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Robo Cart – An Autonomous Enhanced Artificially Intelligent Robot

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Abstract— An autonomous robot (Robo Cart- named by the authors) is designed and developed to detect, avoid obstacles and navigate in the shortest path in an environment with ambience of light. It detects the obstacles and identifies them using a red laser as a source of information, it also plans its path of navigation from the start point to its destination with the shortest path using the A* algorithm implemented on the robot. It also manifests the depth map of the obstacle's image using Gaussian filter derivatives using a single stereo camera vision to find the distance of one obstacle. The distance of each and every obstacle in the path is calculated using the distance approximation algorithm of laser intensity and the background.

Key words: MATLAB R2013a, Image Processing, Depth map, A* algorithm

I. Introduction

As studied so far, the existing system uses a specific algorithm to detect the obstacle using a red laser as a source of information of the obstacle [3] and avoid it and pass on the respective commands for the robot to navigate in a path. The record of the detection of the obstacle is stored in a text file for reference [4].

It does not provide the information of the distance of the obstacle from the robot during the detection during its navigation. It does not record the dynamic video information of the entire robotic navigation along its path. It has no simulation of the shortest path as well as no speech of the motion of the vehicle.

The proposed system faces all those challenges with ease as it uses a red laser light, upon whose intensity the distance of the obstacle from the robot is identified.

The wireless camera unit captures video [4] streams and sends to the base station for analyzing and recording the same. After recording, the entire video is stored in the disk of the base station [6]. The speech provoke is obtained in this system in order to make the users aware of the motion of the vehicle [14]. The estimation of the depth of the captured snapshot which consists of the real time environment along the presence of the obstacle to clarify the existence of the obstacle as the depth information of the entire snapshot will be known [1].

The simulation and the implementation on the hardware part of the robot of the shortest path of an autonomous robot is achieved by A* algorithm [2] to find the shortest path. The GUI is provided for the users to dynamically specify the initial point (source) of the vehicle as well as the target (destination) point along with the likely existence of one or many obstacles along the path of the vehicle navigation in the simulation.

The implementation of the shortest path on real-time Robo Cart is made by image, pattern recognition as the source obstacle and the destination obstacle would be identical to make the autonomous robot start when the command is given to navigate and match the source obstacle with the destination obstacle to stop its navigation automatically. The navigation is guided by the simulation results and the voice provoke of the users.

The proposed system uses very powerful techniques which includes platform, which has a wide range of toolboxes to help overcome drawbacks of the existing systems and an Arduino open source, hardware independent interface. As the system uses wireless media for communication, it uses a great technology called ZigBee Technology, MATLAB R2013 a coding platform and toolboxes such as Image Processing, Image Acquisition and the Serial Communication.

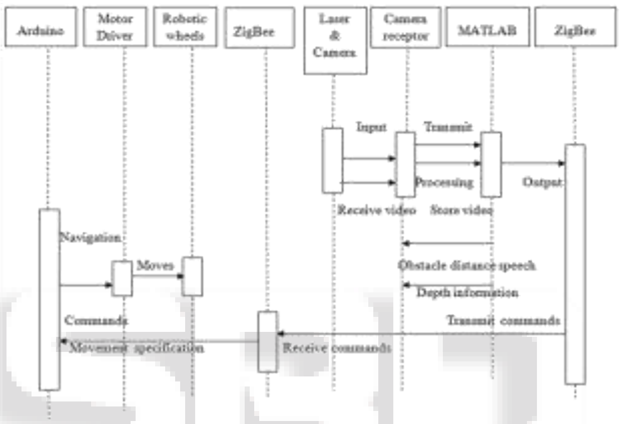

Fig. 1: Sequence Diagram of the execution

The fig 1 represents all the functional requirements of this project. It specifies most of the modules applied in this project and their interactions with other components. The base station processing is the major part of this project. All activities of the path planning are done in the base station and it controls the wheels of the robot [5].

II. MIPT Path Planner

MIPT Path Planner (MATLAB Image Processing Toolbox Path Planner) involves two phases namely; Firstly, Image Acquisition which is the criteria to capture and acquire the video stream or image frames. Secondly, Image Processing which is the method to process either the video stream or the image frames according to the algorithms designed.

