A Multi Functional Robot for Remote Surveillance in Military Applications.

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Abstract- This paper describes the implementation of robotic surveillance system for remote area like warzone or border monitoring purposes. The system can substitute the solider in border to provide surveillance. The robotic vehicle is autonomous and has the ability to detect the human presence and send the information to the control station. Multi sensory capability used to detect humans, gases, fire, temperature and humidity at remote areas. Onboard camera on the system sends continuous visual data to the control station. This system is designed for surveillance as well for reconnaissance circumstances .The system uses GPS and GPRS to determine the position of the system. The robot is aided with GPS Receiver and GSM Modem, the GPS receiver obtains the location coordinates which are decoded and sent to control station using GPRS.PIR sensor detects human presence and triggers system to send alert messages to the control station. The sensor data, GPS coordinates, Images taken are saved to on board memory is continuously sent to control station. At the control station the GPS data is used to show the real time position of the robot using open source Google maps API, also the sensor data and images sent from the remote location can be seen on a webpage which can be accessible from anywhere.

Index Terms - Sensors, Surveillance, Real Time Tracking, GSM, GPS, Camera, PIR Sensor, Temperaure Sensor, Ultrasonic Sensor.

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1 INTRODUCTION

Automation is replacing the humans in hazardous work environments enabling to create safe work environments, border patrolling or surveillance is one workplace where automation can be used for better and safe environment for the solider f work. Robotics systems with capability to monitor the surrounding area for human presence, fire or bomb blasts which can send this information to a central control station simultaneously can be deployed for better border surveillance.

Here the robot proposed is autonomous, which uses ultrasonic sensor to go through the area avoiding obstacles. Sensors on the robot will be continuously monitoring various parameters. Temperature and humidity sensors monitoring for surrounding environment changes. Fire and gas sensors monitoring for any bomb blasts or harmful gases. PIR sensor for continuous human detection. The system continuously extracts this information saves to local memory and sends parallel to remote server.

The Global Positioning System (GPS), is a radio navigation system that allows land, sea and airborne users to determine their current exact location, velocity and time 24 hours a day, in all weather conditions and anywhere in the world, supporting a broad range of military, commercial

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and consumer applications. A GPS receiver on the robot along with GPRS capable GSM Modem sends this data to a server located which can be at the control station.

At the central control station the data sent from the robot system is stored on to a database and is used to represent the information in a graphical view on a webpage. The images sent by camera can also be seen on the webpage. PIR Sensor when ever detects the human presence triggers an event in the system to send the GPS coordinates via SMS as an indication. The server at control station uses Google maps API for showing the real time location of the robot on a map.

The rest of the paper is as follow. Review existing technology in Section II. In Section III, Propose the system architecture and implementation of the tracking system. Section IV, shows the system prototype and some screenshots of our proposed work. Conclusion and future work in Section V.

2. Existing Systems

Most popular surveillance systems use RF[4] based communication for data transmission and DTMF[1][4] for autonomous operation. Use of RF hinders the range of operation as RF has very low communication range as compared to other available communication methods. Line of sight operation makes it not totally apt for use in areas with obstacles or in areas like forests. Use of DTMF for controlling movement of the robot make it semi autonomous as human intervention is always needed for robots to move. Robotic systems as proposed in [1][3] use mobile phone on systems for data collection to data

transmission, which increases cost of system as a good quality mobile device costs high and such systems are not feasible practically.

3. Proposed System Architecture and Implementation

The Multi functional robot is divided in to modules, each with their own functionality and centrally controlled by a controlling system. The figure 1 is block representation of the whole system. The system can be divided in to control station and the autonomous robot.
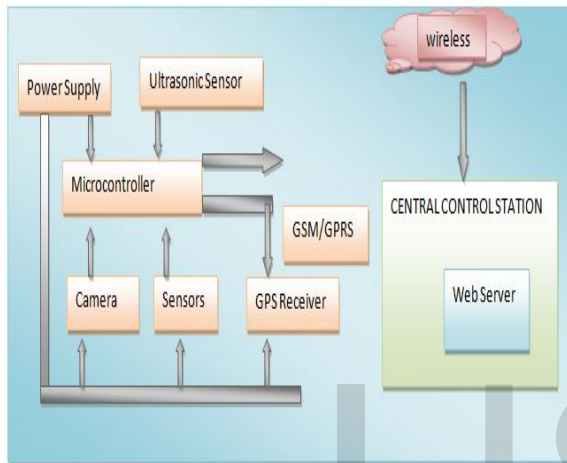

Figure 1 : System Block representation.

