COMP 61342

Two hours

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Computer Vision

Date: Wednesday 5th June 2019

Time: 09:45 - 11:45

Please answer all FOUR Questions.
Each Question is worth 20 marks

Use a SEPARATE answer book for each QUESTION

This is a CLOSED book examination

The use of electronic calculators is NOT permitted

[PTO]

中值滤波器是一种常用的非线性滤波器，其基本原理是选择待处理像素的一个邻域中各像素值的中值来代替待处理的像素，其主要功能是像素的灰度值与周围像素比较接近，从而消除孤立的噪声点，所以中值滤波器能够很好的消除椒盐噪声。不仅如此，中值滤波器在消除噪声的同时，还能有效的保护图像的边界信息，不会对图像造成很大的模糊（相比于均值滤波器）。中值滤波器的效果受滤波窗口尺寸的影响较大，在消除噪声和保护图像的细节存在着矛盾：滤波窗口较小，则能很好的保护图像中的某些细节，但对噪声的过滤效果就不是很好；反之，窗口尺寸较大有较好的噪声过滤效果，但是会对图像造成一定的模糊。另外，根据中值滤波器原理，如果在滤波窗口内的噪声点的个数大于整个窗口内像素的个数，则中值滤波就不能很好的过滤掉噪声。中值滤波对图像的边缘信息保护效果更佳，可以避免图像细节的模糊，但是当中值滤波尺寸变大之后同样会产生图像模糊的效果

https://users.cs.cf.ac.uk/Dave.Marshall/Vision_lecture/node47.html
It is important to note that the optical flow is not uniquely determined by the local information.
You need corner or other....

1.

a) What is the **optical flow constraint** and why does it not uniquely determine the flow at each point in an image? **[5 marks]**

b) How does a **median filter** reduce random noise in an image whilst tending to preserve edges? **[5 marks]**

c) Is the **Harris corner detector** a linear filter? Argue why or why not. Assume that the Harris corner detector is applied to an unsmoothed image. What type of image would trigger the detector at places that clearly don't contain a corner? **[5 marks]**

d) Define **disparity** in stereo vision. Given a pair of stereo images, what do we mean by the term **image rectification**?

Disparity refers to the distance between two corresponding points in the left and right image of a stereo pair. 差异越大，距离越近。

立体校正，使得左右图像的成像原点坐标一致、两摄像头光轴平行、左右成像平面共面，这样一幅图像上任意像素点与其在另一幅图像上的对应点一定在同一行上，只需要对该行进行一维搜索即可匹配到对应点。

[5 marks]

advanced feature 第一个PDF

End of Question 1

SSM模型中，不同手势图片的对应点位，有着相同的标记点，一个点可以认为是一个feature。 这些点有x,y。 实际上和别的模型是一摸一样的。 PCA 生成的东西，实际上是eigenvector, 在平均模型的基础上加上各自的eigenvector * eigenvalue， 就得到了model。 PCA对多个点 features进行了降维，大大节省了计算量

2.

A COMP61342 student is studying learnt, statistical, model-based approaches to computer vision. She has a dataset of n vectors thus:

$$\{\underline{x}^\alpha | \alpha = 1, \ldots n\},$$
$$\underline{x}^\alpha \in \mathbb{R}^d, \ \underline{x}^\alpha = \{x_1^\alpha, x_2^\alpha, \ldots x_d^\alpha\}.$$

a) Explain in detail how **Principal Component Analysis (PCA)** could be applied to this dataset. How are the properties and output of PCA used when building a statistical model of shape (SSM), and explain why PCA is useful in this case.

[5 marks]

b) Explain **in detail** how statistical modelling methods using PCA can be used to build a computer vision system to find a previously unseen example of an object in a new image. You should explain in detail how the datasets used are constructed from the raw data.

[10 marks]

c) Give at least three **disadvantages** of such a model-based approach to computer vision. Discuss whether or not these disadvantages can be overcome, and if so, how they might be overcome.

Mark-up time-consuming, error-prone
Correspondence hard to define on some objects
Surfaces: hard to do & equal-spacing doesn't work!