The MIPT provides the output for the obstacle identification using the RGB intensity of all the pixels and the circular dot like region of the red laser dot [5]. It does not require the image virtual segmentation into regions and then based upon which the robot's navigation follows.

MIPT works so accurate to even detect a red colored object, because when the red laser dot falls on the red colored obstacle, the intensity of 'R' in the RGB of the red laser is much higher than that of the obstacle in color red [4].

A. *Video Store Algorithm*

- Step 1: *Create an object* of video input type.
- Step 2: *Start* the execution of the object.

- Step 3: Record the video stream.
- Step 4: Store or *record* the video in *"avi"* format.
- Step 5: *Save* the video in the local disk of the base station [6].

B. Distance of an Obstacle Algorithm

- Step 1: Start the wireless camera and view the video.
- Step 2: Calibrate the wireless camera.
- Step 3: Construction of a rectangle is made to identify the region of interest to find the distance in each image frame captured at a given time interval from the video.
- Step 4: Differentiate the foreground from the background in the captured image frames using the rectangle construction in the foreground.
- Step 5: Find the area of the rectangle for every image frame. The area forms the approximate value of the distance of the obstacle from the robot.
- Step 6: The distance of the wall from the robot is also taken care of, as the red laser dot falls on the wall; it differentiates the wall from the red laser dot. Only if the red laser dot falls on the wall, distance is calculated otherwise the distance is 0 [11].

C. Depth estimation of the snapshot algorithm

- Step 1: Create an object of the type to represent the image snapshot.
- Step 2: Use Gaussian filters to find the derivatives of the pixel values [10].
- Step 3: Create the 1st derivative of the Gaussian filters and set the critical value.
- Step 4: Create the 2nd derivative of the Gaussian filters and set the critical value.
- Step 5: Create the 3rd derivative of the Gaussian filters and set the critical value.

The one-dimensional Gaussian filter has an impulse response given by

$$g(x) = \sqrt{\frac{a}{\pi}} \cdot e^{-a \cdot x^2}$$

The frequency response is given by the Fourier transform

$$\hat{g}(f) = e^{-\frac{\pi^2 f^2}{a}}$$

f,The ordinary frequency. These equations can also be expressed with the standard deviation as parameter

$$g(x) = \frac{1}{\sqrt{2\pi} \cdot \sigma} \cdot e^{-\frac{x^2}{2\sigma^2}}$$

The frequency response is given by

$$\hat{g}(f) = e^{-\frac{f^2}{2\sigma_f^2}}$$

By writing a as a function of σ with the two equations for $g(x)$ and as a function of σ_f with the two equations for $\hat{g}(f)$ it can be shown that the product of the standard deviation and the standard deviation in the frequency domain is given by

$$\sigma \cdot \sigma_f = \frac{1}{2\pi},$$

Where, the standard deviations are expressed in their physical units, e.g. in the case of time and frequency in seconds and Hertz.

In two dimensions, it is the product of two such Gaussians, one per direction:

$$g(x,y) = \frac{1}{2\pi\sigma^2} \cdot e^{-\frac{x^2+y^2}{2\sigma^2}}$$

Where, x is the distance from the origin in the horizontal axis, y is the distance from the origin in the vertical axis, and σ is the standard deviation of the Gaussian distribution.

- Step 6: Plot all the derivatives of the Gaussian filters in-order to get the information of the depth estimated value of the snapshot to confirm the existence of an obstacle in the navigational path.

D. Shortest Path Simulation and implementation using A Algorithm*

- Step 1: *Create* a graph of the type *grid* to plot the graph.
- Step 2: Select the *initial position* of the vehicle using the pointer of the mouse of the base station.
- Step 3: Select the *final position* of the vehicle using the pointer of the mouse of the base station.
- Step 4: Select the *obstacle positions* for the vehicle using the pointer of the mouse of the base station.
- Step 5: *Calculate* the pixel difference between the initial point to the first occurrence of the obstacle and between each and every obstacles present in the grid of the graph plot and for the final obstacle position to the target position.
- Step 6: If the *difference calculated is less* when on a comparison with other obstacles, then there *exists a shortest path* from one point to another else discard that value and calculate the difference between other point on the grid of the graph.