At the robot, sensors continuously sense and provide data to the controller, which sends the same information to the control station using GPRS.A GPS Receiver continuously provides latitude longitude information to the controller. Camera takes images in predefined time intervals and sends them to the control station. The controller collects the sensor data, GPS data and camera pictures and sends them to the GPRS Module which sends the information to the remote web server located at the control station.

At the control station a web server is deployed along with a database. The data received by the server via http is saved to the database, a script running in behind make use of the data to plot graphical representation of the sensor data and display visual images on the webpage.

3.1 GPS Tracking Module:

The GPS Tracking Module is based on the 8-bit AVR RISC microcontroller which is a low power MCU and has several peripherals such as UART, SPI and I2C to connect to GPRS/GPS module, MMC module and GPIO Control module respectively. GPS tracking is done using a GPS Receiver device which fetches latitude longitude data and sends the data to the controller via the UART Interface. The

GPS data is then given to GPRS Module via UART Interface and GPRS Module transmits the data to a remote server wirelessly.

A SD Card is connected to controller via SPI interface for storing the data for backup and while GPRS Connectivity is not available.

3.2 Camera Module

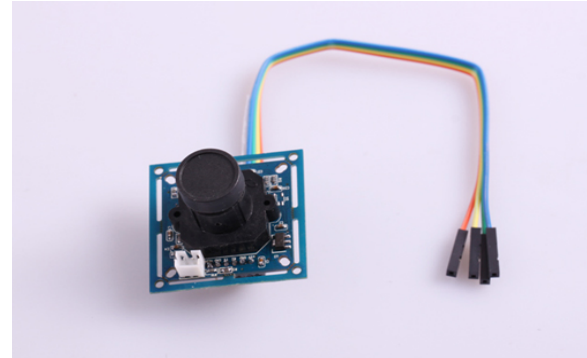The robot has on board camera to take picture of the field.

Figure 2: OV7670 Camera

The camera is OV7670 Serial TTL camera which is interfaced to the controller on the robot using UART interface. The pictures taken by the camera are saved to the on board memory via SPI interface and sent to remote server using GPRS.

3.3 Google Earth and Google Map

Google provide free open source API called Google maps API which can be used to show user location on the webpage. Here we are using the same API's to represent the location of the robot on a web page. In the web server Google maps API is used to show the real time location of the robot on the map. The GPS data is received is saved to the database by the web server script, the GPS data is fetched from database by a php script and XML/Jason format file is generated which is then used by Google maps API to show the real time location on the map.

3.4. Sensors

The robot has onboard sensors to sense various events/parameters and the sensed values are sent to the remote control center. *Temperature:* The DHT11 sensor detects the temperature continuously. *Humidity:* The DHT11 sensor detects the humidity continuously. *Gas sensor:* The gas sensor indicates presence of harmful gases. *PIR Sensor:* the PIR sensor detects the presence of humans on the field.

3.5. Raspberry Pi

The Raspberry Pi 3 Model B is the third generation Raspberry Pi. This powerful credit-card sized single board computer can be used for many applications and supersedes the original Raspberry Pi Model B+ and Raspberry Pi 2 Model B. Whilst maintaining the popular board format the Raspberry Pi 3 Model B brings you a more powerful processer, 10x faster than the first generation Raspberry Pi. Additionally it adds wireless LAN & Bluetooth connectivity making it the ideal solution for powerful connected designs.

Technical Specification:

Processor:

•Broadcom BCM2387 chipset.

