Family Name _____

First Name _____

Student Number |__|__|__|__|__|__|__|__|

Venue _____

Seat Number _____

UNIVERSITY OF CANTERBURY
*Te Whare Wānanga o Waitaha*
CHRISTCHURCH NEW ZEALAND

## No electronic/communication devices are permitted.

**No exam materials may be removed from the exam room.**

## Computer Science and Software Engineering

## EXAMINATION

Mid-year Examinations, 2017

# COSC428-17S1 (C) Computer Vision

**Examination Duration:** 120 minutes

**Exam Conditions:**

Closed Book exam: Students may not bring in anything apart from writing instruments.

No calculators are permitted

**Materials Permitted in the Exam Venue:**

None

**Materials to be Supplied to Students:**

1 x Standard 16-page UC answer book

**Instructions to Students:**

- This exam is worth a total of 100 marks
- Contribution to final grade: 40%
- Length: 10 questions
- Answer all questions.
- Use the separate Answer Booklet for answering all questions.

**Questions Start on Page 3**

## 1 (10 marks)

How do pixels in a camera differ from the photoreceptors in the human retina in terms of colour space, distribution of colour, sensitivity, and resolution? (Use diagrams in your answer.)

## 2 (6 marks)

Describe the three colour spaces, CIE, RGB and HSV, using diagrams and explain their respective strengths and weaknesses and where and how they are most commonly used.

## 3 (12 marks total)

When segmenting a moving object from a static background:

- "***Background subtraction***" usually refers to the first frame, or some derivative of it, being the reference frame.
- "***Difference***" algorithm usually refers to the difference between two adjacent frames where in this case, the previous frame is the reference frame.
- "***Ghosting***" refers to a second image of the moving object appearing as an artefact of a difference algorithm.
- "***Foreground aperture***" refers to a hole appearing in the moving object as an artefact of a difference algorithm.

In the case of a ball rolling into view of a stationary camera (where the ball is not visible in the first frame), compare the visible differences between:

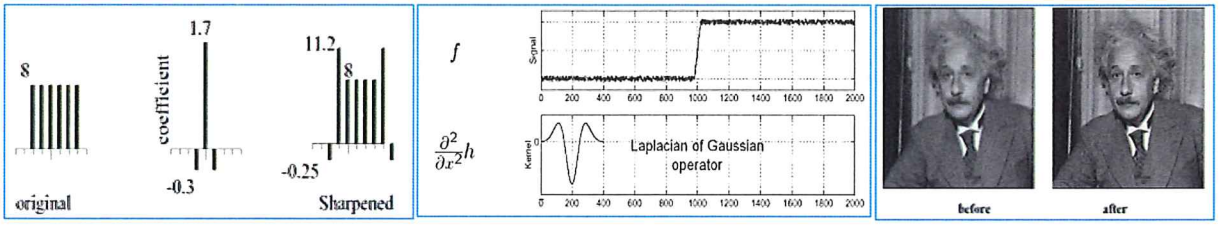
(a) using the previous frame as a reference frame [4 marks]
(b) using the first frame as a reference frame [4 marks]
(c) using the double difference algorithm [4 marks]

In answering each part of this question, explain the consequences of

i. the ball moving at a speed where there is a separation of one ball diameter between the position of the ball in consecutive frames,
ii. the ball moving so fast that it only appears in one single frame,
iii. the ball moving so slowly that the ball overlaps half of the ball in the previous frame,
iv. when the ball stops moving.

## 4 (6 marks total)

A simple discrete equivalent (i) of a Laplacian of Gaussian filter (ii) can sharpen an image (iii) as illustrated.




(i) (ii) (iii)

Explain

(a) how an image becomes sharpened using such a filter [3 marks]

(b) why the "after" image in (iii) appears to have more content than the "before" image [3 marks]

## 5 (10 marks)

A good edge detector should have:

- Good Detection: filter responds to edge, not noise.
- Good Localization: detect edge near true edge.
- Single Response: one per edge.

