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V-DETECT: An Obstacle Detection System for Visually Challenged People Using Grid Algorithm

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Abstract

According to the report published by the World Health Organization in 2017, nearly 253 million people are visually impaired. Out of these, 36 million are totally blind. A range of Obstacle Detection methods have been created to assist the visually impaired people in mobilization. However, the main problem concerned with it is the tracking error of the obstacles leading to some false results. To overcome this problem, we have come up with a new algorithm called as Deformable Grid algorithm. This is normally a grid like structure that gets deformed based on the obstacles with high risk of collision. Experiments have showed that this system has outperformed all the existing conventional methods on terms of processing time and accuracy.

Keywords: Time to Contact, Deformable Grid, Risk of Collision, Electronic Travel Aids.

I. INTRODUCTION

Mobilization is found to be one of the major problems among all visually impaired people. With the advancement in technology, new Electronic Travel Aids [1] have emerged in the market. These devices consists of sensing elements like Ultrasonic sensor [2], Laser Scanner [3], Time of Flight Camera [4], Stereo vision Camera[5], [6] and Monocular Vision Camera. The monocular Vision Camera is the most popularly used because it has high resolution to interfering ambient light and robust to the limitations of operating range. This Camera is also used in many electronic devices like mobile and tablets etc. [7]-[9].

For detection of obstacles in the fore time, the estimates of Time to Contact is used. Time to Contact means the time required to reach the camera from the obstacle, taking the relative speed to remain constant throughout the time period. Some methods use optical flow [10]-[13] for the calculation of TTC. The 2D motion vectors of the objects are captured directly by the camera through a point called the Focus of expansion. TTC is calculated by the geometric relationship between FOE and motion vectors. But results from FOE are affected badly by noise.

Other set of methods use variation in motion between frames. Some of these methods are SIFT method, SURF method [14]-[16] and local neighborhood based on Delaunay triangulation [17], [18]. Complexity in computation of these methods is very high and not accurate for the estimation of TTC. Also Delaunay Triangulation method suffers from unwanted connection between different objects. Some corrections for this problem was given by Chae *et al* [19]. Also a framework of Homographic method was suggested by Tapu *et al* [20]. But these methods produce results with large depth variations.

In this paper, we have suggested an obstacle detection algorithm based on Deformable Grid. It is a regular grid shaped structure. Its deformity is fully concerned with that of the motion of the obstacles in the field view of the camera. The detection of an object as obstacle is based on the Risk of collision. This method has found to reduce the tracking error and improve the ego-motion of the camera.

The result of this system is compared with other conventional methods to show the performance enhancement of our system.

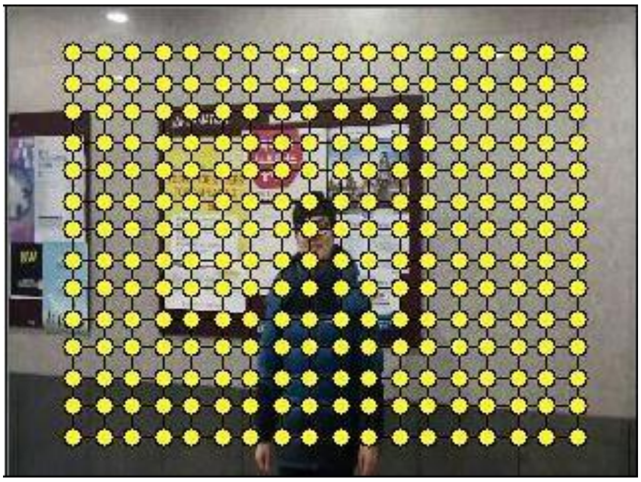

Figure 1. Deformable Grid Structure

II. PROPOSED SYSTEM

Fig.1 shows the deformable grid with a set of vertices and edges with a 4-boundary system. The vertices are at regular intervals and are connected by means of edges.

