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PATH PLANNING FOR A ROBOT WITH SINGLE CAMERA

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Abstract: Path Planning is a specific problem in case of robots. The problem is to compute a path for the robot that can guide it to move in the specific environment. Using this path the robot can reach its goal without colliding to any of the obstacles. A path planning algorithm must ensure that if a solution is possible, it is found and returned. It must also ensure that the algorithm gives its result within the specified amount of time. Path planning usually provides output to the robotic control. This consists of a controller which is supposed to move the robot in the desired path. We present a method to navigate a mobile robot using a camera. This method determines the path for the robot to transverse, while avoiding obstacles along the way. The environment is first captured as an image using an overhead camera. Image processing methods are then performed to identify the existence of obstacles within the environment.

I. INTRODUCTION

The development of robots that are able to assist humans in their day-to-day tasks has become a popular research area over the last few years. Basically, these robots share common control architecture. Some software components were partially modified according to the target robot system. Localization is one of the most important issues for successful autonomous navigation, and a great number of localization methods have been proposed so far. Vision based systems have many advantageous properties such as lightness, compactness and power saving ability. They are also ubiquitous, making cameras ideal sensing devices to be embedded in robots. Vision has great intuitive appeal as it is the primary sense used by humans and most animals for navigation. Vision allows a wide range of essential functions in robotics, for example, obstacle detection, people tracking and visual serving. Mobile robots systems are driven by control systems. The architecture of these control systems provides different blocks to accomplish specific robotic tasks. Traditionally, the research in the field of Robotics is focused on the algorithms used to accomplish fundamental tasks, like path planning. The path-planning task, part of a mobile robot navigation system, involves searching and finding the path in the environment for the robot to navigate avoiding the obstacles.

A. Path planning

Path planning is a term used in robotics for the process of breaking down a desired movement task into discrete motions that satisfy movement constraints and possibly optimize some aspect of the movement. For example, consider navigating a mobile robot inside a building to a distant waypoint. It should execute this task while avoiding walls and not falling down stairs. A path planning algorithm would take a description of these tasks as input, and produce the speed and turning commands sent to the robot's wheels. Path planning algorithms might address robots with a larger number of joints (e.g., industrial manipulators), more complex tasks (e.g. manipulation of objects), different constraints (e.g., a car that can only drive forward), and uncertainty (e.g. imperfect models of the environment or robot).

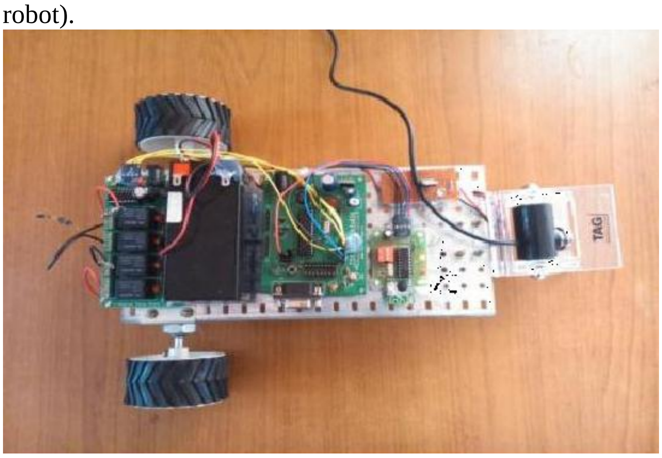

Figure 1 – Robot

Mobile robots systems are driven by control systems. The architecture of these control systems provides different blocks to accomplish specific robotic tasks. Traditionally, the research in the field of Robotics is focused on the algorithms used to accomplish fundamental tasks, like path planning. The path-planning task, part of a mobile robot navigation system, involves searching and finding the path between a Start Point and a Goal Point in the environment where the robots navigate. Mobile robots need to avoid obstacle collisions and generate an optimal result with respect to path dimension or to execution time, this implies different possible implementations. To reach the goal, mobile robots need to have the ability to provide an efficient and reliable navigation.

B. Path planning

Path planning is a fundamental task for a mobile robot by which it guides itself through the environment on the basis of sensory information. The potential of computational vision for robotic navigation is enormous, and vision-based path planning has been actively studied in the last decade. The work has progressed on two separate fronts: 1) vision-based navigation of indoor robot where the complete knowledge of the environment is available and 2) vision-based navigation of outdoor robots where partial knowledge of the environment is only often available. Many existing path-planning algorithms have been designed for implementation in software. It is desirable to develop specialized hardware-directed solutions which operate at high speed and which offer additional advantages, such as re-configurability and portability.

