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Real-Time Remote Monitoring Using Surveillance Robot

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ABSTRACT: We propose a cost-effective two wheeled surveillance robot using an Arduino MEGA R3 2560microcontroller and a Smartphone running the Android Operating System. Surveillance robots typically consist of a video camera, a GPS module, and GSM radios. Android smart phones come with excellent hardware satisfying the above needs. This can be leveraged and used to advantage through APIs (Application Programming Interfaces) provided for the Android operating system. Moreover, the cost for building the robot using a Smartphone is mitigated to a great extent. The robot can be controlled remotely from a PC using the internet and a microcontroller-smart phone interface residing on the robot.

To capture and archive the real time video from the robot, the inbuilt camera input of the phone is utilized. The robot can be controlled based on visual feedback from the same smart phone. Two motors help achieve a zero turning radius. The camera is attached to a stepper motor which makes it feasible to capture the scene or object of interest. The captured video can be enhanced and made intelligible using further image processing on the remote PC thereby eliminating the need for extra DSP hardware on the robot.

KEYWORDS: Zigbee protocol, Bluestacks, Android, Arduino

I.INTRODUCTION

A Surveillance is the process of monitoring a situation, an area or a person. This generally occurs in a military scenario wheresurveillance of borderlines and enemy territory is essential toa country's safety. Human surveillance is achieved bydeploying personnel near sensitive areas in order to constantlymonitor for changes. But humans do have their limitations, and deployment in inaccessible places is not always possible. There are also added risks of losing personnel in the event of getting caught by the enemy.

With advances in technology over the years, however, it is possible to remotely monitor areas of importance by using robots in place of humans. Apart from the obvious advantage of not having to risk any personnel, terrestrial and aerial robots can also pick up details that are not obvious to humans. By equipping them with high resolution cameras and various sensors, it is possible to obtain information about the specific area remotely. Satellite communication makes it possible to communicate seamlessly with the robots and obtain real-time audio visual feedback. Thus, in recent times, surveillance technology has become an area of great research interest.

The field of surveillance robots is quite popular. A lot of work has been done in navigational algorithms and control system of wireless surveillance robots. A common theme is also the use of a camera on the robot in order to receive live video feedback. Wireless robots made using the Arduino microcontroller have been implemented, but wireless communication occurs using the ZigBee protocol, which limits the range of the robot. A robot which performs image processing using the camera on an Android smartphone has also been implemented. However, this method is limited by the processing power of the phone, problem that we have addressed by remotely performing all imaging processing operations on a different computer, after transmitting the camera's feed.Our project is rather unique in the sense that, it is a low-costsolution that offers the ability to remotely control a robot withan unlimited range (by using the internet),

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while also offeringvideo feedback. There is also no constraint on any extraprocessing since everything is done remotely.

II.CHALLENGES

Building a small robot for testing and research purposes proves to be extremely expensive. Primarily, because a security robot would require certain components such as a GPS module (Global Positioning System), High resolution cameras, radios for satellite connectivity, etc. Each of these components are quite expensive and piecing them together for the purpose of a robot is a very costly and time consuming affair. Moreover, a lot oftime is wasted in writing driver code to interface all thesecomponents.

The solution to this dilemma is quite simple. In the last few years, feature-rich smartphones have become popular. These phones come equipped with the required features such as a GPS module, a high resolution camera and internet connectivity. Due to the extremely efficient supply chains that go into manufacturing consumer electronic devices, these phones come quite cheap for the features that they provide. Also, the operating system on these smartphones provide Application Programmer Interfaces (APIs) for using the various sensors with ease. By using the APIs provided, we can easily write apps in a high-level language like Java, without the complication of writing driver code. In our system, we have used a smartphone running the Android Operating System [8], which is one the most popular mobile operating systems today.