The deformable grid is said to have a property called as floating property. This property states that the vertices are free to move according to the current position of the vertices in its current frame. The magnitude of the vertice movement denoted by a variable Pi is high when the camera is closer to the obstacle.

As the obstacle moves away from the camera and disappears from the field of view the magnitude decreases.

These vertices behave like elastic materials so a force Fi acts on the vertices to move freely. Similarly, after deformation the vertices are restored to its original position by a force indicated as Fv.

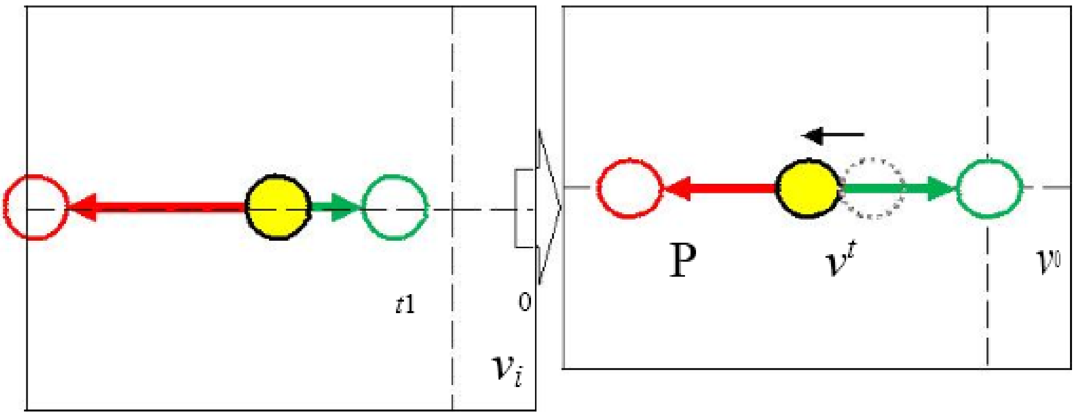

Figure 2. Floating Property of DG

If any region is found to be deformed, it is observed that the vertices in a particular region are located at a certain distance from their original position and the edges also are founded to be elongated or compressed.

Based on this, a Boolean function is formulated such as

Svi= 1, if C1(vi) or C2(vi) = 1 0, otherwise.

This denotes an unstable vertex. All the unstable vertices of a frame are combined to get the risk of collision. An aggregate information is obtained by means of block based voting and component labeling method.

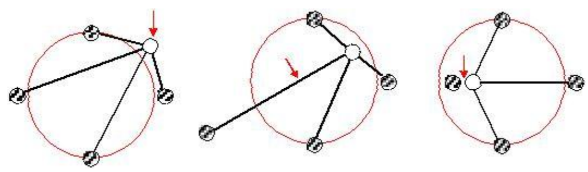

Figure 3. Unstable Vertices condition.

III. ERROR CORRECTION IN DG

From fig.3 we can see that the vertex is out of its region and the edges are also too elongated and compressed. Due to this, chance of false positive rate arises. So obstacles is detected even if the obstacle is not present. The vertices and the edges must try to attain their original position as soon as possible in each frame. To get through this problem, all unstable conditions are eliminated by a special algorithm of collision warning. But important information about the system may be lost. So to quickly do this work an iterative procedure is employed. That is, they must satisfy certain boundary conditions. Firstly, the unstable vertices are moved to their regions for satisfying the condition C1(vi)=0. Then the next adjustment is done by the condition C2(vi)=0. These two adjustments are done iteratively for all the vertices.

