Development of a mobile robot for image acquisition through Teleoperation

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*Abstract:-***This paper describes an approach towards navigation of a self-made robotic module in real time through teleoperation.We detail the Hardware and Software aspects of the system and show how such a platform can be used to provide a high quality, low cost solution for teleoperated mobile robot framework. In addition, we show how the platform can be also used for capturing stereoscopic images for creation of maps of the environments for further implementation of Simultaneous Localization and Mapping (SLAM).For high speed processing and large data storage, microprocessors has been used rather than microcontrollers. An Ad-Hoc network has been created for data transmission between the Server and the Robotic Framework.First, the platform has been tested in indoor environments. Further experiments demonstrate that the platform is also suitable for outdoor environments.**

Keywords: mobile robot, Teleoperation, Robot Control

1. Introduction

Teleoperating a mobile robot, the process of controlling a mobile robot from a distance, has been always a central research topic in the field of mobile robotics.Teleoperation means simply to operate a system or a vehicle over a distance. The distance can vary from the tens of centimeters (micro manipulation) or millions of kilometers (space applications). Our main goal is to provide a mobile robot with autonomous localization and mapping capabilities. In surveying the literature on this subject, it became evident that a benchmark-like comparison of different approaches is difficult because of the lack of commonly accepted test standards and procedures. The research platforms used differ greatly and so do the key assumptions used in different approaches. Further challenges arise from the fact that different systems are at different stages in their development.

Fig.1 The robotic module

So we have decided to make an approach to create a platform that can be suited to our requirements.

We primarily focused on the creation of the hardware of the robotic module. As the construction of a real time robot is a dawdling process and it consists of sheer hard work, the hardware construction process took most of our allotted time.

In its present form the robot is capable of teleoperation in the indoor and outdoor environments. For creating the map by the training dataset which will be created by the acquired images we have performed the teleoperation of the mobile robot. The process of localization or the mapping of the environment is still in progress. In the section that follows, we discuss the mechanism of our pro- totype and the results of experiments

Table1. Specifications

Width(cm)	**32**
Length(cm)	**40**
Front Wheel diameter(cm)	**4.5**
Rear Wheel diameter(cm)	**3.5**
Weight(kg)	**6**

2. ROBOT DESCRIPTION

In this section, the robot systems will be described briefly. In the current stage of development, all the currently available subsystems have been implemented and tested in the indoor environment as well as in the outdoor environment. However, as there are currently some problems are still existent the experiments regarding SLAM has not yet been carried out.

2.1 Structure:-

As the robot will be operated mainly in outdoor environments we have provided the platform with a solid structure containing iron plates for the base and the aluminum sheets for the body.

2.2 Power source:-

The platform is powered by a AMARON lithium battery of 12v and 7.5Amp.The 3DC motors,1 stepper motor and the mini ATX-motherboard is operated by the single battery. The battery is directly connected to custom made motor controller and connected with the motherboard through the custom SMPS.The internal circuits of the motherboard need +12V,-12V,+5V,-5V,GND in different sections for operation. The SPMS circuit just takes +12V from the power supply and provides output as the required voltages needed for operating the motherboard.

2.3 Controller of the robot:-

As there are two types of motors are situated in the robot, we need two different ICs to control it. The first IC is the L298 which is been used for the controlling the movement of the robot. The second IC is the ULN2003 which we are using for the rotating the stepper motor which is been used for the movement of the camera.

The robot is connected with the motherboard through the parallel port. The parallel port is a type of interface in the computer to connect various peripherals to the computer. A parallel port is a 25 pin port where the pin no 1,14,16,17 are control pins.10, 11,12,13 and 15 pins are signal pins .The 8 pins -2,3,4,5,6,7,8,9 are data lines and the 18,19,20,21,22,23,24,25 pins are ground lines.

We have been using the 8 data lines for controlling various movement of the robot. The first 4 of the 8 data lines are used for controlling the stepper motor of the robot. The rest of the 4 data lines are used for controlling the movement of the robot .This 4 data lines are connected with the L298 IC.

