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SURVEY ARTICLE

User-Defined Autonomous Robotic Tracer

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Abstract- A robot is an automatically controlled, reprogrammable, multipurpose device which may be either fixed in place or mobile for use in automation applications. The objective of this paper is to design a robot which can be controlled from a central monitoring console. The operator at the central monitoring console is provided with the blueprint of a building and he chooses the path to be traced by the robot. It is sent through a wireless interface which is received by the robot. In addition to this, the operator is provided with a visual feedback from the robot with the help of a high resolution camera. This will help the operator to know about the obstacles in the surroundings and control the vehicle accordingly.

1. INTRODUCTION

Robotics has turned out to be a new revolution in the life of human beings that varies according to its uses. In modern day environments, robotics and automation are involved in almost every industrial activity including automobile manufacturing facilities and factories which improves the rate of production and significantly reduces the error rate and risk involved. Robotics can also be implemented in medical practices like surgery, construction, space exploration, and defence, transportation of couriers, freight and even for underwater exploration [1].

An autonomously moving vehicular technology has long been a goal for both researchers and manufacturers. Realisation of commercial vehicle autonomy would be a revolutionary step that would certainly change both the automobile industry and the way humans travel forever. It would be possible to use vehicles that drive themselves in all the situations where we are currently using manual vehicles.

The recent advancements in robotics area made the use of robots more relevant and reliable in the modern world. One important advancement that requires special attention is the development of an unmanned aerial vehicle (UAV), which allows an aircraft to fly without having a human crew onboard, although the UAVs' still need to be controlled by a pilot or a navigator.

The work presented in this paper focuses on the navigation problem of mobile robots in a given environment. The robot is given the ability to commute and to navigate autonomously avoiding any type of obstacles coming in its path. The structural modeling of the environment is not at all necessary in this case. The robot is expected to carry out only the requested tasks.

Autonomous navigation means the ability of a mobile robot moving around in an unknown environment without colliding with any obstacles coming in its way [4]. The mobile robot is guided by online information acquired from the central monitoring console while commuting. A mobile robot is an automatic machine that is capable of providing navigation in a given environment. These robots have the capability to move around in their environment and are not fixed to one locality. Mobile robots may be of different classifications. Land or home robots usually have wheels attached to it

and may include legged robots with two or more legs. Aerial robots are usually referred to as unmanned aerial vehicles (UAVs). Underwater robots are usually called autonomous underwater vehicles (AUVs). Polar robots are designed for movement through slippery areas like ice-filled geographical terrain.

Navigation in robotics means the ability of a robot to determine its position in its frame of reference and then to trace a path towards the destination commanded to it [2]. The navigation is made possible in the environment only when the robot is supplied with a representation of the given environment from the database of the central monitoring console and the robot should be given the ability to interpret that precisely with zero or minimum error.

Navigation can be explained as the combination of three fundamental competences. The first one is self-localisation which denotes the ability of the robot to establish and confirm its position and orientation within the environment or the frame of reference. The second one is path planning which is more of an extension of self-localisation where the robot's current position and the destination point is found out and both of which will be within the same frame of reference or coordinates. The third one is map-building and map interpretation which may take the form of a small map or a 3-D view of the environment or any other notations describing location in the frame of reference of the robot.

The easiest way to move the robot will be in an indoor environment. The approach used is to make a robot go to the destination point or to simply guide or trace it to that location. This tracing can be done in different ways like by embedding magnets or inductive loops in the floor or by painting black lines on the floor, or by placing cones, beacons, markers in the field. Vehicles like these can be used in industrial areas for various transportation tasks like parcel collection and freight delivery.

