| **0** | **0** | **1** | **1** | **0** | **0** |
| **0** | **0** | **1** | **1** | **0** | **0** |
| **0** | **0** | **1** | **1** | **0** | **0** |
| **0** | **0** | **0** | **0** | **0** | **0** |

$\boldsymbol{f(x, y, t)}$

| | | | | | |
|---|---|---|---|---|---|
| **0** | **0** | **0** | **0** | **0** | **0** |
| **0** | **0** | **0** | **0** | **0** | **0** |
| **0** | **0** | **0** | **1** | **1** | **0** |
| **0** | **0** | **0** | **1** | **1** | **0** |
| **0** | **0** | **0** | **1** | **1** | **0** |
| **0** | **0** | **0** | **0** | **0** | **0** |

$\boldsymbol{f(x, y, t + \Delta t)}$

**Figure. 1C**

| | | | | | |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 2 | 2 | 2 | 0 | 0 |
| 0 | 2 | 0 | 2 | 0 | 0 |
| 0 | 2 | 0 | 2 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 |

**Figure. 2A**

**Figure 3A**

**Figure. 3B**

**Figure. 4A**