Image Signal Processing

Tutorial – 2 (Solutions): (Mosaicing, Space-invariant Blur)

Q 1. Consider that you are tasked to design a "moving platform" for your mobile phone that is meant to capture multiple images for stitching (all subsets of 6D camera-motions can be allowed in that platform). Assume that you do *not* have depth information of the scene.

1. What all camera motions will you allow in that platform to effectively accommodate planar scenes?
2. What all camera motions will you allow to effectively accommodate *both* planar and 3D scenes?

Sol:

1. All camera motions (6D).
2. Only 3D rotations.

Q 2. Suppose you are trying to fit a homography between two images. Unfortunately, due to the nature of images, SIFT returns a number of false correspondences which amount to 40% of the total correspondences. How many iterations should you run the RANSAC algorithm so that the probability of getting the correct homography is larger than 0.99?

Sol: As long as all the points RANSAC picks in a particular iteration are inliers, it will fit the right homography. The probability that it will pick all inliers in an iteration is 0.6^4. Over n iterations, the probability that it will pick all inliers in at least one iteration is $1-(1-0.6^4)^n$. So the required n is,

$$
\begin{aligned}
1-(1-0.6^4)^n &> 0.99 \\
0.01 &> (1-0.6^4)^n \\
-2 &> n\log(1-0.6^4) \\
n &> 33.18
\end{aligned}
$$

Hence, RANSAC has to be run for at least 34 iterations which is surprisingly low!

Q 3. a) What happens if the aperture size is expanded/shrunk in pin-hole camera model?
b) What is the relation between aperture size and depth of field?

Sol: (a) If the aperture is expanded, more amount of light rays are passed which leads to blurring. If the aperture is shrunk, then less light gets through resulting in noisy and diffraction effects.

(b) A smaller aperture increases the range in which the object is approximately in focus.

Q 4. Considering the space-invariant defocus blur case of $\sigma = 1.2$, answer the following questions:

1. Specify different practical scenes where you can experience this kind of blur.
2. Assume that all scene-points are located after the focal-plane (i.e., $D > w_d$). Suppose that the scene is moved axially (i.e., along the optical axis). What inference can you make of that movement, if the blur obtained is: (1). $\sigma > 1.2$ and (2). $\sigma < 1.2$.
3. Suppose that the scene is moved laterally (i.e., perpendicular to the optical axis). Comment on whether the blur changes at each scene-point (with reason).

Sol:

1. Fronto-parallel scenes that are appropriately placed before or after the focal planes. Also, piece-wise fronto-parallel scenes which spans the previous two planes.
2. $\sigma > 1.2$ - scene moved away from the focal-plane and $\sigma < 1.2$ - scene moved towards the focal-plane.
3. Blur does *not* change because due to fronto-parallel scenes (Z constant), inplane translation warps every neighbouring coordinates equally (i.e., by $\mathbf{KT}/Z$). Therefore, the summation of neighbouring pixels at each image-coordinate remains the same.

Q 5. Consider a camera setting with aperture radius 8 mm, focal length 30 mm, and lens-sensor separation 40 mm. For a sensor resolution of 1280×1280 and sensor width of 10 mm, how many pixels will the blur radius occupy if a scene point is at distance 100 mm from the lens?

Sol: The working distance can be found out as 120 mm. From sensor dimensions, 1 mm = 1280/10 pixels. Therefore, the corresponding blur radius in pixels is (r_b in mm) $\times$ 1280/10 which is 68.2667.