II. METHODOLOGY

In this section, we describe the algorithm we used in the robot path planning. This method determines the path for the robot to transverse to its target location, while avoiding obstacles along the way. The environment is first captured as an image using a camera. Image processing methods are then performed to identify the existence of obstacles within the environment. Images can be captured by camera, and subsequently, processed using some particular software. Information obtained from the image processing exercise can then be used to generate motion commands to be sent to the mobile robot. The proposed system aims at designing an autonomous and an intelligent navigating robot. Hence a powerful platform such as Arduino, a hardware independent interface is used. It is used as the brain of this project. It eases interactions between the robot and the software platform. Wireless camera is used in order to capture video stream and as well to make it to be independent with the base station. ZigBee is used so as to have wireless communication between the robot and the base station, this technology is far better than the Bluetooth in its range of area coverage.

A. Serial communication

Serial communication is the most common low-level protocol for communicating between two or more devices. Normally, one device is a computer, while the other device can be a modem, a printer, another computer, or a scientific instrument such as an oscilloscope or a function generator. As the name suggests, the serial port sends and receives bytes of information in a serial fashion — one bit at a time. These bytes are transmitted using either a binary (numerical) format or a text format. The RS-232 standard supports two types of communication protocols: synchronous and asynchronous. Using the synchronous protocol, all transmitted bits are synchronized to a common clock signal. The two devices initially synchronize themselves to each other, and continually send characters to stay synchronized. Even when actual data is not really being sent, a constant flow of bits allows each device to know where the other is at any given time. That is, each bit that is sent is either actual data or an idle character. Synchronous communications allows faster data transfer rates than asynchronous methods, because additional bits to mark the beginning and end of each data byte are not required. Using the asynchronous protocol, each device uses its own internal clock, resulting in bytes that are transferred at arbitrary times. So, instead of using time as a way to synchronize the bits, the data format is used. In particular, the data transmission is synchronized using the start bit of the word, while one or more stop bits indicate the end of the word.

B. Image Acquisition and Processing

Digital imaging or digital image acquisition is the creation of digital images, typically from a physical scene. The term is often assumed to imply or include the processing, compression, storage, printing, and display of such images. The most usual method is by digital photography with a digital camera but other methods are also employed. Digital image processing is the use of computer algorithms to perform image processing on digital images. As a subcategory or field of digital signal processing, digital image processing has many advantages over analog image processing. It allows a much wider range of algorithms to be applied to the input data and can avoid problems such as the build-up of noise and signal distortion during processing. Since images are defined over two dimensions (perhaps more) digital image processing may be modeled in the form of multidimensional systems.

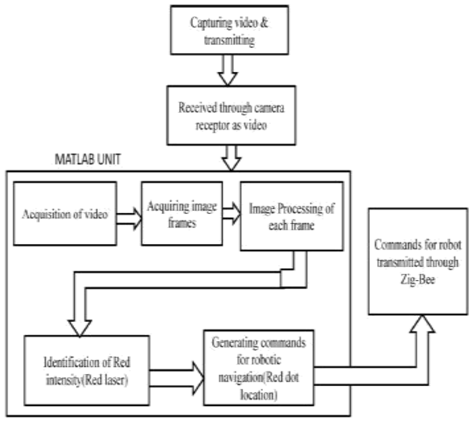

Fig 2- Component diagram

C. Algorithm

This system’s working procedure involves 4 major divisions of algorithms.

D. Motor Driver

Step 1: Start the serial data transfer of the ZigBee. Step 2: Set Input and Output pins.
Step 3: Check conditions for ―”stop”
Step 4: Check for movements either left or right with its respective defined degree values.

E. Image Acquisition

Step 1: Create an object of video input type.
Step 2: Start the execution of the object.
Step 3: Take snapshots of that video creating an object of its respective type.
Step 4: Store or create snapshots of ―”jpeg” type.
Step 5: Delete snapshots after its processing is finished to recover the memory.

F. Image Processing

Step 1: Read the snapshots obtained.
Step 2: Take the information of those snapshots such as its height and width.
Step 3: Divide the width into 6 respective and equal regions.
Step 4: For the height and width of the snapshots, find the RGB intensities of every pixels present in that snapshots.
Step 5: Check for highest 'R' intensity and low intensities of 'G' and 'B' in the snapshots in rgb format of the snapshot.
Step 6: Convert the rgb snapshot to gray scale for converting the snapshot further to binary. Check for the regions where the red laser spot is present.
Step 7: Check for the regions where the red laser spot is present.

