IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 2015-2016

MEng Honours Degrees in Computing Part IV
MSc in Advanced Computing
MSc in Computing Science (Specialist)
MRes in High Performance Embedded and Distributed Systems
for Internal Students of the Imperial College of Science, Technology and Medicine

This paper is also taken for the relevant examinations for the Associateship of the City and Guilds of London Institute

PAPER C407H

MEDICAL IMAGE COMPUTING

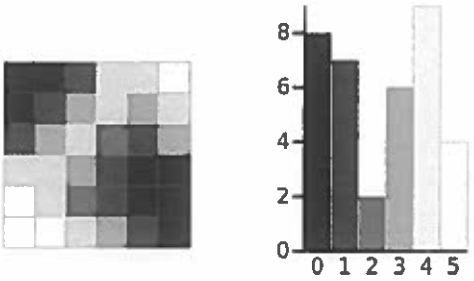
Wednesday 16 December 2015, 14:00
Duration: 70 minutes

Answer TWO questions

Paper contains 3 questions
Calculators required

1 **Segmentation**

Assume the 6 × 6 image below and its associated intensity histogram:



a Describe an algorithm that implements image enhancement via histogram equalisation.

b Calculate the new image intensities after performing histogram equalisation as described in part a.

c Briefly outline the different steps necessary to implement the Otsu thresholding algorithm for image segmentation.

d Compute the optimal threshold value based on the Otsu thresholding algorithm in part c for the image given above.

The four parts carry, respectively, 20%, 30%, 20%, and 30% of the marks.

2 Image registration

a Transformations

i) How many parameters (or degrees of freedom) does a 3D rigid transformation have, and what do those parameters represent?

ii) What is the difference between a rigid transformation and a similarity transformation?

b Coordinate systems

i) What are the three steps to map image coordinates to world coordinates?

ii) Write down the three matrices that correspond to the three steps of mapping a vector with image coordinates $(x\ y\ 1)^\top$ to a vector of world coordinates $(X\ Y\ 1)^\top$.

c Feature-based registration

What are the four steps of the Umeyama method for computing a rigid transformation? No equations are needed; just name the steps.

d (Dis)similarity measures

What are the relationships between image intensities that are assumed for the a) sum of squared differences, b) correlation coefficient, and c) mutual information?

e Applications

For the following two registration scenarios, name an application for which this registration would be useful. Describe which type of registration you would use, either feature-based or intensity-based. If intensity-based, name the transformation model and the dissimilarity measure that you would use.

i) Give an example for intra-subject longitudinal registration.

ii) Give an example for inter-subject mono-modal registration.

The five parts carry, respectively, 15%, 30%, 20%, 15%, and 20% of the marks.

3 Machine learning

a Applications

i) Give two example applications for unsupervised learning in medical imaging.

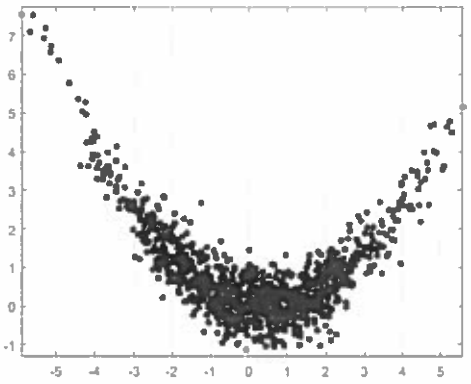
ii) Give two example applications for supervised learning in medical imaging.

b Unsupervised learning

i) What are the two main iterative steps of the k-means clustering algorithm?

ii) What do the eigenvectors and the eigenvalues of the singular value decomposition represent in the context of principal component analysis?

iii) Is it reasonable to apply principal component analysis for dimensionality reduction to the plotted 2D data shown below? Explain your reasoning in one or two sentences.



c Supervised learning

i) Explain briefly how one can use binary classifiers, such as logistic regression, for multiclass classification. Give the name of this strategy.

ii) In one or two sentences, explain the conceptual and the mathematical differences between linear regression and logistic regression.

iii) In one or two sentences, explain what is meant by saying a method suffers from *high bias* or *high variance*.

The three parts carry, respectively, 20%, 50%, and 30% of the marks.