III. SNAPSHOTS AND RESULTS

Fig. 2: Robo Cart and its working. Re-printed with permission [4].

The fig 2 shows the Robo Cart that has been developed and the real-time working of it to detect obstacles and plan the shortest path.

Fig. 3: The processed image of detection of an obstacle.

The fig 3 shows the processed image of the detection of an obstacle even though the obstacle color is red. This would prove the MIPT accuracy level of working.

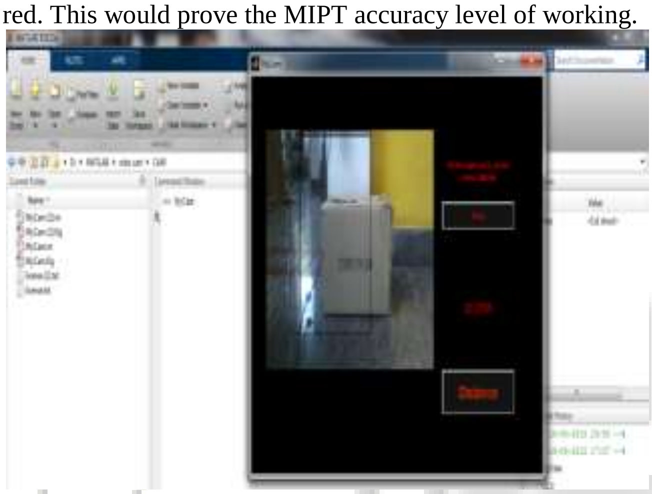

Fig. 4: The results obtained for calculating the distance of an obstacle. Re-printed with permission.

The fig 4 shows the results obtained to calculate the distance of an obstacle with the foreground and background separation of the image and the calibration of the camera placed in the Robo Cart. The calibration is achieved with the Image Processing calibration code of the MATLAB R2013 a commands.

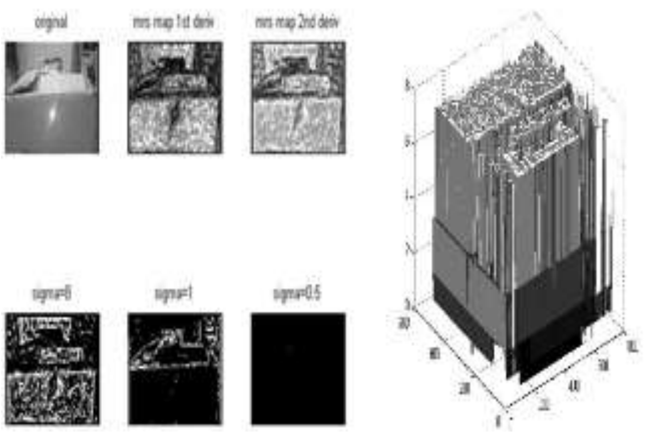

Fig 5: The results of the Gaussian Filter for depth map of any input image.

The fig 5 shows the depth map of an obstacle detected by the robot. The various sigma values are considered for the Gaussian Filters.

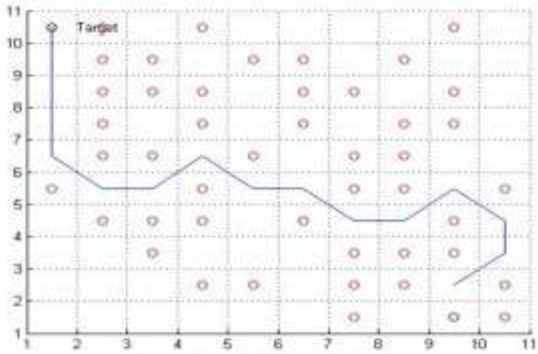

Fig. 6: The shortest path simulation of the A* algorithm. Re-printed with permission.

The fig 6 shows the shortest path simulation of the A* algorithm, having this as a reference model it is implemented on Robo Cart to find the shortest distance of its navigation from the source to destination.

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