III.OBJECTIVE

We propose a cost-effective two wheeled surveillance robot using an Arduino MEGA R3 2560microcontroller and a smartphone running the Android Operating System. Surveillance robots typically consist of a video camera, a GPS module, and GSM radios. Android smartphones come with excellent hardware satisfying the above needs. This can be leveraged and used to advantage through APIs (Application Programming Interfaces) provided for the Android operating system. Moreover, the cost for building the robot using a smartphone is mitigated to a great extent. The robot can be controlled remotely from a PC using theinternet and a microcontroller-smart phone interface residing on the robot.

To capture and archive the real time video from the robot, the inbuilt camera input of the phone is utilized. The robot can be controlled based on visual feedback from the same smart phone. Two motors help achieve a zero turning radius. The camera is attached to a stepper motor which makes it feasible to capture the scene or object of interest. The captured video can beenhanced and made intelligible using further image processing on the remote PC thereby eliminating the need for extra DSP hardware on the robot.Thus, it is our aim to build a fully-featured surveillance robotusing an easily available Android phone, which can beremotely controlled over the internet/ WIFI.

IV. BACKGROUND

A robot is a mechanical or virtual artificial agent, usuallyan electro-mechanical machine that is guided by a computer program or electronic circuitry. Robots can beautonomous or semi-autonomous and range from humanoids such as Honda’s Advanced Step in Innovative Mobility (ASIMO) and TOSY's TOSY Ping Pong Playing Robot (TOPIO) to industrial robots, medical operating robots, patent assist robots, dog therapy robots, collectively programmed swarm robots, UAV drones such as General Atomics MQ-1 Predator and even microscopic Nano robots. By mimicking a lifelike appearance or automating movements, a robot may convey a sense of intelligence or thought of its own.The branch of technology that deals with the design, construction, operation, and application of robots as well as computer systems for their control, sensory feedback, and information processing is robotics. These technologies deal with automated machines that can take the place of humans in dangerous environments or manufacturing processes, or resemble humansin appearance, behaviour, and/or cognition. Robots have replaced humans in performing repetitive and dangerous tasks which humans prefer not to do, or are unable to do because of size limitations, or which take place in extreme environments such as outer space or the bottom of the sea.There are concerns about the increasing use of

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robots and their role in society. Robots are blamed for rising unemployment as they replace workers in increasing numbers of functions. The use of robots in military combat raises ethical concerns. The possibilities of robot autonomy and potential repercussions have been addressed in fiction and may be a realistic concern in the future.

Surveillance is the process of monitoring a situation, an area or a person. This generally occurs in a military scenario where surveillance of borderlines and enemy territory is essential toa country's safety. Human surveillance is achieved bydeploying personnel near sensitive areas in order to constantlymonitor for changes. But humans do have their limitationsand deployment in inaccessible places is not always possible.There are also added risks of losing personnel in the event ofgetting caught by the enemy. With advances in technologyover the years, however, it is possibly to remotely monitorareas of importance by using robots in place of humans. Satellitecommunication makes it possible to communicate seamlesslywith the robots and obtain real-time audiovisualfeedback.Thus, in recent times, surveillance technology has become anarea of great research interest. However, building a smallrobot for testing and research purposes proves to be extremelyexpensive.

Primarily because a security robot would requirecertain components such as a GPS module (GlobalPositioning System), High resolution cameras, radios forsatellite connectivity, etc. Each of these components are quiteexpensive and piecing them together for the purpose of a robotics a very costly and time consuming affair. Moreover, a lot oftime is wasted in writing driver code to interface all thesecomponents. The solution to this dilemma is quite simple. Inthe last few years, feature-rich smartphones have becomepopular. These phones come equipped with the requiredfeatures such as a GPS module, a high resolution camera and internet connectivity. By using the APIs provided, wecan easily write apps in a high-level language like Java,without the complication of writing driver code. In our system,we have used a smartphone running the Android OperatingSystem, which is one the most popular mobile operatingsystemstoday.Thus, it is our aim to build a fully-featured surveillance robotusing an easily available Android phone, which can beremotely controlled over the internet.

