Development of a portable three-dimensional measurement system using stereo vision and optical flow algorithms.

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In this work we combine optical flow and stereo vision algorithms, for obtaining a three dimensional object tracking system capable to follow changes varying in time. The optical flow algorithms allow the study of displacements varying in time and by using a stereo vision system we can retrieve the coordinates of the objects observed in the three axes (x, y, z) and therefore the reconstruction of such objects. A stereo vision system was implemented in Matlab using two identical webcams placed in parallel geometry. The ultimate goal of this project is to have a portable and affordable system that takes into account the disadvantages intrinsic of the implementation such as limited resolution and distortion presented on it for being webcams. Experimental results and system limitation analysis will be presented.

1. Introduction

It is known that for the design of new products it is necessary to make dynamic measurements of displacements and deformations in solid bodies. In this work we present a solution to a specific problem of dynamic tracking in lateral, radial and depth directions by using image analysis of video of a stereo vision system. The images are analyzed using optical flow algorithms [1, 2, 3, 4] and stereo vision [5, 6, 7]. The procedure presented in this paper allows us to follow an object, measure its displacement, reconstruct its surface and measure the distortion.

2. Methodology

Two identical webcam with a 5mm focal length each were placed in parallel and to calibrate the cameras, we took a sequence of 30 images of a flat chessboard regular pattern. In the following subsections we will present the proper description of the two techniques used and the experimental result obtained. The optical flow allows the study of displacement experienced by dynamic objects in two dimensions over time, when the changes are very small. By using a stereo vision system, we can retrieve the coordinates of the objects observed in the three axes (x, y, z) and therefore the reconstruction of such objects. A stereo vision system consists of two cameras where the reconstruction of the object is done in four stages in a sequence of images taken from two cameras simultaneously: The first stage is called calibration and leads us to obtain the extrinsic, and intrinsic parameters and a model lens distortion by using a chessboard flat pattern. The calibration parameter where each pattern is placed on the space is presented in figure 1. By taking a plain sample with a determined structure we will analyze its variation. Figure 2 shows the images taken by the cameras and the superposition of them by color in order to shows the lateral variation obtained between them.

![Figure 1. The spatial configuration of the two cameras and the calibration planes.](image-url)
Figure 2. a) Stereo rectified image camera left, b) stereo rectified image camera right, c) red-cyan composite view of the stereo image. This lateral distribution is used to obtain a disparity map that later will be associated with the depth of the sample. Figure 3 presents the disparity map of the sample. By simplicity the border were superposed on the disparity map for better appreciation of the reconstruction.

Figure 3. Disparity map. Show the disparity map. Brighter pixels indicate objects which are closer to the camera.

By the calibration process and the disparity map obtained we were able to obtain the 3d surface reconstruction of the validity regions. Figure 4.

Figure 4. Surface reconstruction in real scale of the white region retrieved

Figure 5 and figure 6 shows a line profiles corresponded of the 3d reconstruction. The horizontal profile presents a standard deviation of 0.25 mm and the vertical profile is 0.1 mm.

Figure 5. Horizontal profile marked in blue on the disparity map

Figure 6. Vertical profile marked in blue on the disparity map

3. Conclusions
Stereo vision system was implemented with the aims of implement optical flow algorithms. In this submission we presented the analysis of a plain sample to verify the validity of the reconstruction. Tracking of moving samples will be presented.

4. References