00046

# The Open University of Sri Lanka
# Faculty of Engineering Technology

| | | |
|---|---|---|
| Study Programme | : | Bachelor of Technology (Engineering) |
| Name of the Examination | : | Final Examination |
| **Course Code and Title** | : | **MEX5271 Machine vision** |
| Academic Year | : | 2013/2014 |
| Date | : | 14th August 2014 |
| Time | : | 9.30am – 12.30pm |
| Duration | : | 3 hours |

**General instructions**

1. Read all instructions carefully before answering the questions.
2. This question paper consists of 8 questions. All questions carry equal marks.
3. Answer any 5 questions only.

---

Q1.

a) Discuss *Human vision* vs *Machine vision* considering Decision making, Speed of response and Quality of measurements.

b) Discuss three reasons for *Low Contrast Images*?

c) What is the object of applying *Sharpening Filtering* with respect to image processing?

d) Discuss the uses of *Image Addition, Subtraction* and *Multiplication.*

e) Discuss the *various Colour Models* available.

Q2.

a) State the relation between the world coordinate system and the camera coordinate system when the camera model is considered.

b) Consider the following case on composite transformation. Point P has the coordinates of (1,1,0), when referred to its own coordinate frame $[x^1, y^1, z^1]$. The coordinate frame $[x^1, y^1, z^1]$ when referred to the base coordinate frame [x, y, z], has been translated from the origin of [x, y, z] by an amount of (4,4,0). It has been scaled by an amount of (3,2,1) and has been rotated about the z-axis by a positive $30^0$. Find the following

   i. Affine transformation matrix(A), that captures these transformation steps.

   ii. Coordinates of point P, when referred to its base coordinate frame.



68

Q3. A photographer has taken the image below, at night. 0 corresponds to black and 15 to white. In this image we can recognize one bright house in the left (the pixels with gray levels>= 8) and the moon on the right (the pixels with gray level=<6 and >=2). We want to extract a good image of the moon.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 1 | 0 | 0 | 0 | 2 | 3 | 0 |
| 0 | 8 | 0 | 0 | 0 | 5 | 4 | 6 | 3 |
| 9 | 14 | 9 | 0 | 0 | 3 | 4 | 4 | 2 |
| 15 | 12 | 10 | 0 | 0 | 0 | 2 | 2 | 0 |
| 11 | 13 | 13 | 0 | 1 | 0 | 0 | 0 | 0 |

a) Plot the histogram of this image.

b) Design a point processing letting the moon unchanged and transforming the house and the background to black. You are supposed to provide the function and the new image matrix after the point processing operation.

c) Plot the histogram of inverse of the image transformed after b).

d) Apply Gray level reduction operator to the original image to output an image which has only 3 gray levels. Write the function necessary and mention the intervals to be used. What is the new image matrix?

Q4.

a) State the relationship between depth of field and the camera parameters like pixel size, *f* stop and magnification.

b) Consider an automated vision-based system for identifying a label in black colour of an object of a production plant. The current system setup provides an image capturing window measuring 2 cm by 2 cm square. The CCD camera has a solid state sensor array of 0.8 cm by 0.8 cm square, which can have a resolution of 512 by 512, 1024 by 1024 or 2048 by 2048 pixels. For the lens size you are allowed to use only the available sizes, which are 25mm, 35mm or 50mm. If the required tolerance of the measurement is 20 μm and the object distance should be between 100mm to 125mm, design the system by choosing the appropriate lens and sensor array resolution. You are to note that the camera (with any size of the stated array size) costs much more than the lenses. In addition the higher the resolution of the sensor array, the more expensive is the camera.

Discuss your design briefly.

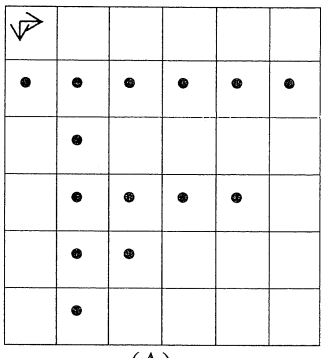
Q5.

a) Briefly explain *Morphological filtering*.