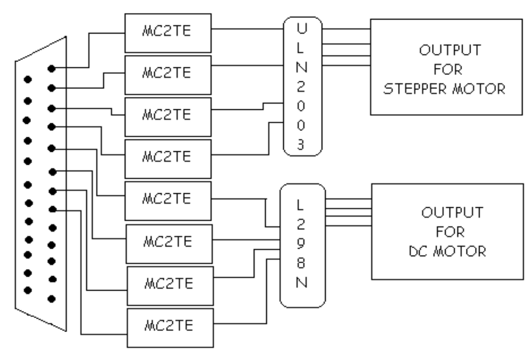

Fig.2 Circuit diagram of the controller

At first the signals are coming through the 8 data lines from the parallel port of the motherboard. For a high signal it generates a 4.3V and for low signal it generates a 1.2V.The 8 outputs from the parallel port will then goes to MC2TE IC.This is an optocoupler IC which prevents current from going to the backside to the motherboard. It is a safety IC.From the optocouplers the signals will go to the 2 ICs.Before that we have connected 8 LEDs for detecting the low and high signal. It also assures us about the current continuity of the board. We have provided a 7805 IC which is a voltage regulating IC.This 7805 IC will provide us a +5V which we will be needed for triggering the L298 IC.The first 4 data lines will go to the ULN2003 IC which will control the movement of the camera panning plate. The rest of the 4 lines will go to the L298 IC which will generate the output needed for controlling the DC motors as well as the robot. We have also provided 2 LEDs.One of them will show us if the 12V voltage supply is connected with the board. Another LED will show us the 7805 IC is working or not. Because when the 7805 IC will provide us with output voltage the LED will get a +5V and it will glow.

2.4 Central processing system of the robot:-

We have implemented a full-fledged motherboard instead of using the microprocessor. The motherboard will provide us the facility of connecting wireless devices easily. It has plenty of disk space and memory needed for computation. As the full computing and processing part will occur on the robot the Main board and the robot will store lots of images for training so the robot should be capable of doing lots of computation onboard and should contain enough memory. The robot is equipped with an ASUS CUSI-FX Mini-ITX motherboard with PENTIUM-3 processor which is capable of doing the computation needed for our project. This motherboard contains 256MB of RAM(random access memory).The hard disk we have used is a Seagate ST380011A with 80Gb of diskspace.The mini-ITX board has a parallel port connection which we are using for giving inputs to the control circuit board of the robot.

2.5 Wireless system of the robot:-

As the mobile robot will be operated wirelessly we used a wireless LAN card connected through the USB peripheral of the motherboard. It is a NETGEAR wireless-G Adapter WG111 which delivers a consistent wireless connection which keeps no dropped connection or dead spots. The wireless adapter connects to the motherboard through USB 2.0. For the server computer we are using laptops for seeing the view of the environment through the robot's eyes and controlling the robot. We are implementing an AD-HOC connection or a peer-to-peer network to connect the server computer with the robot.

2.6 Visual system:-

Two stereo-scope cameras have been used for the visual system of the robot. The two cameras will provide a 3D viewing of the environment. The two cameras have been fixed on a plate. The plate is connected with the stepper motor. The two cameras move with the rotation of the stepper motor .Rotation of the stepper motor gives us freedom of seeing more than 180^0 of the environment. The stepper motor rotates in 3 stages.

1. Half-step mode
2. Full-step mode
3. Single step mode

In the half stage mode by using a single pulse we can rotate the motor 30^0 in a glance. In the half-step motor we can rotate the motor 15^0 in a single pulse. In the full-step mode the motor can move 7.5^0in a single pulse.

