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Autonomous Navigation Mobile Robotic System

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***Abstract*— The project "Prototype of the Mobile Robotic System for the Autonomous Navigation" is to develop a fully automatic robot which senses the area around it (detect objects in the path) while the robot is in motion and move accordingly. This application uses camera vision as a main component and Infra-red sensor technology as a sub system to sense objects which are present in front of the robot. The processing of the image is done on a computer using MATLAB-2013a in Windows OS, and the image can also be processed using ECLIPSE IDE and OpenCV(Open Source Computer Vision)in LINUX for better performance and the decision for the robot is taken according to the algorithm devised. In this paper we discuss the results obtained from the Matlab. An IR ranging device arrangement is also embedded, which senses any objects ahead of it and accordingly the robot change its direction to avoid any collision. Thus we ensure that even in cases of circumstances leading to errors in the output of the image processing algorithm, a decision can be made using the input from the IR sensors.**

The obstacle avoidance problem in robotics has been researched extensively and there are many well established algorithms for this problem. However, most of these algorithms are developed for large robots with expensive, specialised sensors and powerful computing platforms.

***Index terms*—Mobile Robotic System, Autonomous Navigation, IR Sensor, OpenCV.**

I.INTRODUCTION

A robot is a mechanical or virtual artificial agent, usually an electro mechanical machine guided by a computer program or an electronic circuitry. Robots can be autonomous or semi autonomous and range from humanoids to industrial robots. Commercial and Industrial robots are now in widespread use performing jobs more cheaply or with greater accuracy and reliability than humans. They are also employed for jobs which are too dirty, dangerous or dull to be suitable for humans such as space exploration, cleaning floors, mowing lawns, and waste water treatment. Robots are widely used in manufacturing, assembling and packing, transport, earth and space exploration, surgery, weaponry, laboratory research, and mass production of consumer and industrial good.

Line follower and path followers are a class of robots that are in autonomously navigating by following a given path or line. They have multitudes of applications like stocking and retrieving materials in a warehouse, delivering products used in driverless cars etc.

An **autonomous robot** is an intelligent machine that performs desired tasks with a high degree of autonomy. Some modern autonomous robots are "autonomous" within the strict confines of their direct environment.

Some of the characteristics of an autonomous navigation robot are:

- Gain information about the environment without human assistance.
- Moving along the calculated / pre-planned route.
- Computing safe and unsafe areas on the surface within the field of vision.
- Mapping the free path with 2-D / 3-D vision.

In order to realize and design algorithms, a physical hardware or software simulation environment is essential. In this project a Robotic hardware is used which is commercially known as FIREBIRD V, which is an Omni-directional Robotic Research Platform shown in the Figure 1, it has three Omni direction wheels which are placed at 120^0 with respect to one another. Fire bird V supports ATMEGA2560 (AVR), P89V51RD2 (8051) and LPC2148 (ARM7) microcontroller adapter boards. MATLAB-2013a is used for processing of the image.

The main objective of this project is to develop an algorithm which can be incorporated on a Omni-

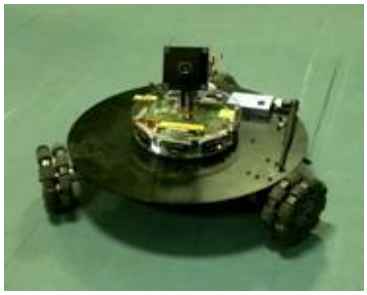

Fig 1: Omni directional Robot under Test.

directional robotic platform to sense the area around it (detect objects in the path) while in motion and move autonomously.

This application uses camera vision as a main component and Infra-red sensor technology as a sub system to sense objects which are present in front of the robot. The processing of the image shall be done on a computer using MATLAB-2013a and the path decided accordingly. An IR ranging device arrangement is also embedded which senses any objects ahead of it and accordingly the robot changes its direction to avoid any collision.

The Motivations for the project are the few autonomous navigation robots available across the world, and several on-going researches in the design of autonomous navigation robot.

Here the limitation is that memory of the micro controller used in the prototype is limited, thus image captured by the camera is sent to the workstation (here computer), where image is processed in MATLAB-2013a and command is sent back to workstation to actuate the rover.

The above problem can be overcome by using a controller with more flash memory enables us to program the code in the fire bird kit. Thus this improves the speed of operation of the system and makes it more reliable.

The navigational algorithm used in the robot so built can be used or modified for future projects in order to get information about places not accessible to humans for instance as in a rover.

Methodology to design and implement the proposed project is as given below:

- The images are captured and sent to the Work Station wirelessly for processing.
- Decision is taken at the Work Station and sent back to Robot using WiFi module.
- Based on received decision and response from the IR sensors, microcontroller controls the direction of movement.
- Measurements obtained using Position encoder is returned to the Work Station wirelessly to keep better track of Robot position

II. LITERATURE SURVEY

Canny John et,al.[1] the design of the Canny edge detector was based on the specification of detection and localization criteria for edges in a mathematical form. It was necessary to augment the original two criteria with a multiple response measure in order to fully capture the intuition of good detection. In this paper a method called feature synthesis where fine to coarse integration of information is done from operators at different scales and show that the step edge detector improves the performance as the operator point spread function is extended along the edges.

