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A Prototype of Automated Child Monitoring System

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Abstract

In present scenario, where most of the parents are working persons, they cannot be around their child all the time. Hence most of the time, the child is either kept with a daycare or childcare facility or a maid is kept at home for taking care of the child. Recent newspaper articles have reported lots of incidents on child abuse, mostly in daycare facilities or by maids at home. Hence the requirement of remote surveillance system is the need of the hour. A major disadvantage of a general surveillance system is that they can only monitor a limited area in room and hence creates blind spots. There is no automatic movement of camera and it needs to be adjusted manually to cover a different angle. In the proposed system, we are using Raspberry Pi microcomputer and a camera, which is made dynamic using Passive Infrared (PIR) sensors and Servo motor. The camera will rotate according to the movement of the child around the room it covers. The camera will be installed in the centre of the room so that it can cover all directions .The video captured can be streamed live online and parents can access the feed by logging in to a website. A GSM module has been used, so that the parents can get SMS alert whenever any sensor is activated. The proposed setup is a low cost surveillance system and can be implemented at home or childcare facilities.

Keywords: Child monitoring system, Raspberry Pi, Video streaming, Servo motor, PIR sensors, GSM module, Arduino.

INTRODUCTION

In India, cases of violence and child abuse have been on an increase. A recent case occurred in Mumbai on November 2016, where a 10-month-old girl was brutally assaulted by a maid-cum-helper in a daycare facility. Complaint was lodged when the

parents saw injury marks on the face of the child. The incident was captured in CCTV and the maid was arrested [1]. Such type of incidents has been reported in other places also. In a daycare center in Florida, a caretaker was caught on camera and was arrested for kicking a sleeping child in the head [2].

The ever increasing cases of child abuse have resulted in an increasing need for implementing surveillance systems, at home or in daycare facilities. Not only for the security of the child while the child is kept with a caretaker, but also in cases where the child is kept alone at home, the parents need to keep an eye on him or her. The existing surveillance systems are costly to install and multiple cameras need to be installed to cover the blind spots.

A lot of works has been done in the field of child monitoring system. But in most of them, there are no methods to keep a physical view on the child. In [3], a system was developed that uses android phone to check whether the child is in safe zone or danger zone and updates the location using GPS. Similarly, another system was designed in which location of child can be monitored, both by school and the parents, using GPS and Google maps [4]. In [5], a telecommunication system was developed in which the parents get warned with a remote alarm whenever there is a critical health situation of the child. But in all of them there is no facility to view the child directly. Video surveillance is widely used in public places or places exposed to criminal activities [6]. Similarly low cost video surveillance systems can also be incorporated in home or childcare facilities. One such work has been done, in which a static camera has been interfaced with a Raspberry Pi and the live video is streamed, that can be viewed by logging in to a website by the parents [7].

In our proposed system, a static camera is interfaced with a Raspberry Pi and the movement of the camera is made dynamic using servo motors and Passive Infrared (PIR) sensors. Raspberry Pi is a small computer that has processing unit and works with low power of 5 V [8]. Also, a GSM module is interfaced along with Arduino that sends alert notifications whenever the camera rotates. A USB camera is interfaced with the Raspberry Pi that streams real-time video to a website that can be accessed through proper authentication. The camera is controlled using Motion software [9], which monitors the changes in video signals and provides a video output in the form of .mpg.

RELATED WORKS

A webcam server is designed using BeagleBone Black in [10], where the video is recorded and stored into a server. The end-user can download and access the video after proper authentication. A disadvantage with this system is that external storage needs to be used to store the video, as video file takes up a lot of space. Also, there is no option for dynamic camera movement.

In [11], a Wireless Automated Video Surveillance System is developed, that uses J2ME technology and cross correlation features for motion detection. Though the system is better than the traditional monitoring system, it still uses microcontroller for processing and there is no particular website to view the video stream, making it hard for end-user to access the video.

