UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Final Exam 2016

Prescription Number: COSC428

Paper Title: *Computer Vision*

Time allowed: TWO hours

Number of pages: 5

- This exam is worth a total of 100 marks
- Contribution to final grade: 40%
- Length: 11 questions
- Answer *all* questions.
- Calculators are *not* allowed.
- *This is a closed book test*.
- Use the separate *Answer Booklet* for answering *all* questions.

1 (6 marks total)

Briefly describe:

a) Homography, H [2 marks]
b) Essential matrix, E [2 marks]
c) Bundle adjustment, BA [2 marks]

2 (10 marks total)

ArUco and AprilTags are two algorithms that find the six degree-of-freedom pose between a camera and a fiducial maker. Briefly describe these two algorithms. [5 marks each]

3 (6 marks total)

(a) Name the three main stages of a convolutional neural network (deep learning) in the order that they operate from an input image. [3 marks]
(b) Name three commonly used deep learning frameworks [3 marks]

4 (6 marks)

In order for a natural feature registration algorithm to work well it must be robust to common image transformations and distortions. List six such image transformations and distortions.

5 (8 marks)

Assume that you already have a reliable model of the camera's intrinsic parameters, have removed any radial distortion and now wish to perform natural feature registration (NFR).

(a) List the five steps of the natural feature **registration** algorithm [5 marks]

(b) Name three natural feature **registration** algorithms [3 marks]

6 (12 marks)

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

7 (4 marks)

Write the equations for finding the

(a) gradient direction (angle) of an edge [2 marks]

(b) gradient strength (absolute value) of an edge in an image [2 marks]

8 (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. [8 marks]

(b) Explain how the choice of Gaussian kernel size affects the desired behavior of the Canny edge detector. [2 marks]

9 (10 marks)

A good local image feature to track should:

- satisfy brightness constancy
- have sufficient texture variation
- correspond to a “real” surface patch
- not deform too much over time

(Such good local image features are used for matching the same point in a stereo pair of images or in successive frames of video.)

Taking into account the above features, describe and compare the following two good local feature detection algorithms:

(a) Harris detector [5 marks]

(b) SIFT [5 marks]

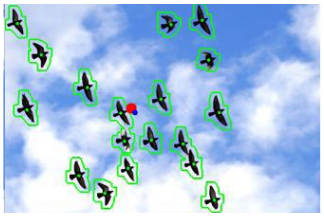
10 (12 marks)

Describe how correctly matched points in two images enable finding:
(a) depth values in a stereo pair of images [4 marks]
(b) optical flow points in two successive frames of video using the Lukas Kanade algorithm [4 marks]
(c) Describe how depth can be calculated from optical flow using a single camera. [4 marks]

11 (16 marks)

You are to briefly describe **only four of the following** 2016 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) "Detection and Tracking of Flying Birds"



(ii) "Guitar String Detection using Edge Detection and Custom Filtering"

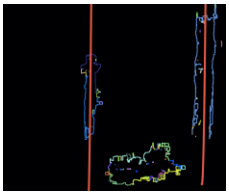
(iii) "Detecting Tramways in Crops for Robot Navigation"

(iv) Detecting hand pose for “Self-Aware Standing Desk: Height Adjustment through Gesture Control”

(v) “Hands Free Wound and Skin Lesion Perimeter Detection”

(vi) Using a fiducial marker for “Automatic UAV landing”

(vii) “Real-time UAV Collision Avoidance Based on Environment Modeling”



(viii) “Iris Pattern Detection for Automated Identification of Hoplodactylus Chrysosireticus Geckos”

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(i)
thresholding
dilation
contouring
centroid of each bird
centroid of flock
moving average filter

or

background subtraction
median filtering
contour detection
distance from cameras (using field-of-view, resolution)
GPS position estimate

(ii)
Canny edge detector
Gaussian filter
Hough line transform
line angle/distance thresholding

(iii)
grayscale transform
skeletonization of crop rows
Hough transform
line angle and proximity thresholding

(iv)
adaptive background subtraction
Gaussian filter
skin colour filtering
erosion, dilation
Canny edge detector
hand pose from covex hull of hand

(v)
skin colour thresholding
hue-saturation histogram to detect wound
morphological closing
blurr
threshold to binary
count pixels for wound area

(vi)
thresholding
extracting contours
extracting corners (using Harris corner detection)
natural feature tracking was done using ORB detection for key point detection
FLANN based matcher for matching keypoints between the reference image and the live image

(vii)
morphological filter to bright or darken the output frames
disparity map from two cameras
least squares filter of disparity map to get potential obstacles
optical flow Shi and Tomasi algorithm to compare flow around potential obstacles to generate the optimal route for collision avoidance

or

Greyscale
Harris
Bucketing
Translation vector calculation

(viii)
Dilation
binary thresholding
canny edge detection to perform pre-processing on the image
Hough line transform
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END OF PAPER