Maynooth University
National University of Ireland Maynooth

OLLSCOIL NA hÉIREANN MÁ NUAD

THE NATIONAL UNIVERSITY OF IRELAND MAYNOOTH

JANUARY 2015 EXAMINATION

CS410

Computer Vision

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Time allowed: 2 hours

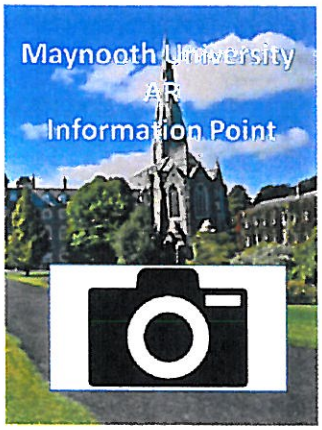
Answer ***three*** questions

All questions carry equal marks

[25 marks]

1 (a) Modelling the projective transformation between a planar surface and an image of that planar surface can be achieved through the use of a 3x3 matrix transformation. Given a set of n correspondences between the image and the planar surface, provide details of the set of steps involved in computing the projective transformation between the two. [13 marks]

(b) The Registrar's office of the of the University has approached you to assist in the development a new mobile augmented reality (AR) app. The purpose of the app is to provide information to students via a set of posters that have been placed on noticeboards around the University. An image of the poster to be used is shown below: [12 marks]



The use case for the application will be that a user will use the app to take a photo of one of the posters. The app will then input the image (taken by the user) to your computer vision subsystem along with an information image that University wishes to be presented to the user.

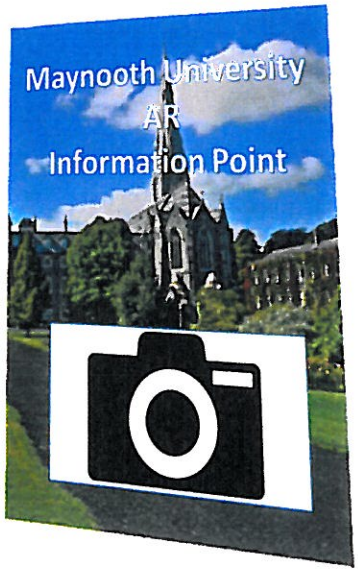
Your subsystem should return the original image to the app with information image rendered within the white camera box on the lower half of the poster. Note that the subsystem should render the information image such that it appears to lie within the 3D plane of the poster (i.e. it should appear to be part of the poster).

An example input image pair and corresponding output is shown on the next page. Here, (a) shows the image captured by the user's device and, (b) shows the information image to be overlaid by the AR system. (c) shows the desired output. Note that in the final application the computer vision system should not make any assumptions regarding (a) the position scale or orientation of the poster within the user's image, and (b) the region of the scene surrounding the posters (i.e. you should **not**

assume that they will appear on plain white backgrounds).

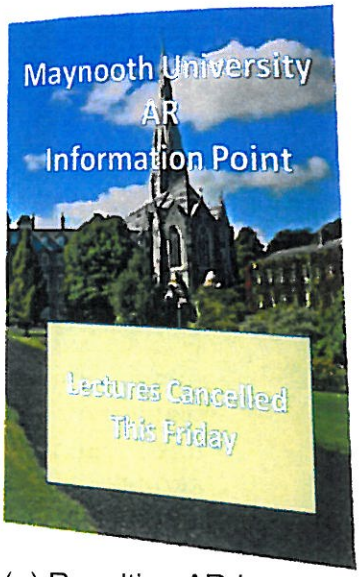
P.T.O.

With reference to part (a), detail the complete set of steps involved in producing the desired output image given the two input images.



(a) Input image from user's device

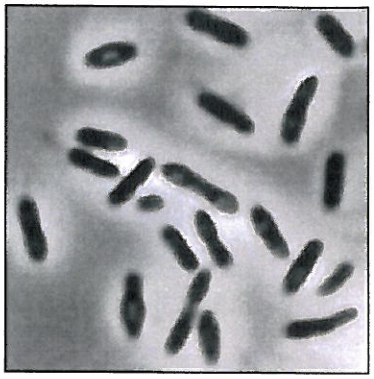
(b) Information Image

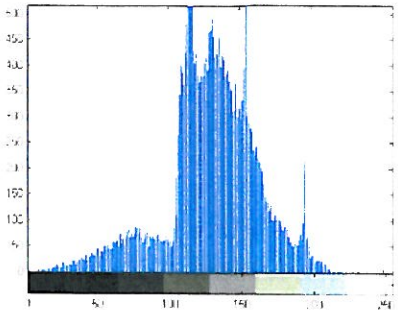


(c) Resulting AR Image

[25 marks]

2 (a) The figure on the left below shows an image of micro-organisms on a petri dish captured by a microscope. The grey level histogram for the figure is shown on the right. [9 marks]





Explain why the histogram takes on the structure shown by relating it to the image data on the left. Given the structure of the histogram, what difficulties will be encountered in using thresholding as an approach to foreground/background segmentation? What morphological operation(s) can be employed as a post-processing step in order to overcome this issue? In your answer you should explain how the operations should be employed.

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(b) Provide details of a computer vision algorithm that (i) counts the number of separate biological entities the image, and (ii) for each entity computes its size, position and orientation. In your answer you should provide complete explanations of each of the sub-algorithms, including pseudo-code where appropriate. [16 marks]

[25 marks]

3 (a) Provide details of how mean, median, and Gaussian filtering can be used to reduce noise in images. Compare and contrast each of the approaches. [9 marks]

(b) The matrix below shows a 3x5 neighbourhood of a grayscale image in the region of a vertical edge. Demonstrate the superiority of median filtering over mean filtering by applying both filters to the **three** central pixels of the image. [8 marks]

10	10	140	140	140
10	10	140	140	140
10	10	140	140	140

(c) The equation below provides an expression for the normalised cross-correlation between an image, $g(x,y)$, and template, $t(x,y)$, where the correlation is evaluated at location (m,n). [8 marks]

$$N(m,n) = \frac{\sum_{x,y} g(x,y)t(x-m,y-n)}{\sqrt{\sum_{x,y} g(x,y)^2}\sqrt{\sum_{x,y} t(x-m,y-n)^2}}$$

Outline how this metric may be used to detect a template in a given image. What range of values can $N(m,n)$ evaluate to? Provide an explanation of why the metric is constrained to these values.

4 (a) List and provide details each of the steps involved in the Canny edge detection algorithm. **[25 marks]** [9 marks]

(b) Give details of how the Hough transform may be used to detect lines in image. [9 marks]

(c) If the Hough transform were applied to the image below what features in the image would lead to the dominant peaks in the Hough space. Given the geometric structure of the image (i.e. multiple lines intersecting at a common horizon point), how will this structure constrain the arrangement of peaks in the Hough space? Explain your answer. [7 marks]