Paul et. al.[2] In this paper a technique called scale multiplication is used which improves the Canny Edge Detector [1]. The detection and localization criteria are derived from the scale multiplication. And shows how the small loss in the detection criterion, the localization criterion can be much improved by scale multiplication, for Canny edge detector. The product of the two criteria for scale multiplication is greater than that for a single scale, which leads to better edge detection performance [3] has a good description of the various edge detection techniques.

Alan J. Lipton et,al.[4] describes the method for extracting moving targets from a real-time video stream. Moving objects are detected using the pixel wise difference between consecutive image frames. Targets in the images are classified with a temporal consistency constraint where it is classified into three categories: human, vehicle or background clutter. The System identifies targets of interest, rejects background clutter. Target recognition and multiple target tracking are some of the disadvantages of this paper.

Reyes, Napoleon H et,al [5] focuses on color as the primary discriminating feature.Since the color is greatly affected by so many underlying factors, so fuzzy logic is incorporated into the system to address the problem of uncertainties in color object classifications. This paper mainly deals with defining the object colours, and to recognize robot fast and accurately.

Aziz N. N. A., et al. [6] provides novel real time system for tracking moving objects across distributed cameras ,with non overlapping views using edge and colour features, and provides trade off in-terms of its speed and accuracy. For single camera the algorithm works efficiently, but for multiple cameras the accuracy degrades, because as

the number of objects starts increasing, the algorithm fails to assign the object label. The performance of the algorithm depends on the accuracy, which can be improved by utilizing additional features such as texture.

Chiang,Jen-Shiun,etal.,[7], this paper mainly deals with object recognition and self-localization system for the humanoid robot. There are two methods, In the object recognition part, the real-time vision based method is based on the adaptive resolution method (ARM). In the self-localization part, adaptive vision-base self localization system (AVBSLS),which uses artificial neural network technique to adjust the humanoid robot position adaptively. The experimental results indicate that the proposed system is not easily affected by the light illumination. The improved IBDMS method is used to measure the distance between the robot and the landmark. Compared with IBDMS, the improved IBDMS approach has less average error.

Chen Chien hsu, et. al., [8], presents a distance measurement method based on pixel number variation of images for digital cameras by referencing to two arbitrarily designated points in image frames. Based on an established relationship between the displacement of the camera movement along the photographing direction and the difference in pixel counts between reference points in the images, distance from an object can be calculated via the proposed method. Another similar distance measurement technique is demonstrated in [9]. [9] Improves the accuracy of the method proposed in [8] by using artificial neural networks.

Shajahan J.A.,et al [10], image processing is implemented by the combination of edge detection, thermal image processing, scale space analysis and virtual 3D sizing in 2D image processing and color detection for military purposes. MATLAB is used to perform the image processing operations.

Ribeiro. F.,et al [11], Traditional two wheels differential drive normally used on mobile robots have manoeuvrability limitations and take time to sort out. A three wheel drive with omni- directional wheel has been tried with success, and was implemented on fast moving autonomous mobile robots.

Oliveira, Hélder P., et al [12], this paper is similar to the one explained in [11], This paper presents model for mobile omni- directional robots with three and four wheels. Where the same mechanical platform can be used with three wheels and then the same model can be disassembled and reassembled for the four wheeled configuration. The results obtained after comparison says that in the four wheeled configuration the current consumption was much larger than when compared to the three wheeled configuration. More than three wheels provides redundancy, i.e, many combinations of motor speeds can provide the same Euclidean movement. The kinematics of movement is shown in [13].

Vision is one of the most powerful and popular sensing method used for autonomous navigation. Compared with other on-board sensing techniques, vision based approaches to navigation continue to demand a lot of attention from the mobile robot research community. This is largely due to its ability to provide detailed information about the environment, which may not be available using combinations of other types of sensors. One of the key research problems in mobile robot navigation is the focus on obstacle avoidance methods. In order to cope this problem, most autonomous navigation systems rely on range data for obstacle detection. **Ultrasonic sensors**, **laser** rangefinders and **stereo vision** techniques are widely used for estimating the range data. However all of these have drawbacks.

Ultrasonic sensors suffer from poor angular resolution. Range sensors are also unable to distinguish between different types of ground surfaces, such as they are not capable of differentiating between the sidewalk pavement and adjacent flat grassy areas. The computational complexity of the avoidance algorithms and the cost of the sensors are the most critical aspects for real time applications. Vision based systems avoid these problems and are able to provide appropriate solution to the obstacle avoidance problem.

Disadvantages of few of the non-image based methods:

- Ultrasonic sensors and IR range sensors suffer from poor angular resolution.
- IR Range sensors and ultrasonic sensors are unable to distinguish between different types of ground surfaces
- Region of operation of LIDARS and SONARS is limited.