G. Serial Communication

Step 1: Create an object of the type of the serial communication which can have the serial data.
Step 2: Set comport to establish connection.
Step 3: Open the connection.
Step 4: Give the commands. Step 5: Close connection.

The algorithm explains the whole system's procedure of execution. It initially includes the power on methods of the base station, the robot, red laser and wireless camera units placed on the robot. The wireless camera will capture the video stream and received at the camera receptor connected to the base station. In the base station, the video stream is converted into image frames using Image Acquisition Toolbox of MATLAB R2013. Then, these image frames are processed using Image Processing Toolbox of MATLAB R2013 in order to identify the obstacles based on the red laser spot and its position in the image frames. The navigation of the robot is done with the help of commands transmitted from the base station to the robot using ZigBee. The commands depend on the position of the obstacles. The ZigBee is communicated using Serial Communication Toolbox of MATLAB R2013. The commands are followed by the motor driver present in the robot for the wheel movements. The motor driver will follow all commands with the help of Arduino hardware interfaced with it and its API present in the base station. Thus, the working procedure of the entire system is explained.

H. Robot movement

The movement of the robot is planned for execution in such a way that it avoids obstacles by taking certain deviation and following the path specified,

Obstacle position	Degree of deviation	Direction
1	30	Right
2	60	Right
3	90	Right
4	90	Left
5	60	Left
6	30	Left

Table 1- Robot movement

III. EXPERIMENTAL RESULTS

In this section, we describe the experiments used to evaluate the developed algorithms. Using the implementation framework,

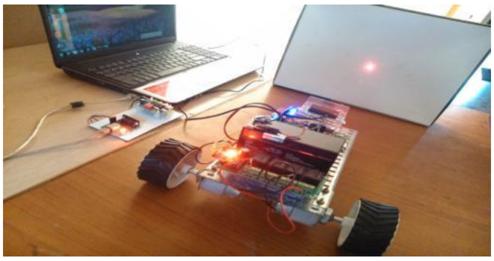

Figure 3- Real time working of the robot

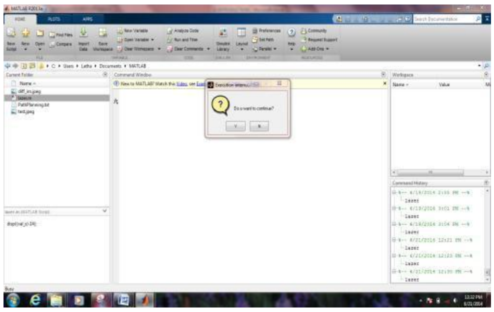

Figure 4- Start page

This figure, describes the start page which shows the user-interaction. When the user clicks on 'Y', the execution continues and the final result is obtained. When the user clicks on 'N', the execution suspends/stops completely.

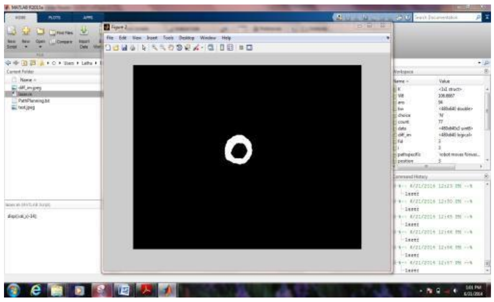

Figure 5- Processed image

The snapshot 3, describes the processed image of the given input of the project. After the user clicks on 'Y' as showed in snapshot 1, the execution takes place. The processed snapshot will be displayed.

IV. CONCLUSION

In this paper we have introduced the methodology of developing wireless mobile robot using Zigbee protocol has been achieved. Zigbee has been proven as a practical solution for low cost monitoring and controlling devices. The project demonstrated that implementing Zigbee network protocol 802.15.4 with microcontrollers ATMEGA8L can be done successfully. This paper is very effective and efficient in planning the path for visual based robots. As it has a wireless camera and ZigBee transmitting modes, the robot can navigate a long distance forming a path. The red laser helps to easily detect obstacles in an environment. The MATLAB R2013 makes things work easily and produces effective results.

The future work can include:

- Implementing Robotic Toolbox of MATLAB.
- Detection of obstacles can be done by depth estimation method.
- Find the distance of the obstacles in a path.
- Find shortest path for robot's navigation.

As such, the scope of this project to demonstrate the successful wireless mobile robot navigation can be further improved. The next step is to build an autonomous robot, which is able to send the environmental status, the temperature condition, with smart obstacle avoidance system.

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