

Exam - Computer Vision

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Duration: 2 hours

Part I - Fundamental Topics (10 points)

- 1. Digital Image.** Consider an image where the only component of the color present is the *intensity* of each pixel, represented in Figure 1. The image is in digital format, has a 5x5 dimension and an 8-bit quantization.

100	100	100	100	100
150	150	150	150	150
150	150	150	150	150
150	150	200	200	200
200	200	200	200	200

Component I

Figure 1

- a) Apply a *contrast stretching operation* to the image represented in Figure 1. Present the calculations performed and the final result in matrix form (2 points).
 - b) Apply a 3-bit quantization to the Matrix I represented in Figure 1. Present the calculations made and the final result in matrix form. (2 points)
 - c) You are developing a video recording system in which the camera has the following features: 5x5 dimension, RGB color space, 4-bit quantization. The maximum storage memory that you can use on this system is 10kB. What is the maximum number of images per second that you can record to film a phenomenon lasting one minute, without exceeding the installed memory capacity? (2 points)
- 2. Digital Filters** Consider the image represented in Figure 2, where each value corresponds to the *intensity* of the color at that point. The image is in digital format, has 4x4 dimension and has a 4-bit quantization .

10	10	5	5
10	10	5	5
0	0	5	5
0	0	0	0

Figure 2

- a) Apply a Median filter *to the* image depicted in Figure 2, 3x3, on the area of the gray-marked image. Present the calculations you find relevant and the final result in matrix form. (3 points)
- b) Discuss the usefulness of this filter, and compare it with the use of a *Gaussian filter*. (Note: You do not need to calculate the result of this filter). (1 point)

Part II - Advanced Topics (10 points)

3. Segmentation

- a) Describe how the *K-Means algorithm* works (use formulas whenever necessary). Present a use case for this algorithm. (2 points)
- b) Describe two algorithms commonly used for region-based segmentation. Characterize and present a use case for each of them. (1 point)

4. Neural Networks

- a) Associated with convolutional networks (CNN) there is the concept of *Pooling*. Explain what it consists of and what its advantages are. (2 points)
- b) Explain the concept of *overfitting*, in what circumstances can occur and how it is possible to mitigate this effect. (2 points)
- c) Explain the concept of *cross-validation* by presenting two examples of this type of technique. (2 points)
- d) Explain what explainable models (XAI) are. Explain the *post-model* models briefly and present two examples. (1 point)