Advantages of image processing algorithms

- Ability to provide detailed information about the environment (resolution is high).
- Applicable to a larger range of systems and more applications.

Edge detection based path finding algorithm has used a spherical omni directional robot with CCD camera. This camera captures a single RGB image which is then converted to grey scale. On this grey scale image a Median filtering is applied to reduce

the noise. Then a well know edge detection algorithm-'Canny' is applied to the image.

Disadvantages of this algorithm are:

- Single image based navigation hence not very accurate.
- Real time changes in the environment not accounted for.
- The proposed algorithm works only for symmetrical indoor environment with straight paths.

III. PROPOSED SYSYEM

The robot which has been adapted for this project is commercially known as "Firebird V-Omni direction robot" which has a camera mounted on top of the Rover with AV transmitter to transmit the images to the AV receiver. The output of the receiver is connected to a TV tuner card which intern is connected to the computer.

The Fig 2 shows the system used during the experimentation, the external workstation (here computer) is used to process the images and make decision as the computational power of the on board microcontroller of the robot is limited. As the external workstation is used, the images need to be transmitted to the workstation.

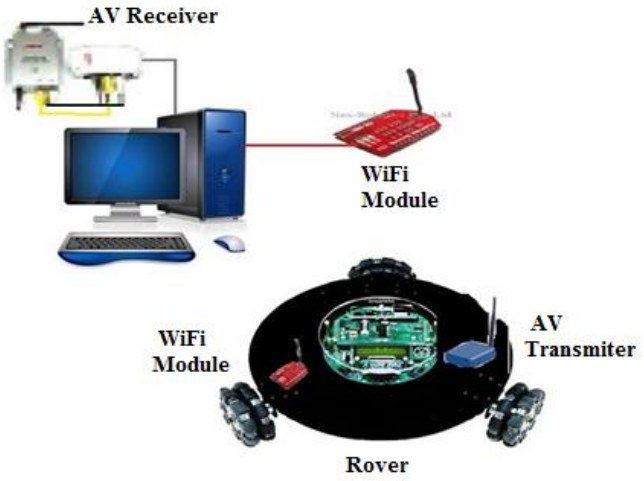

Fig 2: System used during the experimentation.

The images which are received are processed using the MATLAB-2013a software. The acquired image are of size 720x480. The algorithm are coded using MATLAB-2013a and the decision made using the algorithm is sent to the robot using a WiFi module. The other end of the WiFi module is connected to workstation receives the data from the workstation in UART protocol at baud rate of 115200, converts it to TCP/IP protocol and transmits wirelessly. The WiFi module present on the robot receives the data as packets and converts it to UART data and sends it to microcontroller Atmel Atmega 2560 UART port. Microcontroller actuates the robot based on the data sent by the workstation.

IV.RESULTS OF IMAGE PROCESSING ALGORITHM

In the proposed project, the image captured from the webcam is sent to the workstation (i.e Computer) through the sender WiFi module and received on the receiving WiFi module which is connected to the computer and is processed in MATLAB by applying Edge detection Algorithm (here Canny edge detection algorithm) is applied. The Original image is shown in the Fig 3(a) and the result obtained after canny edge detection is shown in the Fig 3(b).

Fig 3(a): Original Image.

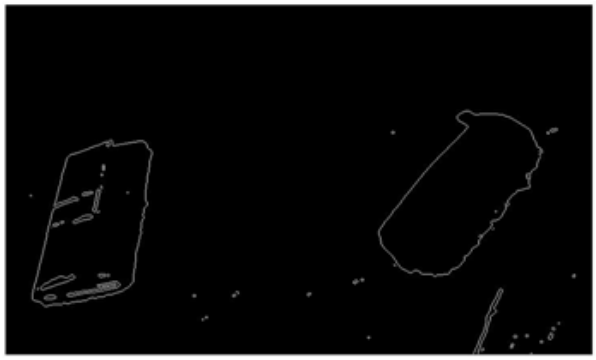

Fig 3(b): Output of the edge detected algorithm.

V.CONCLUSION

The project "Prototype of the Mobile Robotic System for Autonomous Navigation" is being carried out at ISAC ISRO Bangalore. This project uses robotic hardware commercially known as FIREBIRD V, which is an OMNIDIRECTIONAL ROBOT. In the proposed project the robot will be fully automated that senses the area around it moves on a predefined track autonomously. This application uses wireless camera vision as a main component , which is mounted on top of the robot and Infra-red sensor technology as a sub system to

sense objects which are present in front of the robot. The processing of the image is done on a computer using MATLAB-2013a and the decision for the robot is taken according to the algorithm devised.

The Future work involves testing the same image using ECLIPSE IDE and OpenCV (Open Source Computer vision) Library for better performance. And testing the IR range device, which senses any objects ahead of it and accordingly the robot change its direction to avoid any collision.

VI. ACKNOWLEDGEMENT

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