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# Implementation of Vision Based Robot Navigation System in Dynamic Environment

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***Abstract*—** In this paper the implementation of robot navigation in the dynamic environment using vision based approach is proposed. Vision based robot navigation has been a fundamental goal in both robotics and computer vision research. In the visual guidelines based navigation system, the motion instructions required to control the robot can be inferred directly from the acquired images. In this work, the algorithm is designed for an intelligent robot which is placed in an unknown environment. The robot detects the signs from a captured images using features based extraction and moves according to the signs. Also, it is able to tackle an encountered obstacle in its way. The robot successfully detects different signs like right, left and stop from an image.

***Keywords***- *Vision based Autonomous Mobile Robot; Sign Detection; Obstacle Detection*

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## I. INTRODUCTION

Nowadays, various robotic systems are used in many industrial applications. They are applied to perform jobs like welding, packaging etc. Even there are many autonomous robots built on mobile platforms, which require a new level of control flexibility. Unlike industrial robots, they move around in their environments, which is often highly unstructured and unpredictable. Now various markets are emerging for this type of robotic systems and applications. Entertainment applications and different types of household or office assistances are the primary targets in this area of development. However existing applications of autonomous systems have one problem in common, which is navigation. If the working environment is unknown or dynamic, such as in households or offices, the navigation problem becomes more severe. In order to overcome such problems, the system needs to use sensory data to extract representations of the environment. Data gets collected and interpreted by the robot's control system so as to fulfill the navigation task using an appropriate methodology. Vision based Robot navigation is a system that allows an autonomous robot to move throughout its environment under constraints, such as avoiding obstacles. Vision is capable of supplying the robot with detailed information from its environment.

## II. SYSTEM MODEL DESCRIPTION

The system model comprises of both software and hardware. Hardware model is a mobile robot consists of the supporting camera, ATmega8 microcontroller, serial communication through RS232 cable, two DC motors. The mobile robot is powered by a single 12 V 3 Amp battery. These things are mounted on a mobile robot. The system software has two levels. The task of navigation is performed by Microcontroller ATmega8 based algorithm. While the detection and identification of navigation signs and sending the information about the path to follow is implemented using Matlab based software.

## III. WORKING

The block diagram in figure 1 is the complete system of the mobile robot. It's important blocks are described below. Camera is mounted on a wheeled robot and connected to the PC motherboard. Camera continuously captures the images at the speed of 30 frames per second. The captured images are used by the software module, which is present in the PC. The algorithm is implemented to process these images and output is fed to the Microcontroller, which is also mounted on Robot. The output of the PC motherboard is given serially to the Microcontroller through RS-232 cable.

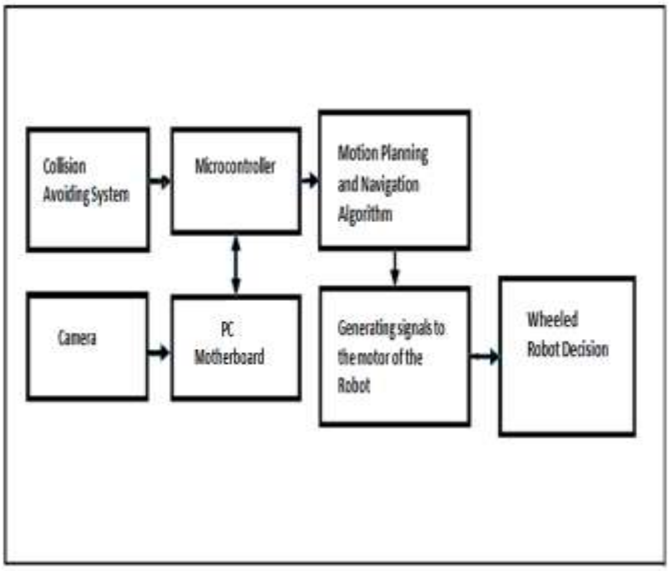


Figure 1. Block diagram of mobile robot

According to the sign detected, the PC motherboard generates the output as a command given to the microcontroller. The microcontroller receives the command and generates a signal, which is given to the motors of the robot to move in the direction according to the command with respect to the detected sign. The Collision Avoidance System is used to tackle the obstacles comes in between the robot navigation path. The collision avoidance consists of an IR sensor that is attached in front of the robot. When the obstacle is detected it take another path to avoid it.

