

Two hours - online hybrid

The exam is hybrid and will be taken on line and answered on paper.

EXAM PAPER MUST NOT BE REMOVED FROM THE EXAM ROOM

**UNIVERSITY OF MANCHESTER  
SCHOOL OF COMPUTER SCIENCE**

Modelling and visualisation of high-dimensional data

Date: Thursday 24th January 2019

Time: 09:45 - 11:45

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**This is a hybrid examination with sections to be answered online and questions to be answered on paper**

**Please answer All Questions in Section A online  
and All Questions in Section B in a separate answerbook**

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This is a CLOSED book examination

The use of electronic calculators is permitted provided they are not programmable and do not store text

**[PTO]**

*Section A  
contains Multiple  
Choice Questions  
and is restricted*

**Section B**

Answer *all* questions from this section.

1. *Singular Value Decomposition* (SVD) is a powerful linear algebraic tool widely used in machine learning. For a  $m \times n$  matrix,  $X$ , describe the SVD and the properties of its components in detail. (6 marks)
  
2. The *Self-organising map* (SOM) is a popular yet biologically inspired dimension reduction method. Describe the following techniques and terminologies used in the SOM:
  - a) What are the *distance metrics* used to measure the difference between a data point and a weight vector and to define a neighbourhood of a neuron, respectively? (2 marks)
  
  - b) What is the *Best-Matching Unit* (BMU)? (2 marks)
  
  - c) What is the *U-matrix*? How is it achieved? (2 marks)
  
3. Making use of the derivation of the *Principal Component Analysis* algorithm learned from this course unit, specify the utility function especially for obtaining *the second principal component* of a data matrix,  $X$ , and prove that it is the eigenvector associated with the second largest eigenvalue of  $\Sigma$ , where  $\Sigma$  is the covariance matrix of  $X$ . (8 marks)