International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 04 | Apr -2017 www.irjet.net p-ISSN: 2395-0072

STEREO VISION

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Abstract - Stereoscopic vision delivers a sense of depth based on binocular information but additionally acts as a mechanism for achieving correspondence between patterns arriving at the left and right eyes. We analyse quantitatively the cortical architecture for stereoscopic vision in two areas of macaque visual cortex. Stereo Vision is an area of study in the field of Machine Vision that attempts to recreate the human vision system by using two or more 2D views of the same scene to derive 3D depth information about the scene. Depth information can be used to track moving objects in 3D space, gather distance information for scene features, or to construct a 3D spatial model of a scene. As an emerging technology, Stereo Vision algorithm are constantly being revised and developed, and as we will discuss in this project, many alternative approaches exist for implementation of a Stereo Vision system. This project introduces Stereo Vision as an area of current international research, presents some interesting applications of Stereo Vision, and discusses implementation of a Stereo Vision system.

Key Words: Stereoscopic, Visual cortex, Stereo Vision, Correspondence, Depth information.

1.INTRODUCTION

Calculating the distance of various points in the scene relative to the position of the camera is one of the important tasks for a computer vision system. A common method for extracting such depth information from intensity images is to acquire a pair of images using two cameras displaced from each other by a known distance. As an alternative, two or more images taken from a moving camera can also be used to compute depth information. In contrast to intensity images, images in which the value at each pixel is a function of the distance of the corresponding point in the scene from the sensor are called range images or density stereo map. Such images are acquired directly using range imaging systems. Two of the most commonly used principles for obtaining such range images are radar and triangulation. In addition to these methods in which the depth information is computed directly, 3-D information can also be estimated indirectly from 2-D intensity images using image cues such as shading and texture. These methods are described briefly in this chapter.

1.1 Objectives

- With stereo vision, we can see WHERE objects are in relation to our own bodies with much greater precision.
- We can see a little bit around solid objects without moving our heads.
- We can even perceive and measure "empty" space with our eyes and brains.

1.2 Literature Survey

Numerous methods of implementation for stereo vision disparity mapping have been established in the past few years. This can be observed from the table listed in below.

S.no	Method	Year	Author	Technique
1	Sum of squared differences (SSD)	1994	Fusiello et al.	Sum of squared differences
2	Normalised cross correlation (NCC)	1997	Satoh	Correspondence
3	Rank Transform (RT)	2002	Gac et al.	Rank Difference
4	Census Transform (CT)	2004	Humen berger et al.	Hamming Distance

Chart-1: Existing Methods Of Stereo Vision

1.2 Algorithm

1.3.1 Semi-Global Matching(SGM)

Semi-Global Matching (Hirschmüller, 2005 and 2008) successfully combines concepts of global and local stereo methods for accurate, pixel-wise matching at low runtime.

The core algorithm considers pairs of images with known intrinsic and extrinsic orientation. The method has been implemented for rectified and unrectified images. In the latter case, epipolar lines are efficiently computed and followed explicitly while matching (Hirschmüller et al., 2005).

1.3.2 Advantages of SGM algorithm

- Semi-global matching allows high-density point clouds of the first reflective surface to be rapidly and automatically extracted from stereo-imagery.
- One advantage of SGM is that these point clouds look and feel much like lidar point clouds. SGM models can be colorized from the available imagery

1.3.3 Matching Costs

Radiometric differences often occur due to different imaging characteristics of the camera due to the vignetting effect, different exposure times, etc, and properties of the scene like non-lambertian reflection, which is viewpoint dependent, changing of the light source (e.g. movement of the sun), etc. The imaging characteristics of the camera can be calibrated and images corrected accordingly. However, the properties of the scene and lighting are typically unknown. Thus, the matching cost, which measures the dissimilarity of corresponding pixels, has to handle radiometric differences. The original SGM implementation (Hirschmüller, 2005) used Mutual Information (MI) as matching cost. MI has been introduced in computer vision by Viola and Wells (1997) for the registration of images from different sensors and is extensively used in the medical image community. With MI, the global radiometric difference is modeled in a joint histogram of corresponding intensities. Kim et al. (2003) applied MI to pixel-wise matching with Graph Cuts by Taylor expansion. MI has been successfully adapted for SGM (Hirschmüller, 2005 and 2008). The pixel-wise MI matching cost is very suitable for matching unrectified images, as corresponding image parts may be rotated or scaled against each other, which is irrelevant if only individual pixels are considered.