Video surveillance system is widely used, but it never has been utilized to provide a low cost solution for monitoring of children at home or childcare facilities that can be accessed very easily by parents. To rule out the disadvantages of previous projects done in this field, we have kept the following things in mind while designing our system, first is to monitor the child with real-time video, second is to provide a dynamic movement of the camera to cover the blind spots, third is to alert the parent whenever a movement of camera is detected and fourth is to view the live video over a website that can be accessed only by the parents using proper authentication.

PROPOSED DESIGN

The design proposed here is an improved and modified version of the design proposed in [7]. The hardware and software requirements have been listed in Table I and II.

TABLE I. HARDWARE COMPONENTS

No	Components
1	Raspberry Pi 3 Model B
2	PIR Sensors
3	Servo Motors
4	Breadboard
5	Arduino UNO
6	USB Webcam
7	GSM Module SIM900A

TABLE II. SOFTWARE REQUIREMENTS AND TOOLS

No	Requirements and Tools
1	Raspbian OS Jessie
2	Python 2.7
3	VNC Viewer
4	PuTTY
5	C/C++ for Arduino
6	WordPress
7	HTML, CSS, PHP

The proposed system has two setup, one for home and the other for the parents, shown in Figure 1 and 2. The home setup is connected to a Wi-Fi modem so that the video captured can be streamed in real-time over the internet. To access the video outside of local network, Ngrok application is installed in Raspberry Pi that can provide a secure global IP address for the Raspberry Pi. The other setup is a website that can be accessed using PC or smart phones by the parents. They can login into the website to access the video. Also with any sensor activation, an alert notification is sent to the parents so that they can login at that instant of time to watch the video.

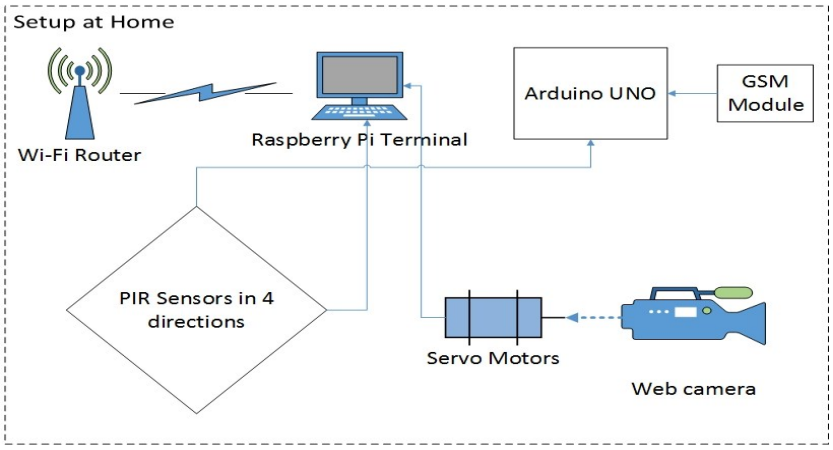

Figure 1. Setup at Home

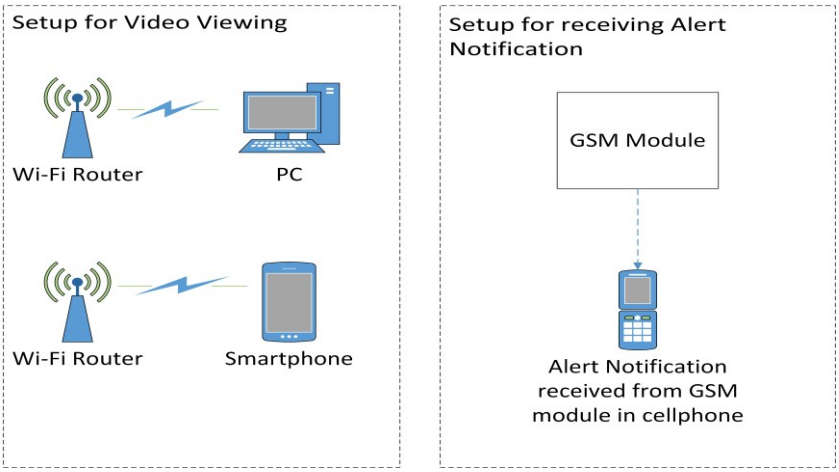

Figure 2. Setup for Parents

The various steps involved in the setup and working of the system have been discussed below.