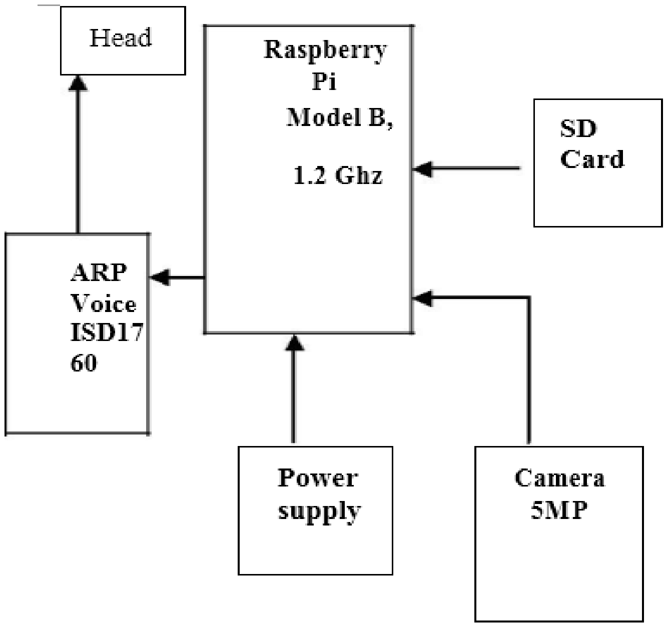

Figure 4. Block diagram

IV. HARDWARE AND SOFTWARE DESIGN

The project tries to provide an interactive system with the user consisting of a central processing embedded board. The block diagram of the system is shown in the fig.2 The system consists of the following modules:

a) Microcontroller: 32-bit raspberry bi embedded processor which serves as the overall controller.

b) SD Card: An 8 GB External memory card to accommodate the software and data classifiers.

c) Camera: A RGB camera module with 5MP to capture the environment.

d) Power Bank: A 5v power supply

e) Voice Playback: ISD1760 module, to give commands to take appropriate action.

f) Headphones: To serve as an interfacing medium to the user.

The communication among the various peripherals is based on I2C bus protocol. The system works on Raspbian Jessie OS. The software is built in the Raspberry Pi IDE environment.

V. **RESULT**

The general assumptions done in the test process are the obstacle become dangerous if its TTC is smaller than 2 seconds when the distance between the camera and the obstacle is reducing at a gradual rate of 1 m/s.

The real type scenario is tested by means of two cases. In the first case the obstacle is approaching the fixed camera and in the next case the camera is moving towards the obstacle. The frame rate is 25 frames per second. The iterative algorithm of Lucas Kanade [21] algorithm is used to get the motion vectors.

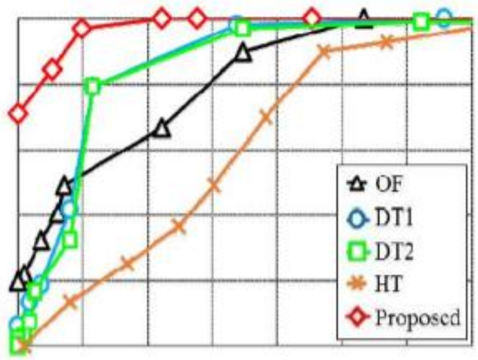

Fig. 5(a)

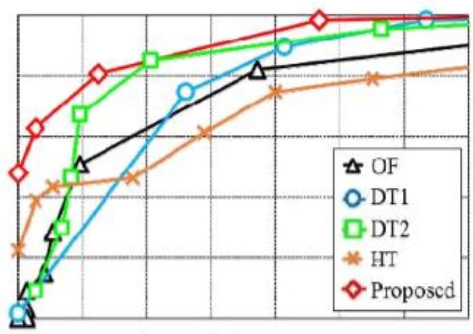

Fig. 5(b)

The above charts give the performance of the Dg method with other conventional algorithms as a plot of TFR vs. FPR for both the cases.

The comparison of processing time is given in the below table:

FIG	OF	DT	HG	DG
A	5.21ms	7.03ms	6.30ms	3.53ms
B	8.32ms	11.63ms	9.48ms	4.72ms

V. CONCLUSION

A new obstacle detection system is proposed by Deformable Grid algorithm. The deformation was found to be with respect to the movement of the obstacles. The tracking error is reduced and the ego-motion of the camera is improved to a greater extent. The method was also compared with other conventional methods available.

As a future work, the system can be enhanced to work for plain walls and pitfalls.

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