2. ROBOTIC TRACING SYSTEM

A. Working Principle

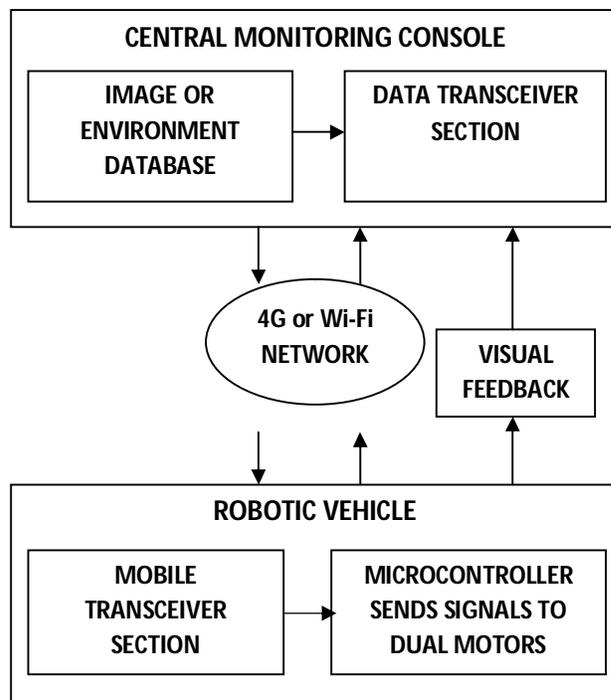


Fig. 1 Block diagram of the robotic tracing system.

Fig. 1 shows the overall block diagram of the robotic tracing system. The blueprint of a hospital or any building is fed to the database of the central monitoring console. The input to the central monitoring console will be in the format of a .jpg or .jpeg image. If a patient in a room wants to see the doctor, the operator at the central monitoring console will draw a route from the patient's ward to the doctor's room. This route will be converted into a different set of data and sent through a high speed network like 4G or Wi-Fi networks [5]. The patient will enter the robotic vehicle and it moves in the path specified by the operator. To be more precise, the set of data will be received by the data transceiver section in the robotic vehicle where the microcontroller will issue control signals which serve as the input to the dual motors connected to the wheels of the robot. Thus, the speed and direction of the robotic vehicle is controlled. A high resolution camera is kept in the robotic vehicle for real time streaming of the environment which allows real time transfer of data through 4G or Wi-Fi

networks. It captures the video signals from the surroundings as the robotic vehicle moves. The captured video is sent via a 4G or Wi-Fi network to the central monitoring console where the operator will stop the vehicle if an obstacle comes in the way and resumes in the path when the obstacle moves away. This serves as the visual feedback system which will significantly reduce the probability of accidents [3]. Thus the central monitoring console will have entire control of the robotic vehicle by using 4G or Wi-Fi networks.

B. Robotic Vehicle Unit Design

A powder coated heavy duty metal chassis containing perforated holes for easy mounting of various size circuit boards and other mechanical components is used [2]. The chassis is in such a way that the motors can be put in place by using normal nut. It is used in the differential configuration (2 rear wheels + 1 front castor wheel) to reduce the complexity of the circuit. If both motors rotate in the same direction, the robot drives straight forward or backward. If one motor is running faster than the other, the robot takes a turn to the left or right directions and if both motors run at the same speed in opposite directions, the robot will rotate in a circle [5].

The front castor wheel is capable of moving in all the directions. The dummy motor gives the castor wheel mounted on it free rotation. The wheels are connected to DC motors because of its high efficiency, high quality and low cost. Nut and threads are tied on the shaft for easily connecting it to wheel. The battery required for the operation of the robotic vehicle is kept underneath the metal chassis and should be placed exactly at the centre of mass of the vehicle to improve the stability as it contributes the majority of the weight.

C. Robotic Vehicle Design Formula

The design of the robotic vehicle is discussed in this section:

Torque = Force x Radius

i.e., $T = k \times F \times R$

The value k is the scaling factor and is taken as 1/20.

Torque of the motor, $T = 5 \text{ Kg cm}$,

Radius of the wheel, $R = 3.5 \text{ cm}$

$5 = 1/20 \times F \times 3.5$

i.e., $F = (5 \times 20)/3.5$

$F = 28.6 \text{ Kg}$

This magnitude of force, F is sufficient to drive the robotic vehicle in the desired directions depending upon the commands from the central monitoring console.