The field of surveillance robots is quite popular. A lot of work has been done in navigational algorithms and control system of wireless surveillance robots. A common theme is also the use of a camera on the robot in order to receive live video feedback. Wireless robots made using the Arduino microcontroller have been implemented, but wireless communication occurs using the ZigBee protocol, which limits the range of the robot. A robot which performs image processing using the camera on an Android smartphone has also been implemented. However, this method is limited by the processing power of the phone, problem that we have addressed by remotely performing all imaging processing operations on a different computer, after transmitting the camera's feed.

Our project is rather unique in the sense that it is a low-cost solution that offers the ability to remotely control a robot with an unlimited range (by using the internet), while also offering video feedback. There is also no constraint on any extra processing since everything is done remotely.

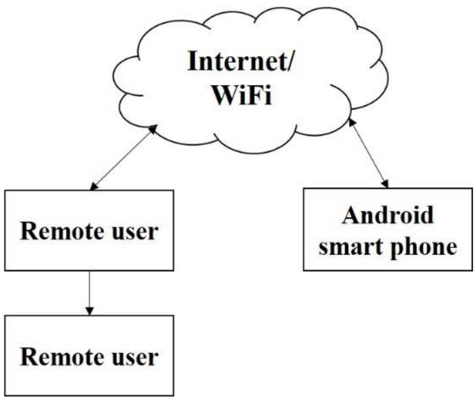

Figure 1. Basic block diagram

Our system consists of a remote computer and a robot. The robot is controlled by a user sitting at the remote computer, over the internet. The robot consists of a smartphone running the Android operating system, an Arduino microcontroller to control the robot's motion, and the requisite hardware (motors, chassis, power supply, etc.)

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The user controls the robot by sending control signals to the Android smartphone. The smartphone then forwards these signals to the Arduino Microcontroller, which then moves the robot in the required direction. The camera on the Android smartphone is used to send video feedback to the remote user simultaneously over the internet. This enables the user to navigate the robot remotely. Additional processing can be performed on the video feed on the remote computer.

A. User to Android communication

At the remote computer, the user can control the robot through the “ANDROID CONTROL FOR ARDUINO APP” which is connected to the android smartphone placed on the robot via “ANDROID HOST FOR ARDUINO”.As seen in the figure, there are navigation buttons to move the robot. There is also a window showing the live video feed from the robot. The Android smartphone on the robot writes the video feed to a particular IP address which is set by the user.

Navigation of the robot, based on the video feed, is done using the buttons on the app. When a particular button/key is pressed, a unique String assigned to it is sent to the same IP address. This String is read by an app on the Android smartphone. Both the video feed (phone to user) and navigation signals (user to phone) occur simultaneously on different ports of the same IP address. This is done with the help of internet sockets.

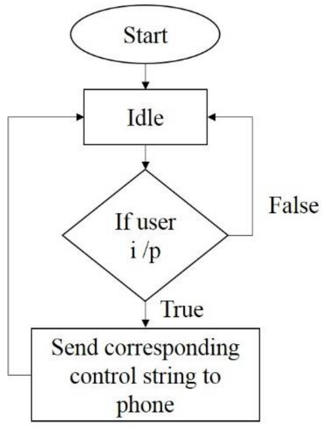

Figure 2. Flow chart of App operation

B. Android to Robot (Arduino) communication

The Android phone is connected to the Arduino using a USB OTG (On-the-Go) cable. Android provides support for USB connected devices through two modes of communication: USB host and USB accessory. In our case, the Android phone acts as the host and powers the Arduino. The Android phone acts as a bridge for communicating between the remote computer and the Arduino.The android phone which is placed on the robot has the “ANDROID HOST FOR ARDUINO APP” which captures the live video and sends it to the remote user which has the “ANDROID CONTROL FOR ARDUINO APP” installed on the smartphone.The app listens for incomingStrings from the Remote User on a specified port. Each Stringis then mapped to a hexadecimal value. For example, an “up”command would be mapped to 0x00, “back” as 0x01 and soon. This hexadecimal value is then sent to the Arduinomicrocontroller. We have used the USB Host API provided by Android for this purpose. The app also has configuration section which has the address of the server which includes both IP address and port address and it also has the option of which camera to select whether the rear or front camera including the resolution and the fps.