## IV. METHODOLOGY

The robot is placed in a controlled indoor environment where direction sign boards are placed along its path systematically but with random order i.e. the track is not the predefined; so it is completely a dynamic path, where the signs are prepared in bold red color. This is the only consideration for this algorithm for the robot navigation. The working methodology of the vision based robot navigation is as follows:

- Capture the video using a camera. Take the snapshot of the video regularly.
- Resize the image. Enhance the image using the Adaptive Histogram Equalization.
- Convert the RGB image to grayscale image and then into binary image.
- Find the percentage of red pixel in the image. If this size is in between the minimum and maximum set threshold range then fill the image with the holes.
- Extract the red colored region from the image, which is nothing but direction sign placed along the path. Use region properties to find the size of the area of the extracted image.
- If the percentage area is less than minimum threshold set value then system will detect nothing and robot will continuously move in the forward direction.
- If the percentage area covered is more than the stop threshold set value. PC motherboard will send the command to microcontroller to stop the system.
- Otherwise divide the image vertically into two halves i.e. Left & Right and check the covered area in both the halves.
- If the left area is more than the right area which indicates the left sign and then PC motherboard will send the command to microcontroller to move the robot the towards left direction and microcontroller will send the signal to the motor in such a way that the motor turn 90 degree towards left.
- If the left area is less than the right area which indicates the right sign and then PC motherboard will send the command to microcontroller to move the robot the towards right direction and microcontroller will send the signal to the motor in such a way that the motor turn 90 degree towards right.

While moving, if an obstacle comes in between the robot, the algorithm is designed in such a way that robot will take the following decision:

- First robot will stop, then it will move backward by a predetermined distance.
- Then turn 45 degree towards right & move forward by a predetermined distance.
- Then take 45 degree towards left & move forward by a predetermined distance.
- Again take 45 degree towards left & move forward by a predetermined distance.
- Then again take 45 degree towards right and finally the robot will come to its original path & then move continuously in the forward direction. The intermediate delay after each primitive actions are introduced.

## V. EXPERMENTAL RESULTS & ANALYSIS

This section present the results of various experiments performed. Each experiment in this project is in the controlled environment. The system captured stream of images directly from USB camera in a real-time, it process an image, analyze the information with a proposed algorithms and send the result to the mobile robot microcontroller via serial interface of PC motherboard in the form of direction to be followed. Various experiments performed are described below.

### *A. Operation None*

In this experiment, the left sign was displayed for the robot, which can be seen in the first axes and in the second axes, it shows the red component in the captured image with 4.18% threshold value, which is below minimum threshold set value and hence in the third axes it shows the Operation None. The results are as shown in figure 2.

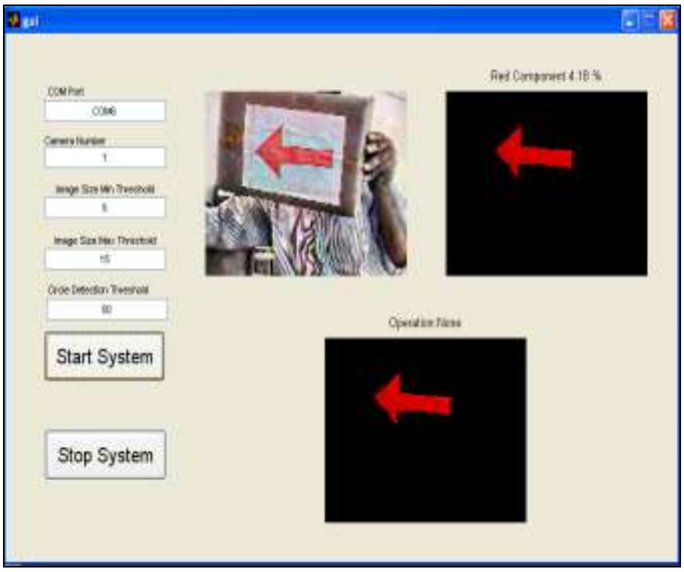


Figure 2. Experimental Result of Operation None.

### *B. Detection of left sign by the robot in a captured image.*

In this experiment, the left sign was displayed for the robot at various angles which can be seen in the first axes. In the second axes, it shows the percentage of red component in the captured image, which is in between minimum and maximum threshold set value. The robot detects the left sign which is shown in the third axes where Operation Left is shown in the message which conveys the command to the robot to move left. The results are as shown in figure 3.