2. Pathwise Aggregation

Pathwise Aggregation SGM uses a slightly different global cost function as shown in equation (1) for penalizing small disparity steps, that are often part of slanted surfaces, less than real discontinuities.(2) The cost function is optimized similarly to scanline optimization (Scharstein and Szeliski, 2002), which can be seen as a subset of dynamic programming. It efficiently optimizes equation (2) in a time that is linear to the number of pixels and disparities. However, the optimization is performed in 1D only (i.e. typically along scanlines) and not in 2D, which is NP complete. Due to individual optimizations along scan lines, streaking artefacts are inherent in scanline optimization and dynamic programming methods. The novel idea of SGM is the computation along several paths, symmetrically from all directions through the image. As shown in Figure 2, eight paths from all directions meet at every pixel. Each path carries the information about the cost for reaching a pixel with a certain disparity. For each pixel and each disparity, the costs are summed over the eight paths. Thereafter, at each pixel, the disparity with the lowest cost is chosen. This formulation ignores occlusions. Thus, arbitrary results occur in occluded areas. However, occlusions can be identified by computing the disparities separately for the left and right image and comparing the results by a left-right consistency check. Further post-processing steps are possible for cleaning up the disparity image. More details about SGM aggregation, matching of multiple and huge images is given in the literature (Hirschmüller, 2008).

2.1 Flow diagram

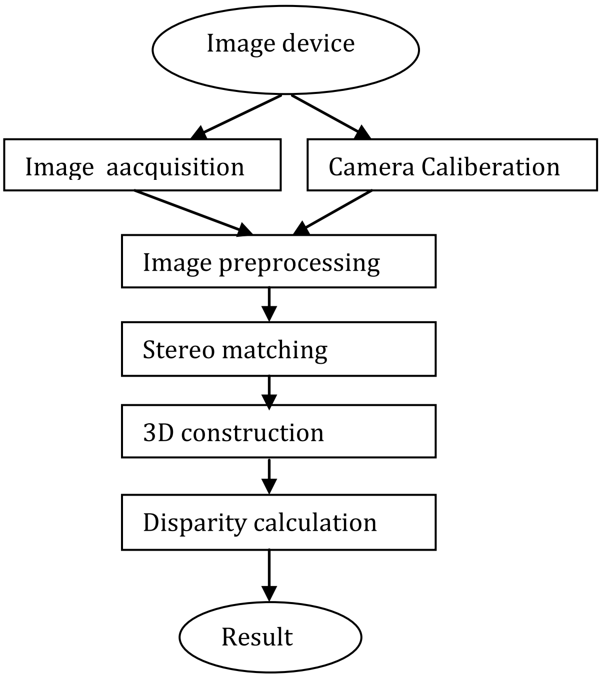

Fig-1: 3D view construction process and disparity calculation

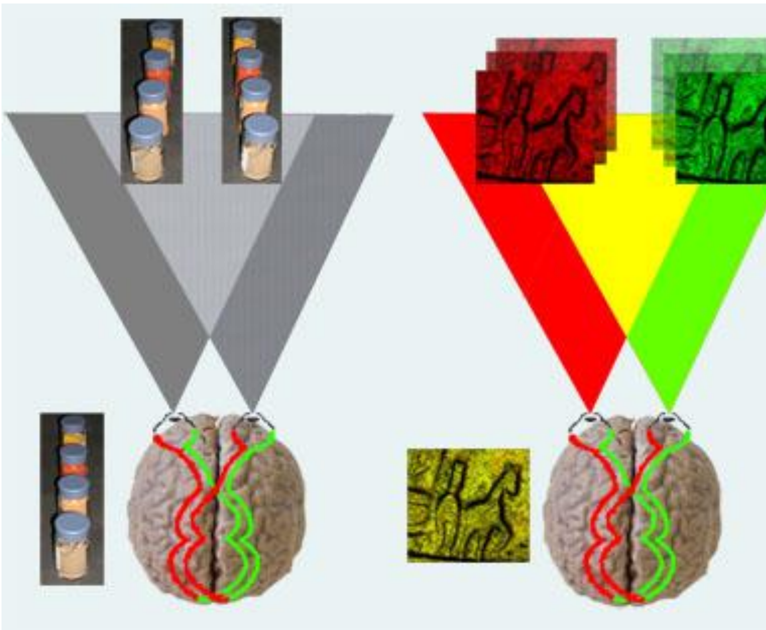

Fig -1: Name of the figure

2.2 Techniques

2.2.1 TRIANGULATION-the principle underlying stereo vision. The technique for gauging depth information given two offset images is called triangulation. Triangulation makes use of a number of variables; the center point of the cameras (c1, c2), the cameras focal lengths (F), the angles (O1, O2), the image planes (IP1, IP2), and the image points (P1, P2).

