UNIVERSITY COLLEGE LONDON

University of London

EXAMINATION FOR INTERNAL STUDENTS

For the following qualifications :-

M.Res

COURSE CODE	:	**MV**
TITLE OF EXAMINATION	:	**Machine Vision**
DATE	:	**04-MARCH-1997**
TIME	:	**09.30**
TIME ALLOWED	:	**2 hours 30 minutes**

*Answer **three** questions in total, **at least one** from section A and **at least one** from section B. Each question is worth 33 marks. The total time allowed is two and a half hours.*

SECTION A

Attempt at least one question from this section.

Question 1

(a) Explain what is meant by a polynomial warp of an image and decribe how you would implement such a transformation of a digital image $I(x)$ to $I'(x')$. Describe how such warps may be defined by the use of a number of control points, explain what determines in principle how many control points should be used for a given warp, and describe what you would do in an implementation if there were: (i) too many control points, (ii) too few control points.

[10 marks]

(b) Describe the formation of an image by an idealised camera showing how the imaging geometry may be modelled as a projection from homogeneous world co-ordinates $(X, Y, Z, W)^T$ to image cordinates $(x, y, w)^T$ and explaining what factors determine the image irradiance or intensity. Comment on the extent to which these ideal models are valid in practice.

[10 marks]

(c) Discuss under what conditions the formation of an image described in (b) above may be regarded as an affine projection and write down the form of the projection matrix P. Show that, in principle, under these conditions any two such views of an object

$\begin{pmatrix} x' \\ y' \\ w' \end{pmatrix} = P' \begin{pmatrix} X \\ Y \\ Z \\ W \end{pmatrix}$ and $\begin{pmatrix} x'' \\ y'' \\ w'' \end{pmatrix} = P'' \begin{pmatrix} X \\ Y \\ Z \\ W \end{pmatrix}$ can be used to construct a third view $\begin{pmatrix} x \\ y \\ w \end{pmatrix}$ and discuss the limitations on using this relationship in practice to generate novel views of an object from existing images.

[13 marks]

[TURN OVER]

Question 2

(a) In an industrial inspection process, thin, flat objects pass over a light source and are viewed from above by a camera. Describe the image processing operations you would use to obtain a labelled, singly connected region describing the silhouette of each object as it passes under the camera. Explain briefly the operation of any standard algorithms you would use.

[10 marks]

(b) Explain how geometric moments may be used to characterise the shape of an object imaged under the conditions described in (a) above. Discuss how you would try to ensure that your shape descriptors were insensitive to details of the set-up of the inspection cell such as the position and orientation of the objects, which way up they are and factors such as the camera's focal length, its height above the objects and its precise orientation. Indicate what other factors might affect validity of the measurements and their accuracy.

[10 marks]

(c) Explain briefly what is meant by a "flexible shape model" and describe how you would would use such models to inspect chocolate wafers designed to be produced in a small variety of shapes if your objective was only to accept chocolates whose shape was close to that intended and to reject grossly distorted or broken chocolates.

[13 marks]

[CONTINUED]

Question 3

(a) Explain what is meant by optical flow and describe how it is related to the motion of a sensor and the objects in a scene. Explain how the motion field may, in principle, be used to obtain information about the shape of objects visible in a scene and discuss why it is often difficult to obtain this information in practice.

[10 marks]

(b) Describe how windowed cross-correlation techniques may be used to estimate motion in an image sequence and explain how you would implement such a scheme efficiently using a local Fourier transform and a coarse to fine strategy.

[10 marks]

(c) Explain what is meant by the term "focus of expansion" and describe the form of the motion field produced when a camera moves with constant speed along its optic axis through a stationary scene. Describe how, under these conditions, you would use a Kalman filtering technique to obtain continually updated estimates of the "time to contact". Discuss the problems you would expect to encounter in trying to utilise such a system for detecting the possibility of collisions with (i) distant, rapidly moving objects and (ii) nearby, slowly moving objects.

[13 marks]

[TURN OVER]

SECTION B

Attempt at least one question from this section.

Question 4

(a) Explain how feature extraction can be applied to the geometric calibration of CCD cameras in close-range applications and discuss why it is necessary to measure these geometric distortions.

[10 marks]

(b) Given an image of a sub-microscopic specimen, what segmentation techniques could be applied to try to extract atomic regions and what difficulties are you likely to encounter. Suggest ways in which these difficulties could be overcome.

[10 marks]

(c) Compare and contrast the Canny and Model edge fitting edge extraction operators. Suggest ways how these operators could be used to extract building hypotheses within a heavily cluttered aerial image and how the accuracy of these techniques could be measured.

[13 marks]

Question 5

(a) Describe the different classification strategies which can be applied to stereo matching operators and discuss two operators in detail which could be used co-operatively.

[10 marks]

(b) Discuss what techniques you would need to perform when attempting to compare the accuracy of 3 independent stereo matching methods for a close-range scene of an industrial object.

[10 marks]

(c) Describe the fundamental basis of shape-from-shading methods and how these might be integrated into improving stereo matched disparities for modelling the human face.

[13 marks]

[CONTINUED]

Question 6

(a) Describe briefly three different techniques for measuring image texture and how these could be applied to the classification of two-dimensional scenes.

[10 marks]

(b) Monofractals have been suggested as a method for segmenting oblique aerial images. Discuss the strengths and limitations of such an approach.

[10 marks]

(c) Describe the strengths and limitations of dynamic programming methods for scene to scene and scene to CAD object registration.

[13 marks]

[END OF PAPER]