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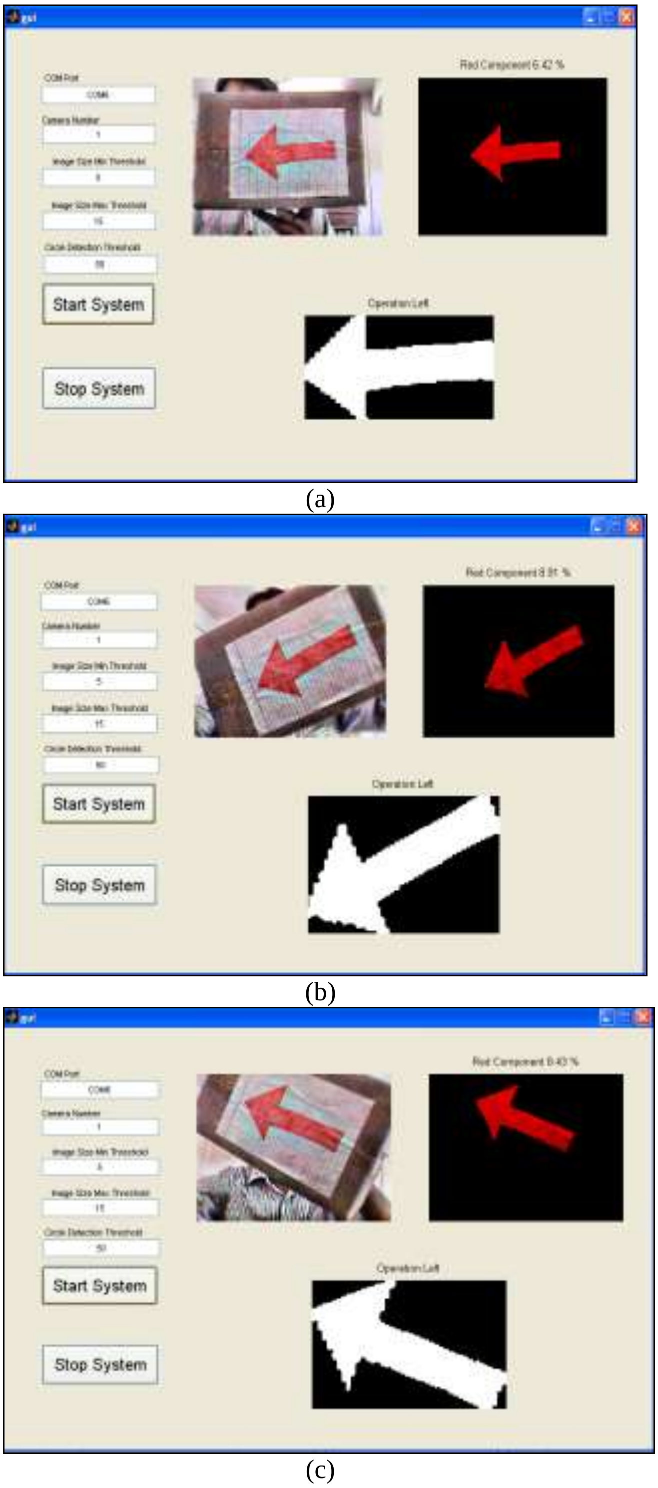
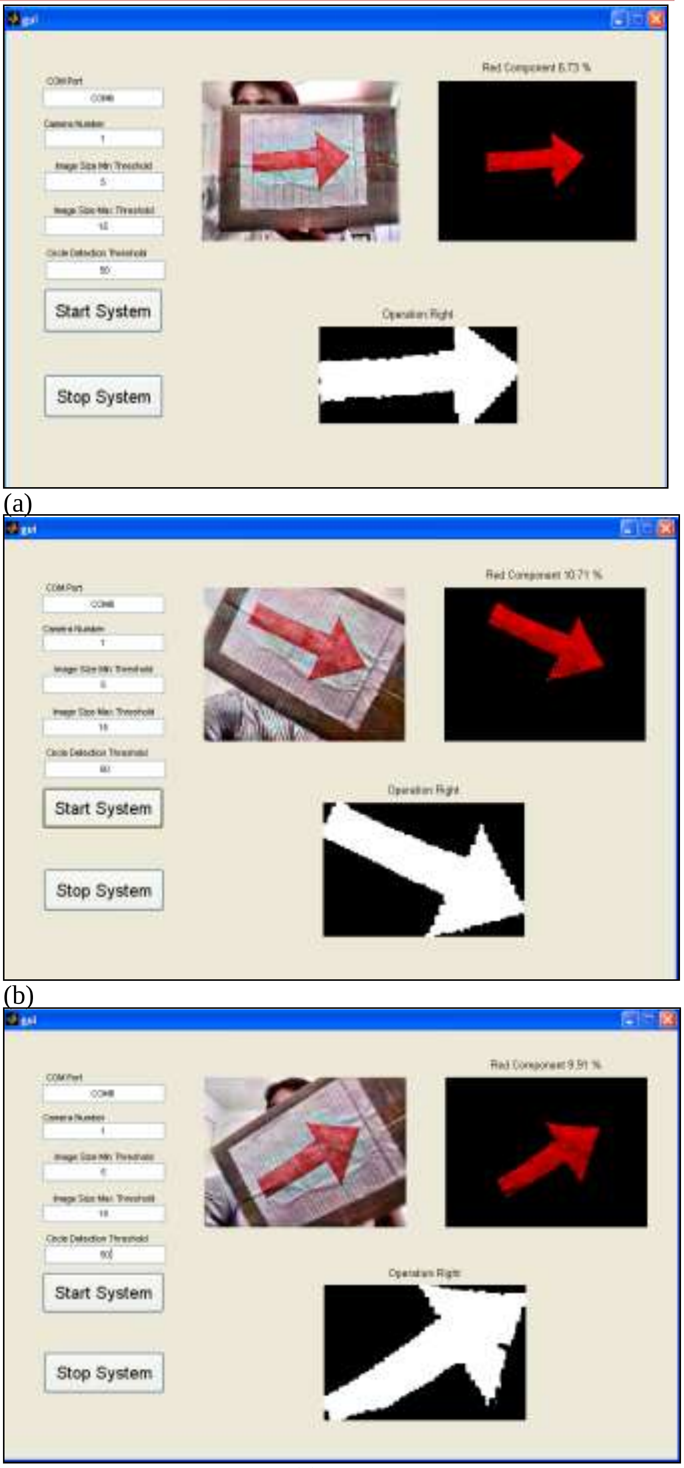