V. ARDUINO IMPLEMENTATION

In our system, we have used an Arduino mega R3 2560 is amicrocontroller board based on the ATmega328. TheArduino project provides an integrated development environment (IDE) based on Processing, and programming isdone using a language based on Wiring, which is very similar to C++.The Arduino microcontroller is configured to receive serialinput from the app running on the Android smartphone, and subsequently control four DC motors (2 front

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and 2 rear).Upon receiving the hexadecimal codes from the Androidphone, the Arduino generates two control signals per DC motor. For example, on receiving 0x00 to indicate a forwardmotion, the code on the Arduino sends one HIGH and oneLOW on each pair of control signals. A backward motionwould involve inverting of the same, and so on. Since theArduino cannot directly power a DC motor due to insufficientcurrent, motor drivers, with their own power supply are used.Each motor driver is capable of controlling 2 DC motors.Hence, two motor drivers are used. In our implementation,the Arduino sends the control signals to two L293D motor drivers each powered by a 12 volt battery.

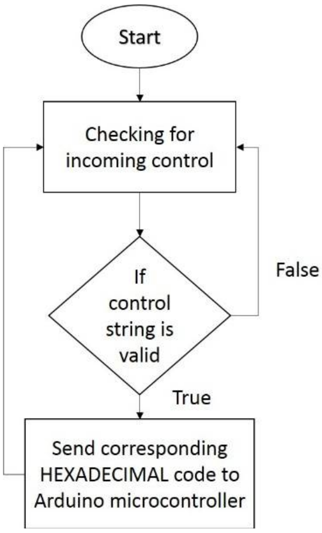

Figure 3. Flowchart depicting functioning of Arduino

Software required are:

- ARDUINO IDE.
- BLUESTACKS.
- DROID HOST AND DROID CONTROL FOR ARDUINO.

A. ARDUINO IDE

The Arduino Integrated Development Environment -or Arduino Software (IDE) - contains a text editor forwriting code, a message area, a text console, a toolbar with buttons for common functions and aseries of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them.Writing SketchesPrograms written using Arduino Software (IDE) are called sketches. These sketches are written in thetext editor and are saved with the file extension in Arduino. The editor has features for cutting/pasting andfor searching/replacing text. The message areagives feedback while saving and exporting and alsodisplays errors. The console displays text output bythe Arduino Software (IDE), including complete error messages and other information. The bottomrighthand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs,create, open, and save sketches, and open the serialmonitor.

B. BLUESTACKS

Bluestacks is an American technology company thatproduces the BlueStacks App Player and other cloud-based cross-platform products. The BlueStacksAppPlayer is designed to enable Android applications to runon Windows PCs and Macintosh computers. The company was founded in 2009 by Jay Vaishnav, SumanSaraf and Rosen Sharma, former CTO at McAfee and aboard member of Cloud.com .Investors include [1] Andreessen-Horowitz, Red point.

On June 27, 2012, the company released an alpha-1version of its App Player software for Mac OS. While the beta version was released on December 27, 2012.The Mac OS version of App Player is no longer available for download on

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their homepage, as support for it was officially dropped in 2014. In April 2015, BlueStacks, Inc.announced that a new version of App Player for Mac OSwas in development. In July 2015, BlueStacks, Inc.releasedthe new version for Mac OS. In December2015, BlueStacks, Inc. released the new versionBlueStacks 2.0 for Windows which lets users runs multipleAndroid Apps simultaneously.

