COMP3710
Take-Home Final Exam

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Pages: 4 (including this one)

Questions: 5

Total Marks: 20

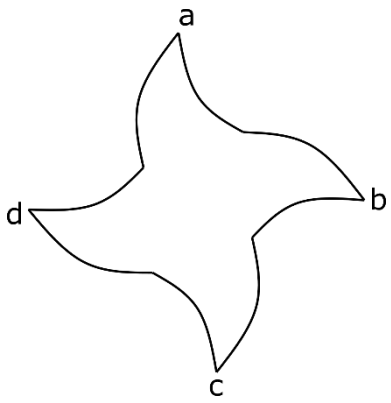
Exam Conditions:

This is a Take-Home Examination – **Submit your typed answers** to the questions provided via Turn-it-in submission on Blackboard. Pay close attention to the word or size limits to the answers.

Instructions To Students:

You should attempt all questions. You MUST show the steps used to arrive at your final solution. Best marks will be awarded to (numerically) correct solutions showing complete working. Partial credit will be given to partially complete solutions or to incorrect solutions where errors have been carried through calculations. Assumptions, if any, should be explicitly stated and justified/verified as appropriate. Best marks will be awarded to the ones most relevant to the course and the course material.

Problem 1 (2 Marks)



For the given starfish shape on this page:

a) determine the symmetries of this shape

b) construct the Cayley table for this shape

What is the main difference in symmetries of this starfish when compared to the symmetries of a square?

Requirements: Present your answer in less than ½ page A4 size, 12 pt with Normal (2.54 cm) margins (excluding figures or tables). Use tables via the word-processor if any are required.

Problem 2 (2 Marks)

Describe the Discrete Fourier transform (DFT) and the physical principles used in constructing this transform, making sure to also include any key equations, how it can be used for pre-processing and the type of signals the DFT would be useful for via an example.

Requirements: Present your answer in less than ½ page A4 size, 12 pt with Normal (2.54 cm) margins (excluding figures or tables). Use tables via the word-processor if any are required.

Problem 3 (3 Marks)

Describe the concept of the autoencoder and the variational autoencoder (VAE) network, its fundamental principles, making sure to include descriptions of

i. its network architecture as a schematic
ii. the mathematical theory it is based upon
iii. the goal(s) of such a network
iv. its main components
v. how these components can be used separately
vi. an example where it might be useful

Requirements: Present your answer in less than 1 page A4 size, 12 pt with Normal (2.54 cm) margins (excluding figures or tables). Use tables via the word-processor if any are required.

Problem 4 (5 Marks)

Write a short technical description of ONE of the following convolutional neural networks (CNNs): the generative adversarial network (GAN), or the Mask RCNN, or context aggregation network (CAN), or transformers, or the residual network (ResNet).

You must:

i. identify the original paper that introduced the network by including a citing of this paper),
ii. include a diagram of the network from this paper or your own diagram,
iii. a review of the network, its new contribution to CNNs, making sure to include any new features and principles it introduces,
iv. the mathematical theory and intuition behind this new network,
v. the advantages of this
vi. any limitations or difficulties associated with this network
vii. an example application of the network, including a citation of another paper where this network was applied successfully.

Requirements: Present your answer in less than 1 page A4 size, 12 pt with Normal (2.54 cm) margins (excluding figures or tables).

Problem 5 (8 Marks)

As part of the Australian Space Agency, it is your role to handle the various pattern recognition problems from optical telescope images obtained from around the world.

In one particular scenario, you have been given access to 4000 images of individual galaxies taken by the Hubble space telescope. Galaxies are mostly blob and disc like objects that are a collection of bright pinpoints of light in an otherwise completely dark background. The galaxies also fall into a set of 9 categories into which each of these 4000 images have been labelled. The scientists at the agency would like to automatically identify and classify the different types of galaxies in large images that contain thousands of such galaxies. They would like at least the location and type of each galaxy in such images. There is a total of 100 of such large images that need to be processed automatically.

The scientists have mentioned that they may be able to do some limited processing by hand if required and there is a database of other galaxies that have been acquired via surface-based telescopes (i.e. not from space like the Hubble space telescope, but through the atmosphere where some distortion may occur) with around 1000 images available.

Given the above imaging data and scenario above, describe a method for solving the problem of automatically locating all the galaxies in the large images as well as classifying them.

(2 Marks)

Be sure to include:

i. The type of algorithm that will be used, how it will be employed (including inputs and outputs) and provide any relevant architectures and block diagrams.
(2 Marks)

ii. Relevant choices of components within the algorithm, such as the optimizer, loss function or hyper-parameters that will needed.
(1 Mark)

iii. Identify the type of manual processing required from the scientists for the algorithm.
(1 Mark)

iv. How you will handle the number of images in the datasets. That is, how will the 4000 galaxy images, 1000 surface-based images and the 100 large images be made useful?
(1 Mark)

v. How you will evaluate the performance of the resulting algorithm including the metrics that will be used.
(1 Mark)

Requirements: Present your answer in less than 1 page A4 size, 12 pt with Normal (2.54 cm) margins.

Assumptions (0 Marks)

Please specify any assumptions you have made in completing this examination and which questions those assumptions relate to. You may also include queries you may have made with respect to a particular question, should you have been able to 'raise your hand' in an examination room.

END OF EXAMINATION