Setting up the Raspberry Pi

Raspberry Pi is a mini-computer and has a processing unit. Hence we can connect monitor, keyboard and mouse to it and can write programs for interfacing and running devices. However in the absence of spare monitor and keyboard, a normal laptop or PC can be used to set up the Pi. For this, SSH client PuTTY is used along with VNC Viewer and the Pi is connected to the laptop using Ethernet cable. After installing the Raspbian OS, the Pi can be accessed by logging into it through the PuTTY terminal. The virtual Raspberry Pi desktop can be viewed using VNC Viewer. PuTTY and VNC Viewer are free and open source software that can be downloaded and used directly.

The Pi is then connected to a Wi-Fi network to enable internet access into it. Using Python text editor, codes can be dumped into the Pi and can be run using terminal for operating the sensors that are connected to it.

Interfacing Servo Motors and PIR sensors

Servo motors work on the principle of change in duty cycle whenever a Pulse Width Modulation (PWM) signal pulse is given as input to it. For rotating the servos, a PWM signal of frequency 50 Hz is chosen as the motor gets a pulse every 20 ms (period), that means 50 pulses per second or 50 Hz. The duty cycle is calculated as a ratio of length of pulse to the time period, as shown by the following equation (1):

Duty Cycle = (Length of given pulse) / (Time Period) (1)

As we are using 180° position control servo motors, with a frequency of 50 Hz, for moving the servo in 0°, 90° and 180°, the duty cycle values are calculated as 2.5%, 7.5% and 12.5% respectively. Two 180° servo motors are attached to one another and the webcam is attached to the top so that when the servo motors move in synchronization, the webcam covers the entire room with 360° view.

The four Passive Infrared (PIR) Sensors are placed in four directions and interfaced with the Pi. Using the concept of interrupt driven sensing in Raspberry Pi, a Python code is developed, so that whenever each sensor gets activated, the servo motor along with the camera moves in that direction and holds that position until another sensor is activated. In this type of sensing, the code does not repeatedly check the GPIO pins for signal, instead it waits until a pin is triggered. As a result, motor moves in four directions, holding at specific positions depending on which sensor gets activated and the camera covers the whole room, covering the blind spots.

Interfacing USB camera

The working of the USB camera, connected to the Raspberry Pi is controlled with software called Motion [8]. It works on the principle of comparing and finding out the pixel changes between the new image and the reference image. Motion provides features like real-time video streaming, motion detection and threshold control.

To control the camera using Motion, we need to download and install Motion in the Raspberry Pi. It is done using the following command.

```
sudo apt-get install motion
```

After installing the application, we need to configure the application by modifying the configuration file. We need to type the following command in terminal to edit the file.

```
sudo nano /etc/motion/motion.conf
```

To live stream video, we need to make some changes to the frame rate, height and width of video according to our needs and set daemon to on, stream_port to 8081 and stream_localhost to off. Now the video can be viewed through port 8081 and also the stream can be put up online as stream_localhost is turned off.

Finally one more configuration change is done using the following command and setting start_motion_daemon to yes.

```
sudo nano /etc/default/motion
```

Now after making all modifications, we can start the Motion application using the following command.

```
sudo service motion start
```

```
sudo motion
```

This will turn the camera on and real-time video streaming will be enabled at port 8081. The video can be viewed in local network by typing http://IP_address_of_pi:8081 into the browser.