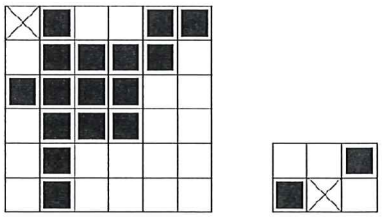
(a) Describe how the Canny edge detection algorithm accomplishes the above attributes of a good edge detector. [6 marks]

(b) Explain how the choice of Gaussian kernel size affects the behavior of the Canny edge detector. [4 marks]

## 6 (8 marks)

The *opening* of an image X is called a "homogeneous opening" when the same structuring element B (similar to a filter) is used for both the erosion and dilation operations. (Note that the crossed pixel in B indicates where B is centred on each successive pixel in X.)

Show the *homogeneous opening* of X with respect to B, for the figures of X and B shown below. Show your answer in two figures (similar to the figure for X) representing the two morphological steps which support opening.



X B

## 7 (10 marks total)

List one advantage and one disadvantage for the following object recognition methods:

(a) Pose clustering [2 marks]
(b) Geometric hashing [2 marks]
(c) Generalised Hough transform [2 marks]
(d) Template matching [2 marks]
(e) Direction histogram [2 marks]

## 8 (16 marks total)

(a) The three main issues in tracking are prediction, data association and correction. Briefly describe these three issues in the context of the Kalman filter.
[3 marks each for 9 marks total]
(b) Describe how we can obtain an improved "smoothed" estimate using a Kalman filter.
[3 marks]
(c) Describe two advantages of a Particle Filter (Condensation Algorithm) over a Kalman Filter. [4 marks]

## 9 (6 marks total)

Briefly describe

(a) Homography [2 marks]
(b) Essential matrix [2 marks]
(c) Bundle adjustment [2 marks]

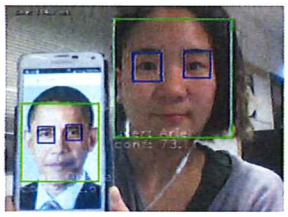
## 10 (16 marks)

You are to briefly describe **only four of the following** class projects [for 4 marks each] by just listing (one per line) at least four algorithmic steps, **naming the algorithms** used in the order they were used.

**Do not select your own or similar project** (e.g. face recognition projects - do not select other face recognition projects, etc).

(i) "Capture of Dynamic Piano Performance with Depth Vision"

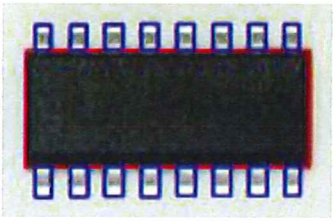
(ii) "Real Time Face Detection and Recognition"



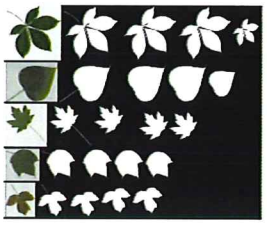
(iii) "Unwashed Dishes & Culprit Detection"

(iv) "Robot Arm Tracking Motion" to track yellow ball

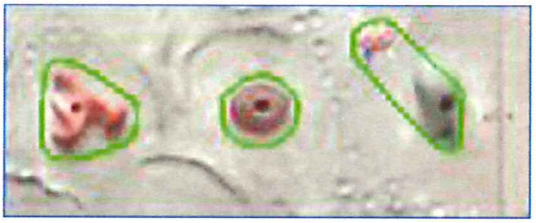
(v) "Vision Based Surface Mount Package Identification"



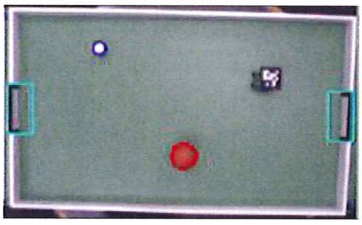
(vi) "Classify Plants by Species"



(vii) "Climbing hold detection in static images"



(viii) Locate robots and boundary for "Robot Football (Soccer)"



**End of Examination**