Family Name _____

First Name _____

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

Venue _____

Seat Number _____

U7ki

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.

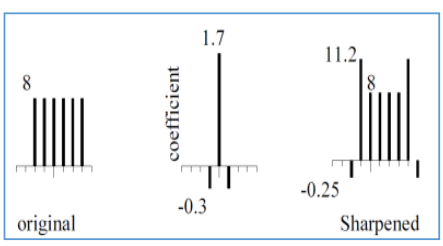
In the case of a ball not visible in the first frame - and then it rolls into view of a stationary camera, compare the visible differences between:
(a) using the previous frame as a reference frame [4 marks]
(b) using the first frame as a reference frame [4 marks]
(c) using the double difference algorithm [4 marks]

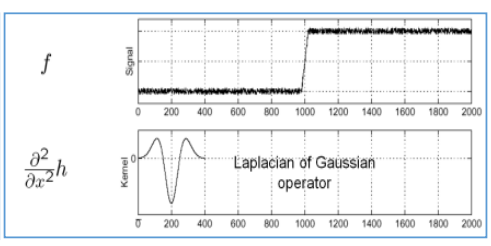
In answering each part of this question above, explain the consequences of
i. the ball moving at a speed where there is a separation of one ball diameter between the position of the ball in consecutive frames,
ii. the ball moving so fast that it only appears in one single frame,
iii. the ball moving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

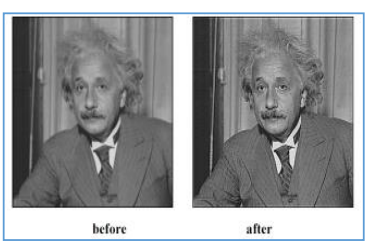
Answer these 12 questions (1 mark each) in the sequence: (a) i,ii,ii,iv (b) i,ii,ii,iv (c) i,ii,ii,iv

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:

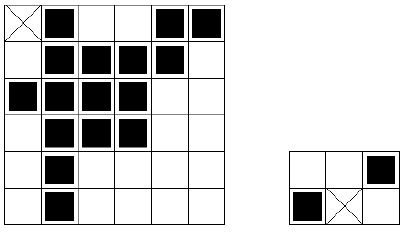
- Good Detection: filter responds to edge, not noise.
- Good Localization: detect edge near true edge.
- Single Response: one per edge.

(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 steps 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)

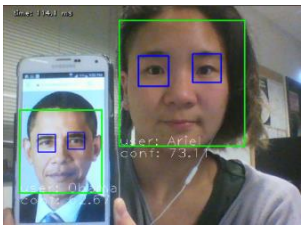
You are to briefly describe **only four of the following** class projects [for 4 marks each] by just listing (one per line) at least four algorithmic steps, **naming the algorithms** used in the order they were used.

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”

[[
difference image
opening and dilation
rolling average of tracking to calc velocity
]]

(ii) “Real Time Face Detection and Recognition”



[[
Local Binary Pattern cascade classifier to locate face
Haar cascade classifier to locate eyes
Local Binary Pattern Histogram to recognise face
]]

(iii) “Unwashed Dishes & Culprit Detection”

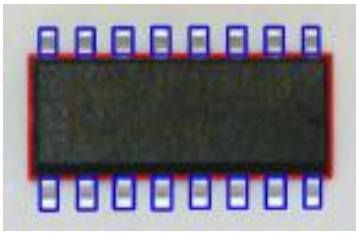
[[
background subtraction using Gaussian mixture model
median filtering

Canny edge detection
Suzuki and Abe contours location
Lienhart and Maydt's face detection using using Haar-like feature based cascade classifiers
]]

(iv) “Robot Arm Tracking Motion” to track yellow ball

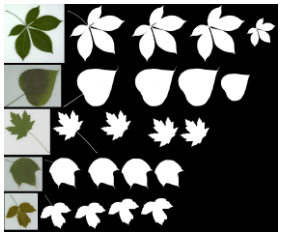
[[
RGB to HSV
colour segmentation
median filter
Guassian blur
Hough circle
]]

(v) “Vision Based Surface Mount Package Identification”



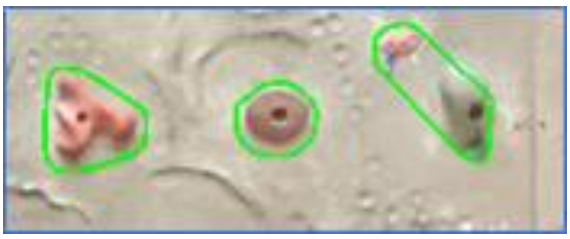
[[
binary thresholding
Canny edge detection
morphological opening
Guassian filter
package and lead shape thresholded on aspect ratio
]]

(vi) “Classify Plants by Species”



[[
expectation-maximisation machine learning utilises colour for the segmentation
top-hat transformation to remove the stem
k nearest neighbour to classify leaf species
]]

(vii) “Climbing hold detection in static images”



[[
HSV conversion
meanshift filtering to quantise colours
adaptive filtering to remove variation in light
morphological erosion and dilation morphology to reduce noise and clarify lines
contours thresholed on size
]]

(viii) Locate robots and boundary for “Robot Football (Soccer)”

[[
Circle Hough Transform
Fiducial Marker tracking
colour filtering and thresholding
Canny Edge detection to eliminate noise
Suzuki and Abe border following algorithm
]]

End of Examination