To stop the application and video stream, we need to type the following command.

```
sudo service motion stop
```

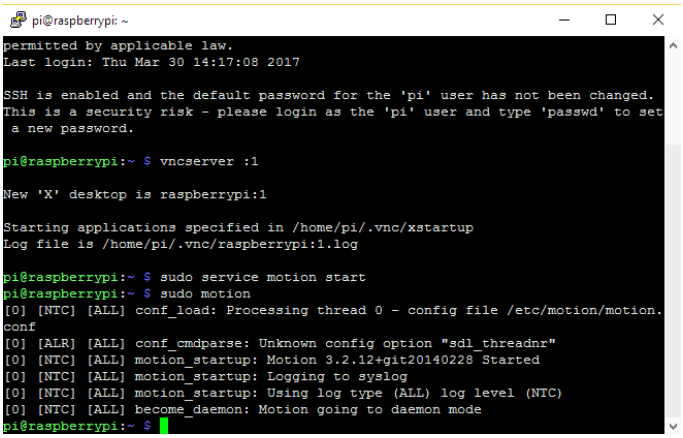

Figure 3. Starting Motion application

Streaming live video over internet

After starting Motion application, the live video can be viewed only in the local network of the Raspberry Pi. To broadcast the stream over internet, Ngrok application is used. Ngrok helps in converting the local IP address of Pi to a global IP address that can be accessed from anywhere in the world over the internet. The public IP address is given in the form of a URL. The following command is used to start Ngrok.

```
./ngrok http <IP_address_of_Pi>:8081
```

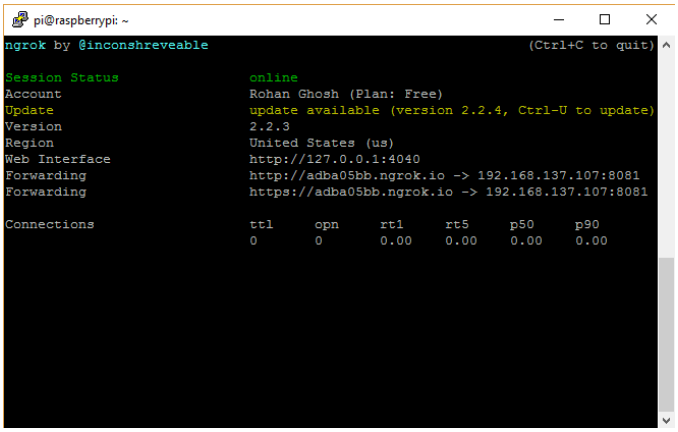

Figure 4. Starting Ngrok application

Configuring the website to access live video through authentication

The live video that is streamed online should be viewed only by the parents and not by anyone else. For this, a dedicated website with authentication feature needs to be there. Using WordPress template, a website is developed https://www.childmonitoringsystem.online. The live video stream is embedded into it and a login feature is provided such that only parents are able to login using their credentials. Hence, the system provides a secure monitoring by preventing unauthorized access by other people.

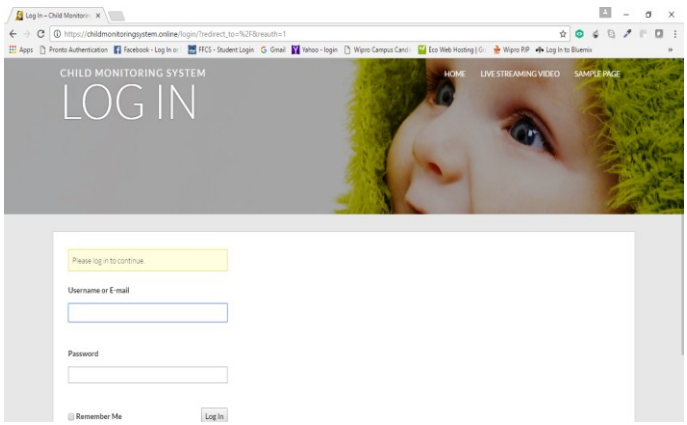

Figure 5. Login page for the website

Configuring GSM module to send notifications

An extra feature has been added to the system, in which a SMS alert notification will be sent to the parents once any sensor gets activated. This is done by interfacing PIR

sensors and a GSM module with Arduino UNO. The setup is kept along with the existing setup, as a result of which the camera moves and the parents get a SMS whenever any sensor gets activated. This provides an added advantage, where the parents will be alerted every time the camera moves and they can login directly at that time to view the real-time video and monitor their child.