- The 3D location of any visible object point in space is restricted to the straight line that passes trough the center of projection and projection of the object point.
- Binocular stereo vision determines the position of a point in space by finding the intersection of the two lines passing through the center of projection an the projection of the point in each image

Two main problems of stereo vision

I. The correspondence problem
II. The reconstruction problem

2.2.1.1 The correspondence problem

Finding pairs of matched points such, that each point in the pair is the projection of the same 3D point. „

- Triangulation depends crucially on the solution of the correspondence problem. „
- Ambiguous correspondence between points in the two images may lead to several different consistent interpretation of the scene.
- Efficient correlation is of technological concern, but even if it were free and instantaneous, it would still be inadequate.
- The basic problems with correlation in stereo imaging relate to the fact that objects can look significantly different from different viewpoints .
- It is possible for the two stereo views to be sufficiently different that corresponding areas may not be matched correctly „ Worse, in scenes with much obstruction, very important features of the scene may be present in only one view.
- This problem is alleviated by decreasing the baseline, but the accuracy of depth determination suffers. „
- One solution is to identify world features, not image appearance, in the two views, and match those (the nose of a person, the corner of a cube).

2.2.1.2 The reconstruction problem

- Given the corresponding points, we can compute the disparity map.
- The disparity can be converted to a 3D map of the scene.

2.3.Depth Estimation

The main advantage of stereovision is the correspondence between differences in the X axis and the distance between the object and the cameras either once the cameras have been calibrated or the required assumptions have been made. The absolute distance of the centroid abscissas (in pixels) is measured for every matched pair of regions. This gives a non-calibrated measure of the depth map. In this work the left image is used as the background and used to compute the depth map. This is an arbitrary choice, without any loss in generality, based on the fact that the left image is the last one to be segmented and processed and, then, the footprint image (that is unique in the algorithm) corresponds to this at the end of the segmentation process.Obtaining depth information is achieved through a process of four steps.

- Firstly the cameras need to be calibrated. After calibrating the cameras the assumption is made that the differences in the images are on the same horizontal or epipolar line [4].
- The secondly step is the decision as to which method is going to be used to find the differences between the two images. Once this decision is made, an algorithm to obtain the disparity map needs to be designed or decided on.
- The third step is to implement the algorithm to obtain the disparity information.
- The final step is to use the disparity information, along with the camera calibration set in step one, to obtain a detailed three dimensional view of the world.

There are many algorithms used to find the disparity between the left and right images. Additionally, there is a large amount of ongoing research into finding quicker and more accurate algorithms. However here we are implementing disparity maps using sgm algorithm.

2.4Assumptions/Limitations

There are two main assumptions that are made when using stereo vision algorithms. These are:

1. The Corresponding image regions are similar
2. A point in one image must be matched by only one point in the other.

These assumptions lead to the following problem areas; the first problem area is occlusion. This is when pixels or features in one image are missing in the other. There are many ways this is dealt with, however to reduce processing time, most algorithms consider this to be an unimportant case. Leaving this important feature out, produces errors in the disparity maps and therefore in the depth estimation. There is research specifically in this area to specifically identify occluded regions [12]. The other problem area is repetition. This is when features or areas are repeated along the epipolar line. This can lead to false match errors. There are algorithms to deal with these problems, but all require additional processor time. So we are using SGM algorithm which is efficient in solving all the problems.

3. CONCLUSIONS

The stereo matching problem remains a challenge for computer vision researchers. A literature survey of the latest stereo vision disparity map algorithms is provided here and all cited algorithms are categorized according to the processing steps with which they are associated in the taxonomy of Scharstein and Szeliski. Becoming familiar with the state-of-the-art algorithms for stereo vision disparity mapping is a time consuming task. In this survey of the latest developments in the area of stereo matching algorithms, the processing steps composing such an algorithm and their software-based implementation was therefore performed and presented to assist in this task. The qualitative measurement of the accuracy of such algorithms was also discussed.

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