(a) (b) (c)

*Figure 3. Experimental Results of Operation Left, tilted at various angles.*

*C. Detection of right sign by the robot in a captured image.*

In this experiment, the right sign was displayed for the robot at various angles which can be seen in the first axes. In the second axes, it shows the percentage of red component in the captured image, which is in between minimum and maximum threshold set value. The robot detects the right sign which is shown in the third axes where Operation right is shown in the message which conveys the command to the robot to move right. The results are as shown in figure 4.




(a) (b) (c)

Figure 4. Experimental Results of Operation Right, tilted at various angles.

*D. Detection of stop sign by the robot in the captured Image.*

In this experiment, stop sign was shown to the robot, which can be seen in the first axes. In the second axes, it shows the red component in the captured image with **13.72%** threshold value, which is in between minimum and maximum threshold set value. Hence in the third axes, it shows the stop sign is detected and therefore Operation Stop is shown in the message

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which convey the command to the robot to stop. The results are as shown in figure 5.

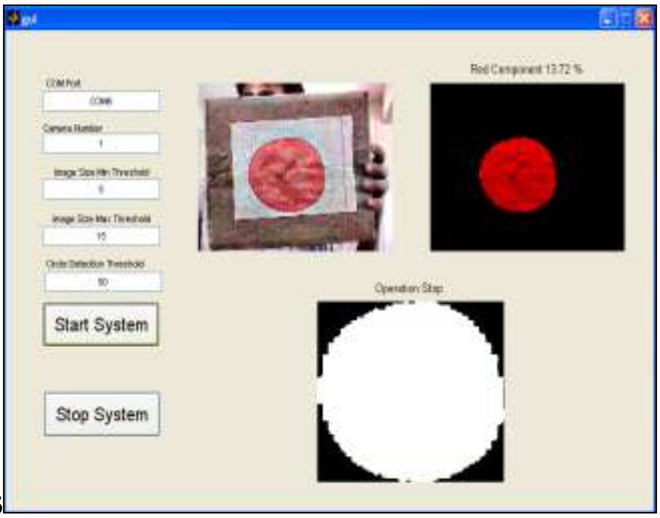


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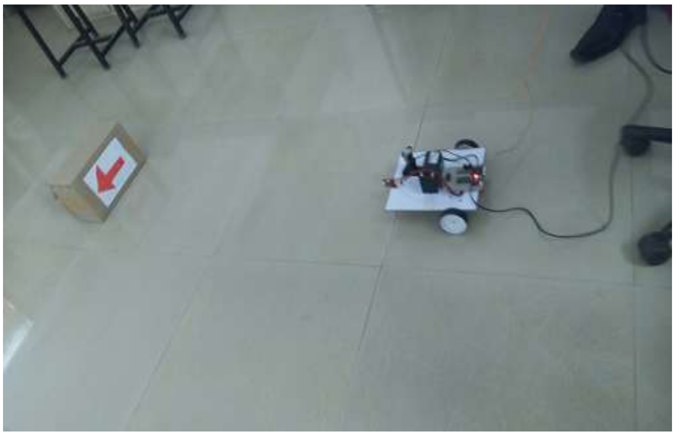
Figure 5. Experimental Result of Operation Stop.

*E. Experimental Set Up*

The set up of the robot navigation is shown in figure below. In this set up the sign boards are placed in such a way that, the robot will detect the signs and moves according to it in the environment.

Figure 6. Experimental setup of robot navigation

The below images show the demonstration of robot's left sign detection and successful movement towards left direction. In the first and second image, the robot is approaching towards the sign, detects it and in the third image it takes the decision to move left as shown in figure 7.



(a)

(b)

(c)

Figure 7. The sequence of images shows the demonstration of the left sign detection & successful movement towards left, by the robot.

The images in figure 8 show the demonstration of robot's right sign detection and successful movement towards right direction. In the first and second image, the robot is approaching towards the sign, detects it and in the third and fourth image it takes the decision to move right

(a)

(b)

. **(c)**

(d)

Figure 8. The sequence of images shows the demonstration of the right sign detection & successful movement towards right by the robot.

*F. Readings taken while the robot was in a steady condition.*

TABLE I. EXPERIMENTAL ANALYSIS WHEN ROBOT IS STEADY.

| Sr. No. | Sign | No. of times experiment performed | No. of times detected correctly | Accuracy of the sign detection of the system ( % ) |
|---|---|---|---|---|
| 1 | LEFT | 50 | 48 | 96 % |
| 2 | RIGHT | 50 | 47 | 94 % |
| 3 | STOP | 50 | 49 | 98 % |

*G. Readings taken while the robot was under navigation condition*

TABLE II. EXPERMENTAL ANALYSIS WHEN THE ROBOT IS NAVIGATING.

| Sr. No. | Sign | No. of times experiment performed | No. of times sign detected correctly | Accuracy of the sign detection of the system ( % ) |
|---|---|---|---|---|
| 1 | LEFT | 30 | 28 | 93.33% |
| 2 | RIGHT | 30 | 27 | 90% |
| 3 | STOP | 30 | 27 | 90% |

TABLE III. EXPERMENTAL ANALYSIS WHEN THE ROBOT IS NAVIGATING.

| Sr. No. | Sign | No. of times experiment performed | No. of times robot moved correctly | Accuracy of the robot movement ( % ) |
|---|---|---|---|---|
| 1 | LEFT | 30 | 24 | 80 % |
| 2 | RIGHT | 30 | 26 | 86.67 % |
| 3 | STOP | 30 | 25 | 83.33 % |

## VI. CONCLUSION

In this work, vision based mobile robot navigation system is successfully navigated robot using appropriate navigation signs. More specifically, it considered the challenges of detecting the different sign and tackling the obstacles in an unknown indoor environment. The navigation performance of the proposed system is good and remains unaffected due to intensity of ambient light. The robot is able to detect the sign at many different angles and in different lighting conditions. The only condition of this system is that any other red colored object, except sign boards, should not be present in the environment. The proposed algorithm and robot system successfully demonstrated the navigation through the unknown dynamic environment

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