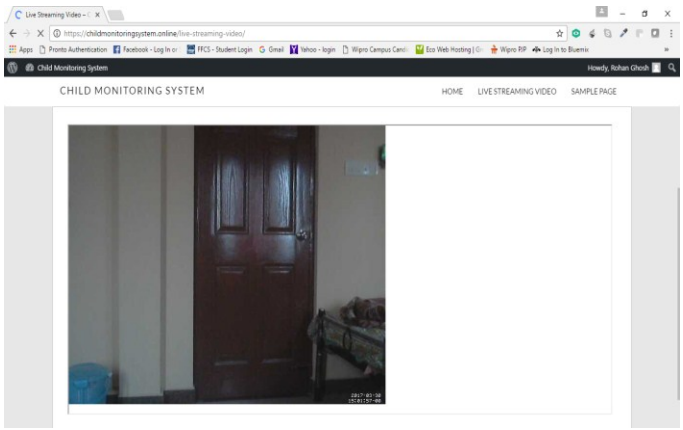

Figure 6. Live streaming video after authentication

RESULTS

We have developed the system with Raspberry Pi as the main processing unit that helps in both servo motor rotation and the real-time streaming of video through USB camera connected to the Pi. The Motion software helps in processing the video and the output is given in .mpg format. With the help of Ngrok, the video streams over internet through the port 8081. The video is viewed by logging in to the website with the username and password predefined for the parents. There is no registration form for new user in the website and hence it stops other people from accessing the video.

For rotation of the servo motors in the directions of the PIR sensors, a Python script is executed inside the Raspberry Pi. The motor moves to the required position when a specific sensor gets activated and holds its position there. We have used a 3 MP USB camera that supports 720p video capturing. The camera has a wide field of view and it covers a wider area in all four directions, hence it covers the whole room, almost without any blind spots in our testing. The PIR sensors have long range of detection and the sensor activation is tested up to 5 metres for our prototype.

For streaming video online seamlessly, a good internet connection is required. We have tested with a bandwidth of 2 Mbps and have noticed a bit of lagging and frame drops due to less internet speed and also the usage of a HD camera. With the use of higher bandwidth, the streaming will be much easier and the videos will have less frame drops.

The GSM module works fine with the PIR sensors. We interfaced the GSM module with Arduino and with activation of any of the sensors, a SMS alert is sent to the parent's mobile. The GSM module should be kept in a place where there is good network connectivity, else there will be some issues in establishing connection and sending SMS.

From all the testing done, we can summarize that the prototype is satisfactory and ready for usage.

TABLE III. TEST RESULTS

No	Testing	Expected Results	Results
1	Website accessible to the user	The login page is displayed	OK
2	Users can login and view live video stream	Users are able to successfully login and can access the live video	OK
3	Rotation of camera with sensor activation	The camera rotates when a sensor is activated and holds that particular position	OK
4	Receiving alert with sensor activation	Users will receive SMS when any sensor gets activated	OK

CONCLUSION AND FUTURE WORKS

Thus, we have designed an affordable and low cost monitoring system to be used by parents for monitoring their child in home or in childcare facilities. The design is secured from unauthorized access and also the alert feature provides a better advantage. This work is an effort to make life easier for parents who work as employees, to take a physical view on their child with the comfort of sitting in office. This system will allow them to keep their children at home with a caretaker or in any day-care facility, without compromising the safety of their child. As of future works, we want to incorporate more features into it, making it more viable and user-friendly. The increasing rate of child abuse is a concern for all of us and we believe that our designed system can be useful to tackle such problems with ease and reduce such incidents in near future.

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