•1.2GHz Quad-Core ARM Cortex-A53 (64Bit)

802.11 b/g/n Wireless LAN and Bluetooth 4.1 (Bluetooth Classic and LE)

•IEEE 802.11 b / g / n Wi-Fi. Protocol: WEP, WPA WPA2, algorithms AES-CCMP (maximum keylength of 256 bits), the maximum range of 100 meters.

•IEEE 802.15 Bluetooth, symmetric encryption algorithm Advanced Encryption Standard (AES)with 128-bit key, the maximum range of 50 meters.

GPU

•Dual Core Video Core IV® Multimedia Co-Processor. Provides Open GL ES 2.0, hardware-acceleratedOpen VG, and 1080p30 H.264 high-profile decode.

•Capable of 1Gpixel/s, 1.5Gtexel/s or 24GFLOPs with texture filtering and DMA infrastructure

Memory

•1GB LPDDR2

Operating System

•Boots from Micro SD card, running a version of the Linux operating system or Windows 10 IoT

Power

•Micro USB socket 5V1, 2.5A

The Raspberry Pi3 has four USB ports to connect mouse keyboard or anything needed . USB Hub can also be connected, given a 2A power supply is provided for it to be able to run the USB devices.

The 40 GPIO Headers on Pi gives access to 27 GPIO, UART, I2C, and SPI as well 3v3 and 5v source pins. The GPIO Header is similar to the one on pi2.

SoC:

Built specifically for the new Pi 3, the Broadcom BCM2837 system-on-chip (SoC) includes

four high-performance ARM Cortex-A53 processing cores running at 1.2GHz with 32kB

Level 1 and 512kB Level 2 cache memory, a VideoCore IV graphics processor, and is linked to a 1GB LPDDR2 memory module on the rear of the board.

Figure 3: Raspberry pi3 SoC.

GPIO:

The Raspberry Pi 3 features the same 40-pin general-purpose input-output (GPIO) header as all the Pis going back to the Model B+ and Model A+. Any existing GPIO hardware will work without modification; the only change is a switch to which UART is exposed on the GPIO's pins, but that's handled internally by the operating system.

USB chip:

The Raspberry Pi 3 shares the same SMSC LAN9514 chip as its predecessor, the Raspberry Pi 2, adding 10/100 Ethernet connectivity and four USB channels to the board. As before, the SMSC chip connects to the SoC via a single USB channel, acting as a USB-to-Ethernet adaptor and USB hub.

Antenna:

There's no need to connect an external antenna to the Raspberry Pi 3. Its radios are connected to this chip antenna soldered directly to the board, in order to keep the size of the device to a minimum. Despite its diminutive stature, this antenna should be more than capable of picking up wireless LAN and Bluetooth signals – even through walls.

4. System Prototype.

As proposed in section in 3, the system prototype is implemented. The figure 3 shows raspberry pi3 SoC used to deploy as web server. Figure 4 shows the autonomous robot using the ultrasonic sensor. The GPS Module with GPRS for tracking along with camera and sensors interfaced to the controller is shown in the figure 5. The sensors continuously monitor the vicinity and send the data to the web server. The camera takes pictures periodically saves to SD Card on the robot which is then sent to web server along with the sensor data.

The figure 6 shows the web page which shows the location of the robot on maps using Google Maps API, figure 7 show the web page displaying the images taken by the robot. The web pages refresh periodically showing the latest data sent by the robot.
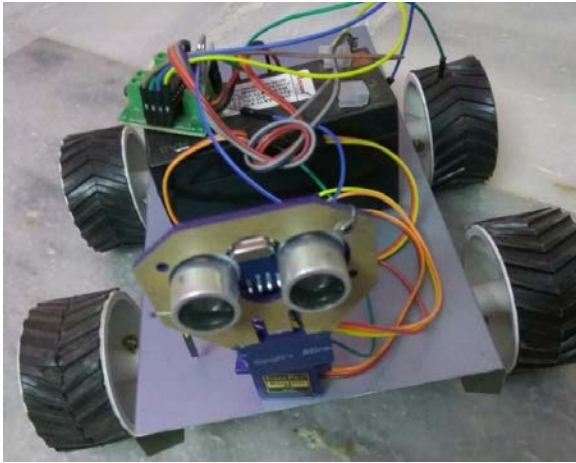

