Introduction to Computer Vision

Final Exam (Example)

- Answer the following 5 questions.
- You may write your answers either in Hebrew or in English.
- Length of exam: 3 hours.

Good luck!

Q1:

Explain in short the following terms:

1. Photoreceptors.
2. Ganglion cells.
3. Visual area V1.

Q2:

For each of the functions $f(x)$ below, answer whether it is possible to discretely sample $f(x)$ without loosing any information (i.e., can we sample $f(x)$ discretely, and be able to reconstruct the continuous $f(x)$ back from its discrete samples?) If the answer is **Yes** - then what constraint must the distance between the samples satisfy? If the answer is **No** - explain why.

(a) $f_1(x) = sin(2x)$.

(b)

$$f_2(x) = \begin{cases} -10 & -\frac{1}{2} \leq x \leq \frac{1}{2} \\ 0 & \text{otherwise.} \end{cases}$$

(c) $f_3(x) = f_1(x) * f_2(x)$ ('$*$' denotes convolution).

Q3:

1. How many point correspondences are needed to recover a homography between two images? Explain why.
2. 12 points are painted on a dark plane. 5 points are colored pure red, 5 are colored pure green, and 2 are colored white. Two cameras take pictures of the plane. One camera is equipped with a red filter (doesn't see pure green color) and one camera is equipped with a green filter (doesn't see pure red color). How many points does each camera see? Is this number sufficient in order to compute the homography relating the two images? Explain why.

Q4:

Let $P_i = (X_i, Y_i, Z_i)^T$, $i = 1, ..., N$ be a set of 3D points in space with image projections $p_i = (x_i, y_i, f)^T = \frac{f}{Z_i} P_i$, where f is the focal length of the camera. The camera undergoes a rigid motion,

$$P'_i = RP_i + t$$

where R is the rotational component and t is the translational component of camera motion. The projections in the new view are $p'_i = \frac{f'}{Z'_i} P'_i$, where f' is the focal length in the new view. All the N points are visible in both images, and the correspondences $p_i \leftrightarrow p'_i$ are given.

Is it possible to recover the depth Z_i of all/any/none of the points in each of the following cases:

(a) Pure camera rotation.

(b) Pure camera zoom ($f' \neq f$).

(c) Pure camera translation.

Show why.

Q5:

We mentioned in class two problems that can be solved by SVD factorization: (1) Recovering of 3D structure and motion from a collection of 2D images, and (2) Photometric stereo (recovering shape and lighting from a collection of images).

Choose ONE of the above problems and answer the following questions:

1. What is the input matrix?
2. What are the underlying assumptions about the scene or the camera that allow you to use factorization?
3. What is the rank of the input matrix if these assumptions hold (assuming there is no noise)?
4. What kind of ambiguity remains after the SVD step? Explain in short how this ambiguity can be removed.