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Endurance the MAT lab Controlled Surveillance Robot

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Abstract: **This paper deals with the design and implementation of a multi-purpose wireless surveillance robot which is operated with the help of Graphical User Interface (GUI) of MATLAB. Surveillance robots find many applications in a variety of fields such as military surveillance, fault detection in large pipelines like penstock pipes and surveillance of areas hostile to humans, like areas vulnerable to nuclear radiations. The robot uses Open Source Arduino microcontroller for the control of various dynamic parts of the machine. It is one of the latest and simplest microcontrollers for development of robotic projects. The mobility is imparted to the machine via geared DC motors which are driven by motor controllers. The night vision camera which is made dynamic with the help of controlled servomotors enables the users to get a detailed view of the area in which the robot is sent. The air quality sensor in the robot enables us to detect whether the environment is feasible to humans. Wireless operation is made possible with the help of ZigBee pair, programmed with AT commands which can give a range up to 300m. The mechanical design is also tuned by imparting belt driven wheels which provides a wide area of contact for greater grip and angle of ascend. Humidity and temperature sensors provide an exact idea about the surroundings being observed. The MATLAB interface will provide greater flexibility to the system and thus makes it easier to install for a handful of operations. It is sure that the paper will prove to be a breakthrough in surveillance vehicles and thereby a great scope of future development due to the flexibility of the system.**

Keywords: **Graphical User Interface, ZigBee pair, Hardware in the loop, X-CTU.**

I. INTRODUCTION

Extensive research and developments are being done on mobile robots because of their potential capabilities in hazardous environments [1], military intelligence [2], surveillance [3], and fault detection in areas which are not easily accessible to humans [4]. The core technologies involved in these applications are sensory augmented remote control of mobile robots, capability of self-localized autonomous navigation, obstacles avoidance, and examination of various environmental parameters like temperature and air quality [5]. The multi functionality of this machine greatly depends on various sensors, e.g., air quality sensors to determine the toxicity of the environment, range finder for obstacle avoidance, vision system which incorporates wireless cameras for visual recognition of areas to be surveyed and torque and stabilising requirements for traversing terrains.

They prove to be one of the leading research areas owing to their multiple automation capabilities and highly modifiable characteristics [1]. Most of these capabilities are controlled and coordinated with the help of microcontroller platforms like Arduino, PIC and Raspberry Pi microcomputers. These existing robotic platforms provide robust robotic architectures for different applications. However, their software framework requires hand-coded program for concept testing, which is a barrier for fast development process of control algorithms. Various simulation programs can be used for the verification of the reliability of these programmed platforms. The hardware remote control operation may also reduce the flexibility of the machine, since any repair or modification requires time consuming design and fabrication processes.

To make this system more practical and friendly, we have developed a mobile robot control framework using the MATLAB Graphical User Interface as the controller with the customizable set of block libraries provided in it. This control framework accelerates the development process with hardware-in the-loop (HIL) testing in GUI environment, which facilitates the design, simulation, and implementation of a wide variety of robotic applications. Glasgow Caledonian University has also developed a Simulink-based mobile robot team control toolbox. The toolbox, however, was developed only for homemade microcontroller-based robots and it does not provide interfaces to existing commercially available robots and sensors. The rest of the paper is organized as follows. Section 2 describes the hardware and software framework for 'The Endurance', as we call it, the Matlab controlled surveillance robot. Section 3 illustrates the development process of control algorithms of the robot. Experimental Observations are illustrated in Section 4. Finally, Section 5 draws the conclusion and future scope of the technology.

II. HARDWARE FRAMEWORK

The Endurance is a four wheel differential robot which is equipped with various built-in sensors for data acquisition. The frame shape of the total assembly is designed to be square framed for optimal load distribution and the belt driven coupled wheels are provided for evenness of torque delivery while going through tough

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topographic terrains. This also provides greater contact area with the ground and thereby increasing the stability. The programming platform and various sensors incorporated in the system are stated as follows:

A. Microcontroller and Communication Device

Arduino based on board robotic platform that uses ATmega328 IC as its motherboard with 2KB of SRAM and 1 kB of EEPROM, and 32 kB of program memory. It has an inbuilt ADC and 14 digital IO pins of which 6 of them can be used as PWM pins. It is characterised by serial communication capabilities which enables wireless communication up to a certain range of operation [5].