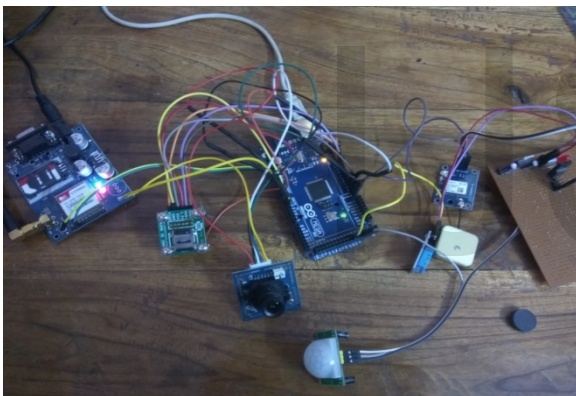Figure 4: Autonomous Robot using Ultrasonic sensor.

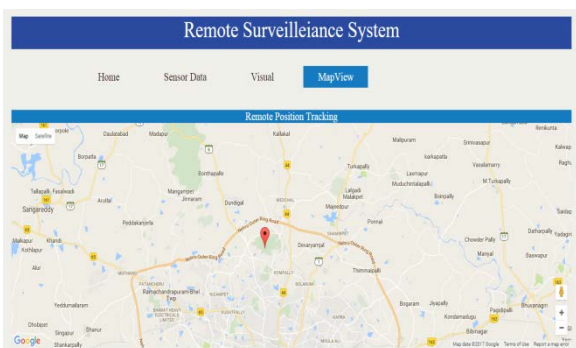Figure 5: Prototype System on robot to collect data.

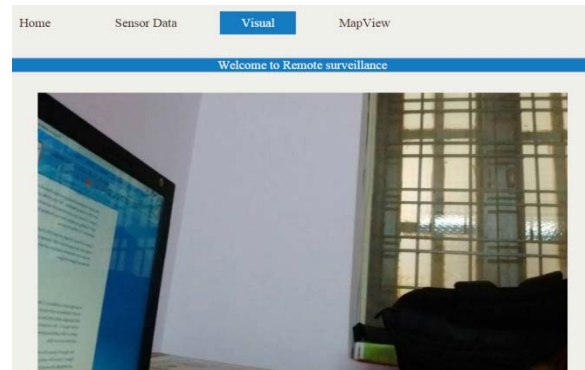Figure 6 : Web Page showing real time location.

Figure 7 : Web Page showing images from the robot.

5. Conclusion and Future Work.

In this paper we have proposed a robotic surveillance system for the military and security purpose. The robot system is ideal to use in remote locations because of size and with proper outer body design the robot can camouflage itself with the surroundings not easy to be detected by anyone in the vicinity. The system relies on GPRS for data transmission which makes operable far away from the operators location. The GPS Receiver provides continuously the location information. The open source Google maps API used give the location on a map view making the system to be used without much effort. The system can give false GPS position if confined in a building or under a bridge where there is no possibility to capture a GPS position. The system requires less memory as the robot needs to store only latest information for less period of time before being sent to the remote server. The sensors along with camera give real-time information about the situation on the field which can be viewed on the webpage at the control station alongside with the GPS data.

The system currently relies on GPS and GPRS connectivity for data transfer, the data speeds achieved with GPRS are low and can be improved by upgrading over to 3G or LTE technology, other connectivity technology like Wi-Fi can be integrated in to the system.

The system proposed has one robot operating in a area allowing only one part to be monitored at a time, by integration technologies like 6lowPan, number of robots can be deployed for monitoring a large area at the same time. With integration of 6lowPan the systems can become energy efficient as the battery energy used for data transmission over GPRS can be reduced to minimal.

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