The Australian National University
College of Engineering and Computer Science
Mid-semester test, First Semester 2021

ENGN6528 Computer Vision

Question Booklet

Reading time: 15 minutes
Writing time: 1 hour
Uploading time: 15 minutes

Instructions on next page

Allotted Time

You will have 1 hour to complete the exam plus 15 minutes of reading time (you are allowed to write during this time. An additional 15 minutes has also been allowed to accommodate the additional task of uploading your completed exam to the final exam Turnitin submission portal on the ENGN6528 Wattle site. Thus you have 1 hour and 30 minutes to complete the exam. NO late exams and submissions will be accepted. You may begin the exam as soon as you download it.

Minimal requirements:

You may attempt all questions

You SHOULD NOT include an assignment cover sheet

You must type your ANU student identification number at the top of the first page of your submission

You must monitor your own time (i.e. there is no invigilator to tell you how many minutes are left).

Your answers must be clear enough that another person can read, understand and mark your answer. 11 or 12 point font with 1.5 spacing is preferred. Scanned images of handwritten equations or diagrams must be legible and of a suitable size. Please be aware that your submitted document should have at least 20 words based on the requirement of Turnitin. If it is not satisfied, it may lead to unsuccessful submission.

Numbering questions
* You must specify the question you are answering by typing the relevant question number at the top the page
* Each question should begin on a new page
* Multi-part questions (e.g. question 1 parts a and b) may be addressed on the same page but should be clearly labelled (e.g. 1a, 1b)
* Questions should be answered in order

You must upload your completed answers in a single document file within the allotted time using a compatible file type for Turnitin (Preference: MS Word's .doc or .docx or .pdf format) **It is the student's responsibility to check that the file has uploaded correctly within Turnitin. No late submission will be accepted.** Access to the Turnitin practise site can be found here: https://www.anu.edu.au/students/academic-skills/academic-integrity/turnitin

Academic integrity

Students are reminded of the declaration that they agree to when submitting this exam paper via Turnitin:
I declare that this work:
* upholds the principles of academic integrity as defined in the University Academic Misconduct Rules;
* is original, except where collaboration (for example group work) has been authorised in writing by the course convener in the course outline and/or Wattle site;
* is produced for the purposes of this assessment task and has not been submitted for assessment in any other context, except where authorised in writing by the course convener;
* gives appropriate acknowledgement of the ideas, scholarship and intellectual property of others insofar as these have been used;
* in no part involves copying, cheating, collusion, fabrication, plagiarism or recycling.

Mid-Semester Exam: How to

Do's and Don't's:

- You are recommended to record your exam process and keep the video to yourself (for at least 4 weeks).
- **Do not submit your video recording.** This file stays private to you, unless we have a specific reason to request this file from you.
- Feel free to **ask question directly posting to "Instructors"** on Piazza (public posting will be disabled for you during the exam) or send email to course convenors. Our class link on Piazza is: http://piazza.com/anu.edu.au/spring2021/engn6528
- **Do not use any communication system** (other than direct posts on Piazza to Instructors or sending emails to your course convenor) during your exam - if you do, it will be counted instantly as collusion and will have serious academic honesty consequences.
- **Do not upload any material** anywhere (other than to the Wattle upload link at the end of the exam). If you do so, you will also become part of an academic collusion case which will stay on your permanent record at the ANU.
- Be very careful **searching for any material on-line**. If you find yourself seeing references to material which might be the result of collusion (which hopefully will not exist), you are one click away from becoming part of a serious academic honesty case yourself. Remember that all of your activity must appear in your recording, and according to basic academic standards, we also expect you to reference in your pdf file anything which you might have included in your working. You will likely waste valuable time for your exam and expose yourself to serious risks, so we recommend to defer from doing so.

Step-by-step guide on how to sit your actual on-line mid-semester exam:

1. Find yourself a cozy spot and **power down all communication channels**, besides this forum here.
2. Start your full screen **recording now**.
3. **Download** the exam paper from wattle (link will become active at the time of the exam).
4. **Open** the exam in the pdf reader, which you tested before.
5. Take a moment to **read** the whole document. You don't need to spend exactly 15 minutes for reading and you can start working on the exam after you finish reading it at your pace.
6. Fill in **your answers**. You can initially write your answer using your favourite editor. You are strongly recommended to submit a word document or Pdf document. Whichever way you chose, all your activities **must appear on your recording**.
7. Don't forget to **save regularly,** or use a system which does that for you.
8. When you are complete, upload a single file (word or PDF are OK), and upload via the Wattle Link. You can make multiple uploads, they will overwrite the last. Ensure you upload before the end of the time. We have allowed 15 minutes upload time so submit with some time to spare.
9. **Stop your screen recording** and make sure the video file is saved (keep this file for at least 4 weeks). **Do not submit** your video recording.

There are 4 questions in total. (Q1-Q4)

Please name your submission as
ENGN6528_midsem_u1234567.docx

(or PDF as you prefer)

Questions on the next page

Q1: (10 marks) [basic concepts]

Answer the following questions concisely. Each of the questions must be answered in no more than 5 lines of text. Longer answers will be penalized.

1. Consider the HSV colour space. What does H stand for? [1 mark]

2. Describe the information that the H channel contains. [1 mark]

3. Is a Bilateral filter a linear filter? Explain in one or two sentences why or why not? [2 marks]

4. Suppose that we have a histogram modification function as follows:
   M1(v) = c(v/255)^γ, where 0 <= v <= 255 (assuming pixel values for the camera are in the range of [0, 255], where γ = 0.4, and c is 1.

