Answer the following questions (Total Marks: 60 M):

1. Fill in the spaces (8 M):

a. The most common sources of image noise are ……., ……., ……., ……., and ……..
b. Image filters in the frequency domain is a way to modify the frequencies of images to perform……., ……., and ……..
c. Templates and Image Pyramids are a way to match a template to the image to perform ……., and ……..
d. The linear blend operator can be used to perform a …….. between two images or videos.
e. In compositing and matting processes, the intermediate representation used for the foreground object between these two stages is called……...
f. When sampling a signal at discrete intervals, the sampling frequency must be ……... to reconstruct the original perfectly from the sampled version.
g. A key advantage of interest points is that they permit matching even in the presence of ……., ……., and ……..
h. In information/document retrieval, the term recall is used instead of ……., whereas the term precision is used instead of ……..
i. In feature tracking, …….. is used if the images are undergoing brightness change, whereas …….. is used if the search range is large.

2. True or False. Correct the false statement (7 M):

a. Computer vision is considered as a forward problem, in which we seek to recover some unknowns given insufficient information to fully specify the solution.
b. In engineering approach, we build detailed models of the image formation process and develop mathematical techniques to invert these in order to recover the quantities of interest.
c. In point operators, $g(x) = af(x) + b$. The parameters a and b are often called the gain and bias parameters. These parameters are said to control brightness and contrast, respectively.
d. Fourier transform of a real signal is symmetric about the origin. The energy of the signal is the same as the energy of its Fourier transform.
e. In template matching, zero-mean correlation response is stronger for higher intensity.
f. GLOH is sampled at a spacing of five pixels relative to the detection scale. It is using a coarser level of the image pyramid to avoid aliasing.
g. PCA-SIFT detector computes the x and y derivatives over a 36x36 patch and then reduces the resulting 3042-dimensional vector to 30 using PCA.
h. In contingency table, the rows sum up to the predicted number of positives (P') and negatives (N').

3. Corner and key point detection (10 M):

a. Write the main outline steps of the basic Harris corner detection algorithm?
b. How are the key points described in SIFT? How is the key point matching done in SIFT technique?

4. Edge detection (10 M):

a. Describe the main stages of Canny edge detector with appropriate equations in each stage?
b. Write four different methods for color edge detection?
c. How to make edge linking by using chain code?

5. Hough Transform and RANSAC (7 M)

a. Write the main steps of circle Hough transform algorithm?

b. After running your favorite stereo algorithm assume you have produced a dense depth map such that for each pixel in the input image you have its associated scene point's (X, Y , Z) coordinates in the camera coordinate frame. Assume the image is of a scene that contains a single dominant plane (e.g., the front wall of a building) at unknown orientation, plus smaller numbers of other scene points (e.g., from trees, poles and a street) that are not part of this plane. As you know, the plane equation is given by $ax + by + cz + d = 0$.
   i. Define a Hough transform based algorithm for detecting the orientation of the plane in the scene. That is, define the dimensions of your Hough space, a procedure for mapping the scene points (i.e., the (X, Y , Z) coordinates for each pixel) into this space, and how the plane's orientation is determined.
   ii. Describe how the RANSAC algorithm could be used to detect the orientation of the plane in the scene from the scene points.

6. Optical Flow(8 M):

a. Calculate the values of the optical flow, normal flow, and parallel flow by using Horn & Schunck technique beginning with smoothness constraint and brightness constancy assumption.
b. Write the main steps of Lucas & Kanade with Pyramids technique.

7. Camera Model and Stereo Vision (10 M):

a. A scene point at coordinates (400,600,1200) is perspectively projected into an image at coordinates (24,36), where both coordinates are given in millimeters in the camera coordinate frame and the camera's principal point is at coordinates (0,0,f) (i.e., $u_0 = 0$ and $v_0 = 0$). Assuming the aspect ratio of the pixels in the camera is 1, what is the focal length of the camera? (Note: the aspect ratio is defined as the ratio between the width and the height of a pixel; i.e., k_u/k_v.)
b. The relationship between a 3D point at world coordinates (X,Y,Z) and its corresponding 2D pixel at image coordinates (u,v) can be defined as a projective transformation using a 3×4 camera projection matrix P.
   i. Can the matrix P incorporate any lens distortions that might be in the camera? Briefly explain.
   ii. Give two lists, one specifying the intrinsic camera parameters and the other giving the extrinsic camera parameters.
   iii. Show how P can be decomposed into a product of matrices that contain elements expressed in terms of the intrinsic and extrinsic camera parameters.
   iv. Give the main steps of an algorithm for computing the matrix P from a single image of a known 3D "calibration object."
c. Write the five main steps of stereo version?

With my best wishes
Dr. Mohammed Elmogy