Chapter 9
Comparison of Focus Measures under the Influence of Various Factors Effecting their Performance

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ABSTRACT

This chapter presents a comparison of eleven focus measures which are categorized in four main classes or groups. The performance of focus measures is evaluated by considering various factors that might hinder their smooth operation. These factors include illumination variation, texture reflectance, object distance variation, distance variation in between consecutive frames, and various types of noise including Gaussian, Shot, and Speckle noise. The focus measures are tested for depth estimation for 3D shape recovery using Shape From Focus (SFF) techniques. Three measures are used to compare the performance of the focus measures, namely, visual inspection as a qualitative measure and root mean square error and correlation as quantitative measures.

INTRODUCTION

Depth map estimation for three-dimensional shape recovery from one or multiple observations is a challenging problem of computer vision. This depth map can subsequently be used in interpolation and approximation techniques and algorithms leading to the recovery of a three dimensional structure of the object, a requirement of a number of high level vision applications. However, the basic problem of imaging systems, such as the digital-camera, is that depth information is lost while projecting a 3D scene onto 2D image plane.

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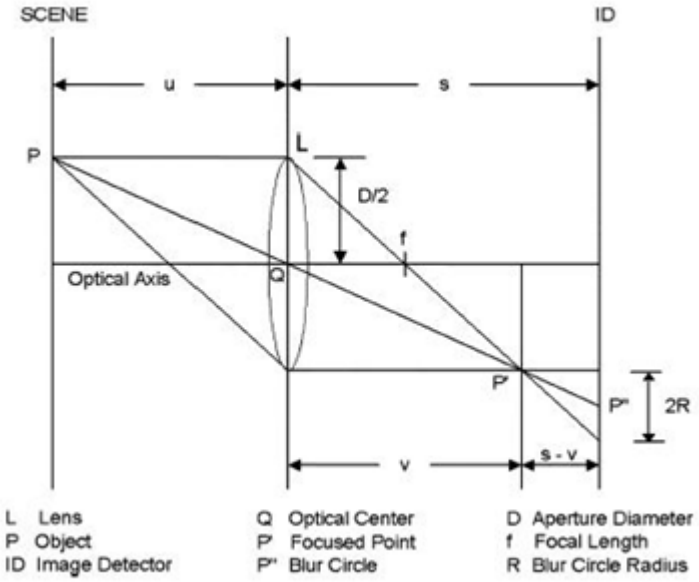
Figure 1. Image formation of a 3D object



Therefore, one fundamental problem in computer vision is the reconstruction of a geometric object from one or several observations.

There are a variety of 3D Shape estimation methods that try to address this problem. They include Shape From Focus, Defocus, Texture, Motion etc. They are generally referred to as Shape From X and are classified as optical passive methods. In this chapter, we limit our discussion to Shape From Focus (SFF). SFF is based on focus which is an accommodation cue (Mennucciy, 1999) that can be measured from blurring in the image, which increases with the distance of imaging system from the plane of focus. Techniques that retrieve spatial information, by looking at multiple images of the same scene, taken with different geometry or position of imaging devices, are classified as Shape From Focus (SFF).

The objective of Shape From Focus (SFF) is to find out the depth of every point of the object from the camera lens. Hence, finally we get a depth map which contains the depth of all points of the object from the camera lens where they are best focused or in other words, where they show maximum sharpness.

The basic image formation geometry is shown in Figure 1. In Figure 1, the parameters related to the camera are already known. We need to calculate 'u', i.e., depth of object from the lens. We make a depth map by calculating 'u' for every pixel. We can use the lens formula to calculate 'u'. If the image detector (ID) is placed exactly at a distance v, sharp image P' of the point P is formed at v (see Figure 1). Then the relationship between the object distance u, focal distance of the lens f, and the image distance v is given by the Gaussian lens law:

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \tag{1}$$

Therefore, in SFF, a sequence of images that correspond to different levels of object focus is obtained. A sharp image and the relative depth can be retrieved by collecting the best focused points in each image. The absolute depth of object