   (a) Suppose that we apply this to the following image. Describe what the effect will be on the modified histogram? [2 marks]
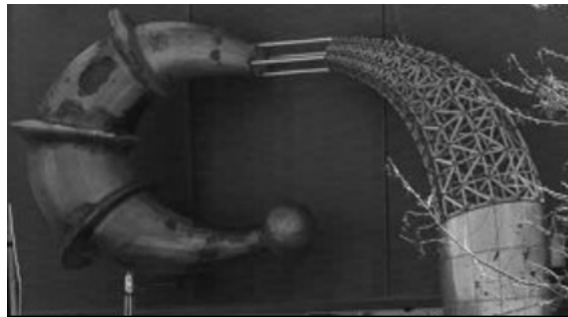

   (b) Suppose we now use a different function that operates as follows:
   M2(v) = c(v/255)^ γ, where v < 30
   M2(v) = c((v-20)/255)^ γ, where 30 <= v < 50
   M2(v) = c(v/255)^ γ, where v >=50

   where γ = 0.4, and c is 1.
   What would be the new value for a pixel when its current value is 42? [1 mark]

   (c) Describe in one or two sentences what the differences are between the resultant images after applying M1 and M2 to the original one, respectively. [3 marks]

Answer the following questions concisely. If you are unsure about some part along the way of your working on the questions, state your best assumption and use it for the remaining parts. Similarly, if you think some aspect is ambiguous, state your assumption and write the answer as clearly as you can.

Q2: (10 marks) [Calculations]

1. Homogeneous transformations of a 2D image can be represented by a single 3x3 matrix. What would be 3x3 the matrix of transformation matrix that results in an output image being translated 6 pixels to the left and 8 pixels upwards? (where up and left are defined from an image origin at the top left-hand corner. [3 mark] Notes: detailed image coordinate system and the result after translation are defined below.
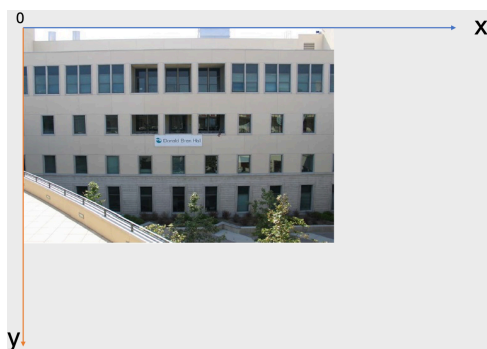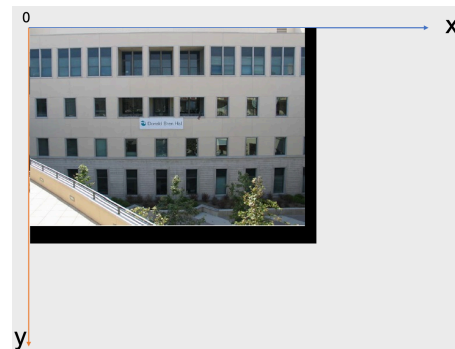
(a) Original Image   (b) Image after Translation

2. If you were to apply the following filter as a correlation :

0	-1	-2
1	0	-1
2	1	0

to the blue and red regions separately following image patch:

0	27	10	0	1
2	4	29	7	2
0	3	23	22	20
3	3	3	27	31
4	0	2	3	22

Calculate the result of the correlation applied to the red (upper left) and the blue square (bottom right) (Note: you are going to obtain one value for each region). [3 marks]

Describe what operation this filter performs/achieves in one or two sentences. [2 marks]

3. If you apply a filter F =

4	0	3

followed by a filter G =

4
0
3

to an image, What is the equivalent 3x3 filter to these operations? [2 marks]

Q3. Basic Algorithm [8 marks]

(a) Consider the RANSAC algorithm for fitting a line for a set of points. Let us denote e the probability that a point being an outlier, we have $e = 0.25$ for the current case and the number of points in a sample be $s = 2$. Determine the required number of sampling iterations (N) to ensure that at least one of the samples is free from outliers with probability $p = 0.97$. [4 marks]

(b) Briefly explain the steps of the histogram equalization algorithm. [3 marks]

(c) What is the effect of applying histogram equalization to an image twice? Justify your answer. [1 mark]

Q4. Algorithm Design. [12 marks]

Please design an algorithm to detect ellipses from the following binary image. Please list the key steps and ideas to detect ellipses. [Namely, we would like to find the membership of each pixel whether it belongs to an ellipse or not and which ellipse it belongs to.] Note that the question must be answered in less than one page. Longer answers will be penalized.
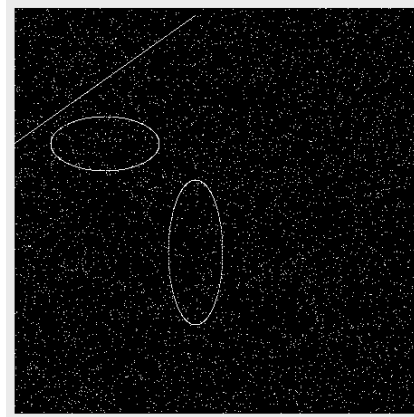
Notes:
The parametric equation for an ellipse is defined below

$$\frac{(x - x_0)^2}{a^2} + \frac{(y - y_0)^2}{b^2} = 1$$

Where (x_0, y_0) defines the centre of the ellipse, (a, b) defines the length of semi-major axes, respectively.

======= END of ALL QUESTIONS in the EXAM ===========