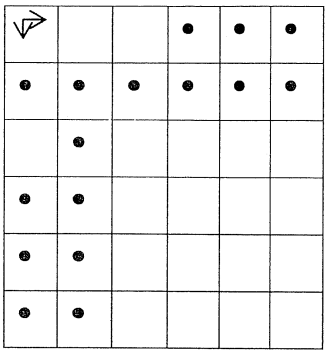
b) Prove the **Decomposition theorem** given below using the binary images shown in Figure Q5(a).

$(A \cap B) \ominus K = (A \ominus K) \cap (B \ominus K)$

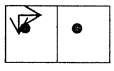
[Note : Submit your results in the sheet provided for Figure Q5(a) along with the question paper]



(A)



(B)



( K)

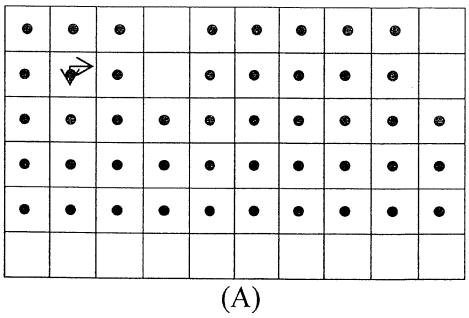
Figure Q5(a)

c) Figure Q5(b) shows a digital image (A) and a structured element (B), respectively. Determine the digital image after the following morphological operation:

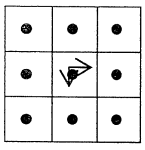
$$A - (A \ominus B)$$

Describe the function of the operation.

[Note : Submit your results in the sheet provided for Figure Q5(b) along with the question paper]



(A)



(B)

Figure Q5(b)

Q6.

a) Amal is an undergraduate student who tries to apply different lighting systems to machine vision systems. You are supposed to correct him if he has taken wrong decisions (mentioned below), by explaining the reason.

i. He needs to get *surface details* of an object. He has decided to use back lighting method for the purpose.

ii. He needs to examine *bone fractures with X-ray plates*. He decided to use front lighting method for the purpose.

iii. He needs to examine the height of an object which is *moving on a convey belt*. He decided to use structured lighting method for the purpose.

iv. He needs to find the *depth of the groove of a channel* found in a wood toy. He decided to use strobe lighting method for the purpose.

Your answer must clearly state whether the selected system is suitable or not and the best method for the tasks from i to iv and the reasons for your choice.

b) Consider the image given in Figure Q6 and answer the following giving suitable justifications.



Figure Q6

i. What is the noise that is applied to the image?

ii. What is the best filter to be used to remove this noise?

iii. Now, it is necessary to find the edge of the guitar. What are the methods available for the purpose?

iv. The image needs to be enhanced to capture the fine of the handle of the guitar. What is the best approach to be used here? Is it local enhancement or global enhancement?

Q7. Imagine that you are assigned to develop a vision based non contactable system for identifying the straw that should be attached with a fruit juice pack (Figure Q7) at a fruit juice packet manufacturing factory.

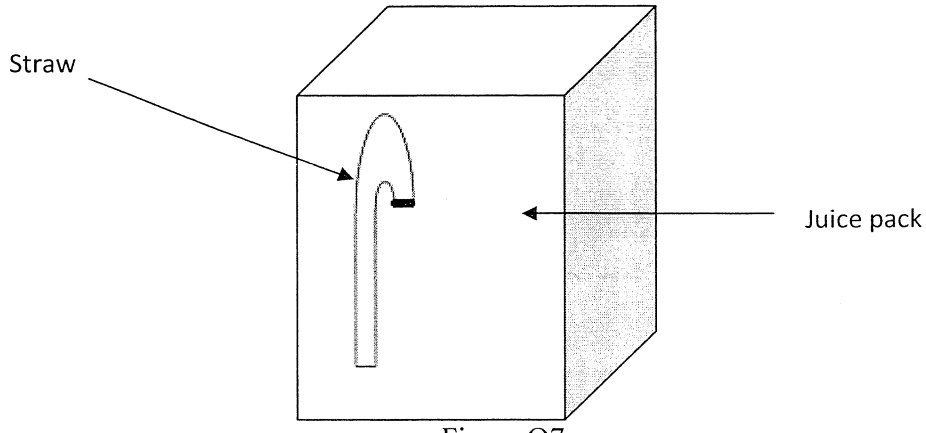



Figure Q7

This juice pack must be checked when it is on the conveyor belt.

