CSE 573: Homework Assignment 4

Name: Sokhey, Harshdeep , UB#50247213

July 16, 2018

1 Solution 1

1.1 Part 1

Exposure Fusion is a technique that blends together multiple exposures of the same scene into a single image.It takes the best pixels from each image in the sequence and combines them to create a fused image.

One of the key challenges is the limited CPU resource for a mobile device, thus the exposure fusion should be able to work in this constraint. Camera sensors on mobile phones may have even less dynamic range than regular cameras, so it may require more shots to capture the same dynamic range. [https://dl.acm.org/citation.cfm?id=1874088]

1.2 Part 2

A **Light Field** describes the amount of light flowing in every direction through every point in space. This information, that is intensity and the direction of the light, is captured by a camera called the **light field camera** or a **plenoptic camera**. A conventional camera records only the intensity of the light in a scene.

The **Lytro** light field camera's sensor captures intensity, color and directional information using an array of micro-lenses instead of a conventional image sensors. This information is used to create 2D or 3D images.

1.3 Part 3

Coded Aperture photography involves creating a mask (code) in the aperture plane that makes the defocus planes different when they register on the sensor, thus making it easier to discriminate. In simple terms, the coded aperture now allows less light but in a known pattern. An object placed at the focal point will be recorded as a sharp image irrespective of the coded aperture, where as an object place farther from the focal point will be seen blurry. Similarly, an object placed closer to the lens will be seen extra sharp.

Coded Exposure photography involves controlling light entering the camera over time. It is different from the Coded aperture as it is concerned with the overall light instead of the light near the senor as in the coded aperture case. It is useful for improving the performance of motion deblurring.

1.4 Part 4

Image averaging is a common method to reduce noise in an image. This method is based on the assumption that the noise is Gaussian in nature and would even out on averaging multiple images.This increases the signal-to-noise ratio (SNR) of the image. Thereby, resulting in a cleaner image. However, averaging may lead to loss of finer detail which can be improved by sharpening the image.

1.5 Part 1

There are 2 cases for special motion:

1. Pure Translation: This case considers no rotation. In this case, points move along lines parallel to **t** and the imaginary extension of these parallel lines intersect at a vanishing point, **v**.General motion can be represented in terms of pure translation of the optical centre, followed by a rotation of the image plane about the optical centre.

2. Pure Planar Motion, involves the translation direction vector (**t**) is orthogonal to the direction of the rotation axis (**a**). The orthogonality imposes the constraint that the $\det F = 0$, thus reducing the degrees of freedom to 6 for a pure planar motion.

1.6 Part 2

The **Fundamental Matrix**, represented by **F**,comprises of points with respect to the stereo image. All pairs of $(x\prime, x)$, homogeneous image coordinates, satisfy the equation:

$$x'^T F x = 0 \tag{1}$$

Equation 1 refers to the condition that the point x' must line on the line Fx. The matrix,**F**, has 7 degrees of freedom and has a rank of 2.

The Fundamental Matrix Song mentions the properties and use of the **Trifocal Tensor**. The matrix F, can be estimated using a coplanar set of points. But the sample set turns out to be degenerate. During estimation without rank deprivation, the epipolar line and epipoles do not coincide. Thus, we use a third view and perform estimation using this **Trifocal Tensor**.

2 Solution 3

2.1 Part 1

In the bar pole illusion, the motion of the bar is around the z-axis making the the motion field along the x-axis and the optical flow along the z-axis. The motion direction of a contour can be regarded as ambiguous, since the motion component parallel to the line cannot be inferred based on the visual input. In terms of the equations of Optical flow,

$$\nabla I^T \cdot \vec{V} = -I_t \tag{2}$$

,where $I = \{I_x,\, I_y\}$, $V = \{V_x, V_y\}$ cannot be solved since it has 2 unknowns. We need another set of equations, given by some additional constraints, to find the unknowns. This is regarded as the **Aperture Problem**.

2.2 Part 2

The **Lucas-Kanade** method estimates the optical flow using the differential method. It assumes optical flow is constant in a local neighborhood of the pixel under consideration and solves the equation 2 by using this pixel neighborhood as an additional constraint. Traditionally, it runs the algorithm on 5x5 window but can be scaled.

2.3 Part 3

Let L be the height of the object from the z-axis, moving at a velocity v. Given, at time t=0, the object is at :

$$D(0) = D_0 \tag{3}$$

At time t it is at :

$$D(t) = D_0 - vt \tag{4}$$

Let t' be the time of impact such that:

$$D(t') = D_0 - vt' = 0 \tag{5}$$

Let $l(t)$ be the image size of the object, given by

$$l(t) = \frac{fL}{D(t)} \tag{6}$$

Taking derivative with respect to time:

$$\begin{aligned} l'(t) =& \frac{dl(t)}{dt} \\ =& fL\frac{d(D(t)^{-1})}{dt} \\ =& fL\frac{-1d(D(t))}{D^2(t)dt} \end{aligned}$$

Given and from previous equations, we can say,

$$\begin{aligned} D(t) &= D_0 - vt \\ \frac{d(D(t))}{dt} &= -v \\ l\prime(t) &= fL\frac{v}{D^2(t)} \end{aligned}$$

Taking ratios we get,

$$\frac{l(t)}{l\prime(t)} = \frac{fL}{D(t)}\frac{D^2(t)}{fLv} = \frac{D(t)}{v} = t' \tag{7}$$

Thus, the time of impact is t'.