Zigbee Series 2 duplex wireless serial communicator pair which enables control signal and sensor data to be sent over the air with a frequency of 2 MHz The high baud rate of the system can process the data continuously and mesh networking capability gives a scope for a connected system of robots which is under development [6].

Fig. 1. Arduino platform and ZigBee module

B. Data Acquisition Elements

The second part of the hardware assembly is dedicated to various types of sensors used in the working of the robot. There are 4 main sensors incorporated in the machine, namely, temperature sensor, air quality sensor, proximity sensor, and the IR night vision camera, each of whose specifications are described below:

A 6-array Infrared Night Vision Wireless Camera, capable of real time surveillance and a separate RF transmitter receiver pair has to be fine-tuned to receive the frequency coming from the wireless camera.

An LM35 temperature sensor with a range of 0 to 250 m [6] and the precision has been checked by comparing the observed value and the value shown in www.accuweather.com.

An infrared range finder that helps to detect whether any obstacle is approaching in the path of the surveillance vehicle. Its range can be varied with the help of the potentiometer connected in series by varying the voltage given to the Infrared led.

Air Quality sensor MQ135 that is capable of providing the ppm value of the gas, whose concentration is being measured .It is highly sensitive to a variety of toxic gases like nitrous oxide, sulphur dioxide, methane, ammonia, CO2 etc.

Fig. 2. IR Camera, IR Range Sensor, LM35 Sensor

III. SOFTWARE FRAMEWORK

The software framework part of the project includes analysis on the capabilities which the machine have to be imparted with and the deciding the sensors on the basis of the range of environmental conditions this machine is subjected to. This included programming on the Arduino interface, Zigbee programming through the X-CTU platform and the forced feedback of the sensory information back to the system for evaluation. The procedural methods which were adopted for the implementation can be summarised in the following steps:

A simulation program based on the existing circuit has been designed in Proteus 8.1 Professional simulation software and the results are obtained as expected.

The wireless communication configuration is set using programming the X-CTU software and the test for maximum range has to be conducted by sending random data bits.

The Arduino platform has to be programmed and it is experimentally verified by arranging and by driving DC motors with the help of motor driver L293D IC.

Individual tests are conducted for each sensor by varying the input parameters and simultaneously verifying the outputs with the help of specialised devices. The temperature sensor was used to test the temperature of a particular area and the results matched with the information given from the GPS based temperature information in that area. Similarly, a series of toxic gases were subjected to go through the MQ135 sensor and the results yielded positive outcomes.

IV. EXPERIMENTATION AND TESTING

A variety of experiments have been conducted to test the ability and reliability of the machine under various circumstances. The machine could deliver a wireless communication distance of about 300 m LOS communication without any noise interference. However due to interference, the camera could provide satisfactory functions only up to a certain range but this can definitely be improved by adjusting the band width and the power of the transmitter receiver pair. The infrared vision was quite satisfactory. The temperature sensor was subjected to various temperatures and the outputs were verified with the help of digital thermometers. The turning radius required was even lesser due to differential control and the torque of the motors provided a climb of 55 degrees at the controlled environment used.

Fig. 3. The Endurance under experimentation after partial hardware assembly

V. CONCLUSION

This paper described a robotic control framework in MATLAB GUI environment. The control framework has been developed using Arduino Robotic platform. This framework includes a mobile robot platform, which is equipped with an ATmega microchip, a wireless IR camera, and infrared range sensors and provided. The performance of the developed architecture has also been tested using several experiments in various research fields of mobile robots,
e.g., tele-operation, obstacle avoidance and surveillance. The future developmental scopes are immense for this project keeping in mind the high flexibility of the architecture and the wide variety of utilities for which these mobile robots can be employed.

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