**Stating clearly the assumptions** write an algorithm for this straw detection system.

You need to address the three main functions of a machine vision system that are Image acquisition, Processing and Display. Describe how you are going to place the necessary components on the manufacturing cell. Give suitable drawings to support your answer.

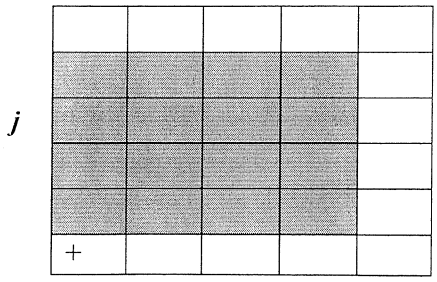
Consider the function of Image Processing of the system you selected.

Briefly describe the Image enhancement methods and Feature extraction methods that you can apply to this system?

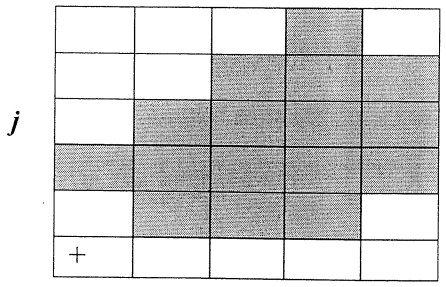
[Note: You may use a flow chart to describe the algorithm. Try to avoid ideal situations whenever possible and focus on a real system setup.]

Q8. For a spatially discretised $M$ x $N$ image, denoted by $f(i,j)$, the $p^{th}$ , $q^{th}$ moment is given by: $m_{pq} = \sum_{i=0}^{M} \sum_{j=0}^{N} i^p \, j^q \, f(i, j)$

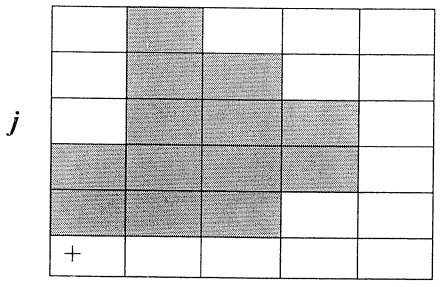
Figure Q8 shows images of a rectangle in 3 orientations formed by 6×5 arrays of gray or white pixels. For each orientation, determine the moments $m_{00}$, $m_{10}$ , $m_{01}$ and comment on your results. Use an intensity of 1 for gray pixels and 0 for white pixels. The origin of the array is indicated by '+'.




(i)




(ii)




(iii)

Figure Q8

The central moment is defined as: $\mu_{pq} = \sum_{i=0}^{M}\sum_{j=0}^{N}(i-i_c)^p(j-j_c)^q f(i,j)$

where $i_c$ and $j_c$ are the coordinates of the centroid of a given image region.

Calculate the values of $\mu_{02}$, $\mu_{20}$ and $\theta$ of the two images shown in Figure 8, where $\theta$ is given by : $\tan 2\theta = \dfrac{2\mu_{11}}{\mu_{20} - \mu_{02}}$

The values of $\mu_{11}$ for the regions shown in Figure Q8 (i),(ii) and (iii) are 0, 1.2 and 1.6 respectively.

Explain the physical significance of $\mu_{02}$, $\mu_{20}$ and $\theta$.

Note that :

$$\mu_{20} = m_{20} - i_c m_{10}$$
$$\mu_{02} = m_{02} - i_c m_{01}$$
$$\mu_{11} = m_{11} - m_{10}m_{01}/m_{00}$$

END

Index No:-

NOTE:- Please use this sheet to answer the question related to Figure Q5(a)