3. SOFTWARE DESIGN

The software design and implementation is discussed in this part. The central monitoring console includes a software interface which processes the path image to be traced. The robotic vehicle uses microcontroller to decode the received information [1]. Two kinds of programs are used and are mentioned below:

A. Central monitoring console software

The central monitoring console runs on Microsoft Windows platform. Any version higher than Windows XP can be used. Intel Core processor i7 is used to improve the performance and processing speed of the data. Here, the robotic tracing system has been developed in MATLAB. MATLAB is widely used for research in robotics. The blueprint of a building is fed as the input to the central monitoring console.

The user at the central monitoring console will select the required path to be traced and give it as the input to the software. The software will convert this input image to a set of codes and send it via the transceiver section. These codes are sent over to the receiver section using the 4G or Wi-Fi connection of the central monitoring console. The set of codes is received by the mobile transceiver section in the robotic vehicle.

B. Microcontroller program

The microcontroller used here is ATMEL 89C52 which has 8K bytes of flash memory. It is incorporated onto the circuitry on top of the robotic vehicle. C program is burnt in the microcontroller. The compiler used is Keil which is used for the compilation of C program in microcontroller. The mobile transceiver section will send data via Bluetooth to the microcontroller. Depending upon the codes received, the microcontroller issues control signals to the motor driver IC L293D. The bits from the microcontroller will drive the motor driver IC and the output of which is given to the two DC motors which will rotate according to the signals given.

4. IMPLEMENTATION DETAILS

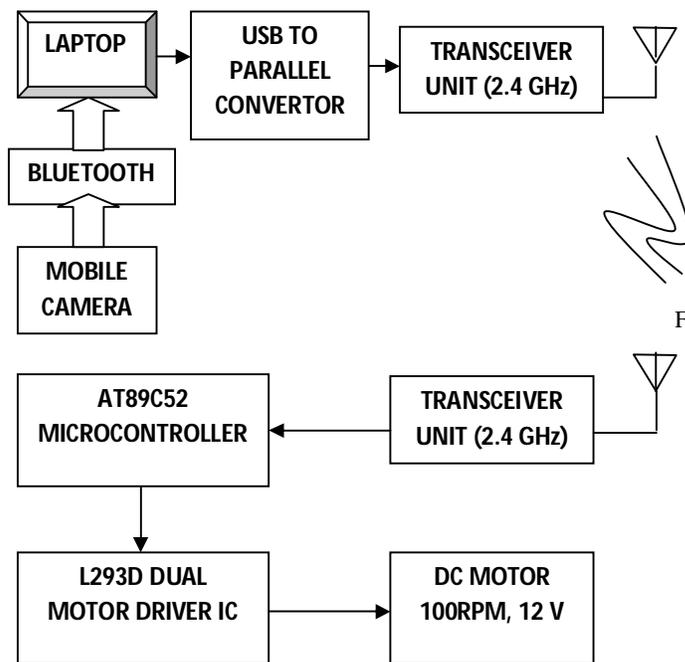


Fig. 2 Block diagram of the implemented concept.

The concept was implemented in real time practice using a laptop and a robotic vehicle. The path to be followed is drawn by the user in an image drawing software like paint and is saved as a .jpg or .jpeg image file. Laptop is installed with MATLAB software. The input to the MATLAB software in laptop is a .jpg or .jpeg image. The MATLAB program converts the pixel variations in the image to a set of codes which represent the directional changes.

Four codes namely 'F' for forward, 'H' for backward, 'L' for left and 'R' for right are used to provide the movements to the robotic vehicle. Thus, path image in the laptop is converted to a set of codes. These codes are sent wirelessly from the laptop to the robotic vehicle unit using a bluetooth or wireless module. The codes sent are received by the vehicle unit using another bluetooth module having the same specifications as that used in the transmitting section. The codes are given to the microcontroller AT89C52 after performing voltage level conversion by MAX232 IC. The microcontroller issues the control signals based on the codes received. The control signals from the microcontroller are given as the input to the dual motor driver IC L293D. The output from the driver IC is given to the two DC motors to regulate the movement of the robotic vehicle.

