2021-2022春季学期
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云课堂

计算机视觉期末考试

结束于：4月21日 10:30

测验说明

问题 1 16 分

Part I Short questions.

1. (8 points) The fundamental theories and tools of the computer vision field were contributed by many eminent scientists and engineers. In our lectures, we have mentioned some guys, e.g. Chris Harris, Zhengyou Zhang, David Lowe, Tony Lindeberg, Yann LeCun, Geoffrey Hinton, David Marr, Marvin Minsky. You can select 5 of the aforementioned guys and for each guy, please write out his/her major contributions to the CV field.

2. (8 points) Suppose that on the projective plane, there is a line $x-3y+4=0$. What is the homogeneous coordinate of this line's infinity point?

HW2—(Math)2

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问题 2 16 分

3. (8 points) In machine learning community, there is an issue named "class imbalance". Please describe 1) What is the class imbalance problem? 2) Why is it a problem for learning algorithms? 3) Are there any ways to deal with this issue?

4. (8 points) RANSAC (random sample consensus) is a framework commonly used for fitting models from observations with potential outliers. Suppose that I_1 and I_2 are two images, captured from the same physical plane. $\{\mathbf{x}_i, \mathbf{y}_i\}_{i=1}^{n}$ are correspondence pairs, where $\mathbf{x}_i$ and $\mathbf{y}_i$ are the positions of the key points in I_1 and I_2 respectively. What are the steps for estimating the homography matrix between I_1 and I_2 based on $\{\mathbf{x}_i, \mathbf{y}_i\}_{i=1}^{n}$ using RANSAC?

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问题 3 16 分

5. (8 points) SIFT (Scale Invariant Feature Transform) is a classical and powerful approach to construct local descriptors. Please present the basic steps to construct a SIFT descriptor. Given an image, what are the outputs when you apply the SIFT operator to it?

Part II Long questions.

1. (10 points) Vanishing points l_1 and l_2 are two world lines perpendicular to each other on the same plane, and $\mathbf{v}_1$ and $\mathbf{v}_2$ are their vanishing points on the imaging plane, respectively. Please prove that

$$\mathbf{v}_1^T(\mathbf{K}^{-T}\mathbf{K}^{-1})\mathbf{v}_2=0$$

where $\mathbf{K}$ is the intrinsic matrix of the pinhole camera.

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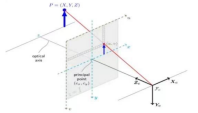
问题 4 20 分

2. (20 points) Imaging model of the camera. For many machine vision applications, we need to model the process of imaging, i.e., how a point in the 3D world space is mapped to a pixel on an image. The pinhole model is widely used to model such a process as depicted in the following figure.



Please present in details how a 3D point $(X, Y, Z)^T$ in the world coordinate system is mapped to a pixel $(u,v)^T$ on the image.

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问题 5 20 分

3. (20 points) Camera intrinsics calibration. Suppose that we have a calibration board with chessboard patterns. Altogether, there are N cross-points on the calibration board. For calibration, M images of the calibration board are taken.
1) (10 points) In our lecture, we formulated the intrinsics calibration problem as a nonlinear least-squares problem. Please write down the objective function of such a nonlinear least-squares problem and try to explain its physical meaning in detail.

2) (10 points) Nonlinear least-squares. Suppose that $\mathbf{f}(\mathbf{x}): \mathbb{R}^n \to \mathbb{R}^m, \mathbf{x} \in \mathbb{R}^n, \mathbf{f} \in \mathbb{R}^m$,

and some $f_i(\mathbf{x}): \mathbb{R}^n \to \mathbb{R}$ is a (are) non-linear function(s). Then, the problem,

$\mathbf{x}^* = \arg\min_{\mathbf{x}} \frac{1}{2}\|\mathbf{f}(\mathbf{x})\|_2^2 = \arg\min_{\mathbf{x}} \frac{1}{2}\mathbf{f}(\mathbf{x})^T\mathbf{f}(\mathbf{x})$ is a nonlinear least-squares problem. In our lecture, we mentioned that Levenberg-Marquardt algorithm is a typical method to solve this problem. In LM algorithm, for each updating step, at the current $\mathbf{x}$, a local approximation model is constructed as,

$$L(\mathbf{h}) = \frac{1}{2}\mathbf{f}(\mathbf{x}+\mathbf{h})^T\mathbf{f}(\mathbf{x}+\mathbf{h}) \approx \frac{1}{2}\mathbf{J}\mathbf{h}^T\mathbf{h}$$
$$\approx \frac{1}{2}\mathbf{f}(\mathbf{x})^T\mathbf{f}(\mathbf{x}) + \mathbf{h}^T(\mathbf{J}(\mathbf{x})^T\mathbf{f}(\mathbf{x})) + \frac{1}{2}\mathbf{h}^T(\mathbf{J}(\mathbf{x})^T\mathbf{J}(\mathbf{x}))\mathbf{h} + \frac{1}{2}\mu\mathbf{h}^T\mathbf{h}$$

where $\mathbf{J}(\mathbf{x})$ is $\mathbf{f}(\mathbf{x})$'s Jacobian matrix, and $\mu > 0$ is the damped coefficient. Please prove that $L(\mathbf{h})$ is a strictly convex function. (Hint: If a function $L(\mathbf{h})$ is differentiable up to at least second order, L is strictly convex, if its Hessian matrix is positive definite.)

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问题 6 10 分

4. (10 points) In some vision-based ADAS systems, walking pedestrian detection and distance measurement are required. Suppose that you are confronted with such a task. The only sensor supplied to you is a monocular camera. Please give your solutions and provide as many details as possible.

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没有要保存的新数据。最后检查时间是 12:18 提交测验

问题

- 问题 1
- 问题 2
- 问题 3
- 问题 4
- 问题 5
- 问题 6

运行时间：0:02
10 分钟 34 秒