Fig.3 The visual system of the robot

2.7 Software aspect:-

The interface or the control software of the robot has been made through VB.NET with the use of various extra applications for the cameras. Two cameras can simultaneously show the images of the environment from different perspectives. The tabs of the robot UP, DOWN, LEFT, RIGHT are used for controlling the robot. We can also control the movement of the robot by using the W,S,A,D keys of the keyboard as corresponding to the forward,backward,left,right movement of the robot. The 'UP' tab or the 'W' key will move the robot forward. The 'DOWN' tab or the 'S' key will move the robot backward. The 'LEFT' tab or the 'A' key will move the robot to the left. The 'RIGHT' tab or the 'D' key will move the robot to the right. The camera panning plate of the robot will move with the scrolling of the mouse. As we scroll the mouse upward the camera panning plate of the robot will move at the left side and with the scrolling of the mouse downwards the plate will move at the right side. There is also a tab showing the modes of the stepper motor. The options are the half-step mode, Full-step mode, single mode. With the right clicking of the mouse the modes will be altered. The capture image tab will capture images of the current environment. The capture video tab will capture the video of the environment as the robot moves in the environment.

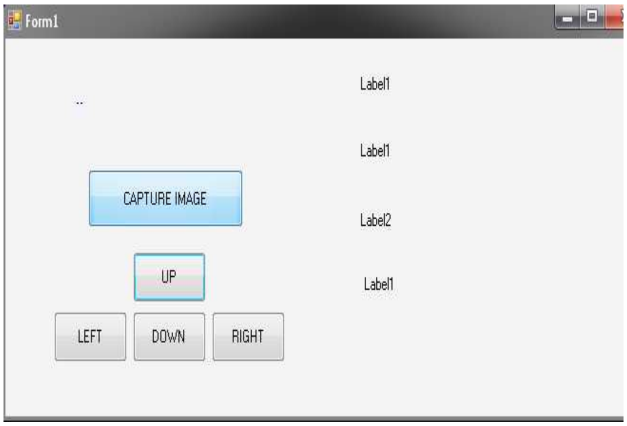

Fig.4 The control interface of the robot

The 4 levels at the right binary low or high data that is going to the stepper motor of the robot. A display will be also there which will show us the corresponding binary values that are going to the controller for navigating the robot.

Results:-

In earlier stages teleoperation has been performed on the robot only inside the laboratory environment.First, the robot has been powered on by the custom made switches which have been situated at the front side of the robot. Two LEDs show us the current status of the robot. As the booting process has been completed the robot can be remotely connected to the other wireless device. After wireless connection has been established we can remotely control the robot by the server. From the server we can see the environment where the robot has been located, by the two cameras of the robot which can directly transmit the images of the environment. By the images of the environment we can now teleoperate the robot by the control software. We can also capture images by the two cameras of the robot.

Fig.5(a) The robot is facing towards the table **(b)**The images taken by the robot while facing towards the table

At the second phase, the robot has been tested at outdoor environments. Various images has been captured of different buildings of the campus while the robot has been teleoperated.

Fig.6 Images taken by the robot while facing the building in the outside environment

Discussions:-

As our long-term objective is to provide the robot with autonomous Localization and Mapping capabilities, still the prototype is not capable of fulfilling the requirements. But with some modifications in the hardware aspect, the module would be ready to face SLAM problems. As we are using a Pentium 4 motherboard and there is only 256mb of RAM is available the computational capability is quiet low. As the processor is slow it creates the network delay by which sometimes the robot sticks at just one instruction. Then it continues to perform just one task unless it is manually stopped. The small scale stepper motor is not capable of moving the camera panning plate freely. The cameras are not capable of delivering high quality real time video streaming or images.

Future work:-

As we have created a handmade robotic module, it allows us to modify its performance or tasks in many aspects. It is a test bed which has opened lots of options to us.

The module can be provided with sonar, Infrared sensor or other proximity sensors, which can help us to use the framework as an obstacle detection or path following robot.

The robot can be mounted with a GPS (Global Positioning System) device which can help us to get accurate location of the robot in the environment. The sensor fusion technique will be used by the information of the proximity sensors and GPS device to accurately perform Map Matching.

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