Test 1: preparation sheet

Computer Vision (CS364/AM792)

The points below are what I consider to be the important theoretical aspects covered in the module thus far, and the things that could be expected of you in the test on **Thursday 19 Sep 2019 at 17:30 in A305**.

Basics of image processing

- representation of greyscale images as matrices, and colour images in the RGB scheme
- be able to predict the outcome of a given pixel transformation function, on both an image and its histogram
- understand and know the method of histogram equalisation (the test won't cover histogram matching)
- be aware of the averaging, Gaussian and median filters, how they operate and their effects on images (skip the adaptive median filter)
- know and understand the theory behind sharpening by means of unsharp masking (skip the Laplacian)
- understand what is meant by an image gradient (two values per pixel giving direction and magnitude), and how edge detection is performed with the Sobel masks
- have an idea of where and why image interpolation is needed
- understand when, why and how we inversely map pixels in the output to pixels in the input (also how the output is initialised and how the origin can shift)
- be aware of nearest-neighbour and bilinear interpolation (no need to memorize the formulas)

Feature detection and matching

- have an idea of what good image features are, and where feature matching is used
- know about the typical pipeline in feature matching: detection, description, matching
- be aware of Harris and SIFT, and how they compare (don't memorise any details of the algorithms)
- be aware of window matching, with maximum disparity and consistency checks, how it works, and why it is not such a good matching strategy

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Projective geometry

- know and understand how points and lines in 2D are represented with homogeneous vectors, and what homogeneous equivalence means
- know the statements on slide 7 of Lecture 8 (with the proofs discussed in class) and be able to use them
- have an understanding of ideal points and the line at infinity, and how they are represented
- know the definition of a projective transformation, and how points as well as lines are transformed by a given projective transformation
- know the forms of an isometry, similarity, affinity and general projectivity, as well as the degrees of freedom and invariants of each
- understand what is meant by a perspective transformation (or plane-to-plane homography)
- be able to **derive** the system on slide 6 of Lecture 10, know how it (and the SVD) is used to calculate a homography from point correspondences, and how such a homography can be used to remove perspective distortion or to stitch two images together (also be aware of the planar assumption we make here)

RANSAC

- be aware of where and why RANSAC is useful for model fitting, know its general form (slide 6 of Lecture 11) and why it usually works well
- be able to explain how RANSAC can be used to robustly find a homography from automatically determined feature correspondences across two images

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Camera geometry

- be aware of the different coordinate systems (image, camera, world), and know what the principal axis, the image plane and the camera centre are
- be able to **derive** the full camera matrix $P = K\,R\,[\,I \mid -\underline{\tilde{C}}\,]$
- know about all the intrinsic parameters in K, and understand the equation $\underline{\tilde{X}}_{\text{cam}} = R(\underline{\tilde{X}} - \underline{\tilde{C}})$ which essentially defines R and $\underline{\tilde{C}}$
- have a very good grasp on the equation $\underline{x} = P\underline{X}$
- know how a camera matrix can be computed from image $\leftrightarrow$ world point correspondences: be able to **derive** the system on slide 6 of Lecture 13, and know how it is solved in order to find P
- know that the camera matrix can be decomposed into K, R and $\underline{\tilde{C}}$ (end of Lecture 13, but no need to memorise the details of the algorithm)
- you may skip all the content of Lecture 14

Depth from two views

- have a very good understanding of epipolar geometry: know what the baseline, epipoles, epipolar planes and epipolar lines are, and how they lead to the epipolar constraint
- know how to calculate the fundamental matrix from given camera matrices (the **derivation** on slides 7 and 8 of Lecture 15)
- know how to determine epipolar lines in the second (or first) image given points in the first (or second)
- know the equation $\underline{x}'^T F \underline{x} = 0$, where it comes from and what it means
- be able to **derive** the system on slide 5 of Lecture 16, and know how we can then compute a fundamental matrix from image $\leftrightarrow$ image point correspondences (and how we force its rank to be 2 by way of the SVD)
- know how to wrap the calculation of F from point correspondences into a RANSAC framework, to robustly find F and remove errors from a set of image feature matches
- know the details of triangulation: the **derivation** of systems (1) and (2) in Lecture 17, as well as how they are combined and then solved by way of the SVD
- you may stop at the end of slide 7 of Lecture 17; the test will not cover image rectification or any material from further lectures

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