[5 marks]

End of Question 2

SIFT候选关键点：由于平滑区域临近像素之间变化不大，但是在边、角、点这些特征较丰富的地方变化较大，因此通过DOG比较临近像素可以检测出候选关键点

The terms corners and interest points are used somewhat interchangeably and refer to point-like features in an image, which have a local two dimensional structure. The name "Corner" arose since early algorithms first performed edge detection, and then analysed the edges to find rapid changes in direction (corners). These algorithms were then developed so that explicit edge detection was no longer required, for instance by looking for high levels of curvature in the image gradient. It was then noticed that the so-called corners were also being detected on parts of the image which were not corners in the traditional sense (for instance a small bright spot on a dark background may be detected). These points are frequently known as interest points, but the term "corner" is used by tradition

3.

a) Explain what an **interest point** is.

[2 marks]

b) You are asked to develop a computer vision system that can detect motorbikes from side views, such in the images below (**Figure 1**).

Figure 1

https://www.zhihu.com/search?type=content&q=bag%20of%20word

Suppose that we have computed clusters of local features from a training set, and determined how likely features in each cluster are to be part of a motorbike. Describe how this information could be used in a "Bag of Words" motorbike detector. **[8 marks]**

c) Explain how you could use the pair of images in **figure 2** to calculate the distances from the camera of the surface features that appear in the scene.

Figure 2

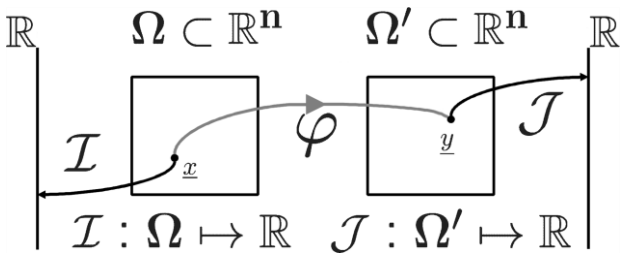
In your answer you need to consider all steps in the process, from images to depth values. You also need to give a diagram to illustrate your answer.

[10 marks]

End of Question 3

4.

a) The following diagram is a mathematical representation of two greyscale images, in the context of non-rigid image registration.



By referring to this diagram, or otherwise, explain the concepts of the **pullback** and **pushforward** mappings, and how they are used to create warped images. Why might one mapping be preferred over the other when building an implementation of pairwise image registration?

[4 marks]

b) Outline at least **three** distinct applications of non-rigid image registration to biomedical imaging, making clear in each case why registration is either required or useful.

[6 marks]

c) Consider the data in **figure 3**.

i) What do you expect to happen if we run the K-means algorithm with *three* clusters on this data set? Explain why you expect this to happen. **[6 marks]**

ii) What will happen if instead we run the EM algorithm with *three* clusters on this data set? Explain why you expect this to happen. **[4 marks]**

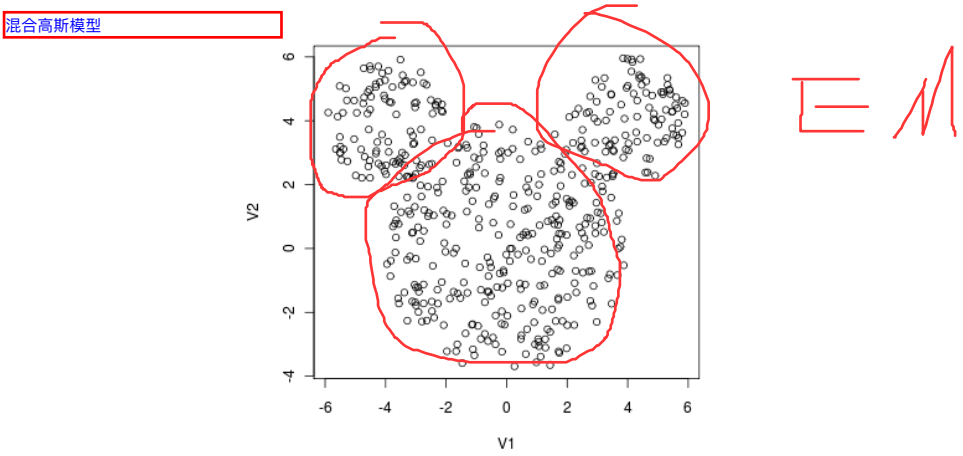


Figure 3

End of Question 4

END OF EXAMINATION