Development status	Active
Operating system	Windows XP or later; Mac OS X Mavericks or later
Platform	x86, x64
Size	294MB
Available in	16 languages
Type	Virtual machine, Android emulator
License	Freeware

Table 1. Bluestacks Specifications

C. DROID HOST FOR ARDUINO

Fwsnort is software written in Perl and translates Snort rules into equivalent iptables rules. The fwsnort project utilizes the filtering and inspection capabilities of iptables including heavy use of the iptables string match extension in order to match Snort rules as closely as possible within an iptables rule set.Although fwsnort is not able to translate the complete Snort signature set into iptables rules, fwsnort is always deployed inline to network traffic. Snort is typically deployed in a passive stance and used to monitor a network for suspicious activity. Any policy built by fwsnort is not constrained to passive packet inspection; an fwsnort policy can be configured to drop malicious packets via the iptables DROP target.In general this app is something like WiFi/3G modem/shield for your Arduino board and "Droid Control for Arduino" is something like a joystick/controller that can send commands to this application and the Arduino board. This application in combination with "Droid Control for Arduino" allows you to remote control your Arduino project via WiFi / 3G *without* any shields.

VI.HARDWARE REQUIRED

- **ARDUINO MEGA R3 2560**
- **L293D MOTOR DRIVER**
- **TEMPERATURE SENSOR(LM35)**
- **ANDROID SMARTPHONE**
- **ULTRASONIC SENSOR**
- **RAIN SENSOR**
- **SOIL MOISTURE SENSOR**
- **LIGHT SENSOR**

VII. RESULTS AND FUTURE WORK

This application in combination with "Droid Host for Arduino" allows you to remote control your Arduino project via WiFi / 3G *without* any shields.This application can also stream video content from "Droid Host for Arduino". In general this app is something like WiFi/3G modem/shield for your Arduino board and "Droid Control for Arduino" is something like a joystick/controller that can send commands to this application and the Arduino board.

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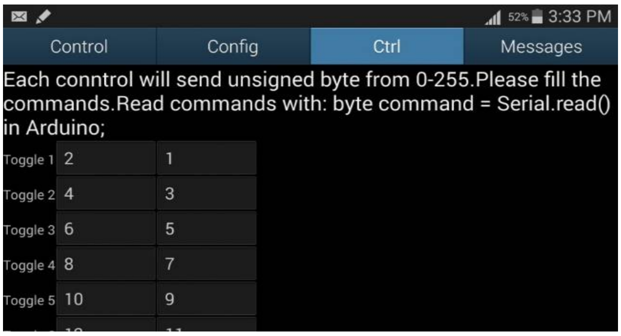

Figure 4.Command window of droid control for Arduino

This project offers a lot of scope for adding newer features. Since all image processing is done remotely, there are noresource constraints apart from the bandwidth of the network.We can program the robot such that it can detect objects and reach them on its own. Thus, we can make it completely autonomous. Also, with the presence of GPS navigation and mapping software, the robot has the capability of finding thebest route possible to reach a certain location. Also, by making it sturdier and giving it extra protection, we can make it an all-terrainrobot, which would make it ideal for a surveillance robot.

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Figure 5. Setup the commands for the robot

There is also the option of adding sounds processing to the remote computer, thus giving it greater surveillance capabilities.The possibilities are endless. This robot in its current state provides a platform for further research into improving its capabilities. In the command window of the droid for Arduino, the commands are entered to control the robot and after setting the commands, using the joystick the robot is controlled for surveillance

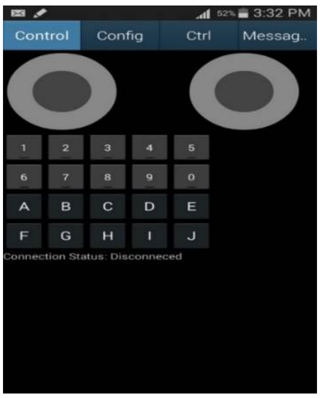

Figure 6. Control robot using Joystick

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VIII.CONCLUSION

To capture and archive the real time video from the robot, the inbuilt camera input of the phone is utilized. The robot can be controlled based on visual feedback from the same smart phone. Two motors help achieve a zero turning radius. The camera is attached to a stepper motor which makes it feasible to capture the scene or object of interest. The captured video can beenhanced and made intelligible using further image processing on the remote PC thereby eliminating the need for extra DSP hardware on the robot.Thus, with all these advanced technologies, a fully-featured surveillance robotusing Android phone, which can beremotely controlled over the internet/ WIFI is built successfully.

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