Differential drive system is used in the vehicle where two motors rotate in the same direction when the currents of same polarity is given, resulting in the forward/backward movement of the vehicle. When currents of opposite polarity are given to the motors, the robot will turn in the left/right direction [5]. A visual feedback system constituting a mobile camera mounted in the vehicle captures the details of the terrain through which the vehicle is moving and is sent back to the laptop via bluetooth.

MATLAB has a serial port interface which will allow connection to computer's serial communication (COM) port. This is established through a serial port object which should be created using serial () function. Graphical User Interface (GUI) in MATLAB is used in the software part to control the robotic vehicle. It is a type of user interface that allows the user to interact with electronic devices like the robotic vehicle. Interaction happens through graphical icons and visual indicators. Graphical User Interfaces were introduced in reaction to the usual command-line interfaces (CLI) where each of the command has to be typed on the keyboard. An example of command line interface is HyperTerminal. The usual typed commands are replaced by icons marked by START, RESUME, and STOP etc. in the GUI window. The following shows the screenshot of the GUI when the input image is given. The black solid line is the path given as the input to the robotic vehicle by the user which is to be traced by the robotic vehicle.

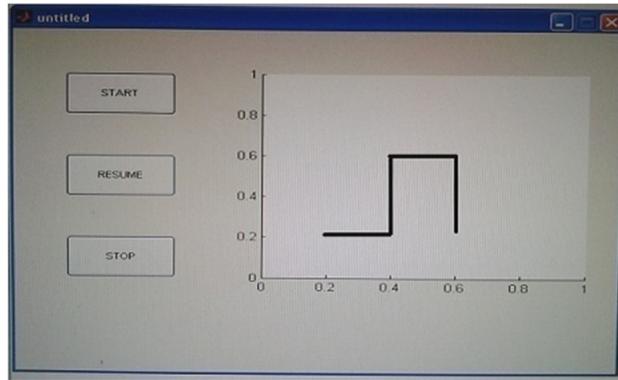


Fig. 3 Screenshot of GUI before START button is pressed.

When the START button in the GUI window is pressed, the vehicle will start to move tracing the path shown. A solid red line will appear above the solid black line indicating that the codes are being sent successfully.

The following figure shows the screenshot when the vehicle is progressing in the path specified.

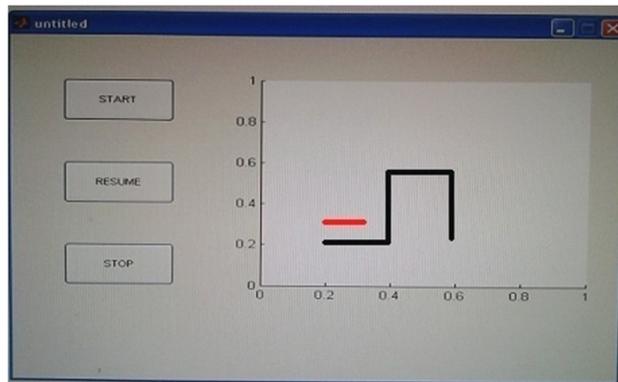


Fig. 4 Screenshot of GUI after START button is pressed.

If an obstacle comes in front, the user presses the STOP button so the movement of the robotic vehicle stops and correspondingly the trace of the red line also stops. When the obstacle moves away from the path, the user presses the RESUME button, the vehicle moves again from the point where it last stopped and the red line is traced again starting from the point where it stopped. Thus, the entire path is traced.

5. CONCLUSION

This paper presents a robot which can be controlled from a central monitoring console. The hardware section and the software required are explained in detail. The concept was implemented in real time and the proof of the concept is also explained. The main advantage here is that the user at the central monitoring console is the only person who has the sole authority to control the vehicle. At the transmitter side, the user can know if the codes are being processed. The visual feedback given will let the operator at the central monitoring console know whether the robotic vehicle is moving or not.

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