Live Video Streaming with Audio Using Raspberry Pi in IoT Devices

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Abstract: This system describes the design and implementation of a low-cost system for live video streaming with audio and monitoring based on Raspberry Pi, a single board computer which follows Motion Detection algorithm written in Python as a default programming environment. In addition, the system uses the motion detection algorithm to significantly decrease storage usage and save investment costs. The algorithm for motion detection is being implemented on Raspberry Pi, which enables live streaming camera with audio along with detection of motion. The live video camera can be viewed from any web browser, even from mobile in real-time.

Keywords: Video Streaming with audio, Video surveillance system, Motion detection, Raspberry Pi.

1. Introduction

Now-a-days use of digital technology increases day-by-day such that people need the digital technology which fulfill their needs and wants in a low-cost budget. So, this system is developed in consideration of every society, Education, Business and local user purposes. So, it can be available for everyone in a minimum low-cost budget.

The Internet of Things is predicted to consist of over 50 billion devices aiming to solve problems in most areas of our digital society. A large part of the data communicated is expected to consist of various multimedia contents, such as live audio and video. This project presents a solution for the communication of high definition video in low-delay scenarios (<200ms) under the constraints of devices with limited hardware resources, such as the Raspberry Pi. It can be verified that it is possible to enable low delay video streaming between Raspberry Pi devices using a distributed Internet of Things system called the Sensible Things platform.

Specifically, our implementation transfers a 6 Mbps H.264 video stream of 1280x720 pixels at 25 frames per second between devices with a total delay of 181 ms on the public Internet, of which the overhead of the distributed Internet of Things communication platform only accounts for 18 ms of this delay. We have found that the most significant bottleneck of video transfer on limited Internet of Things devices is the video coding and not the distributed communication platform, since the video coding accounts for 90% of the total delay.

2. Related Work

There are several researches and studies those uses Raspberry Pi for live video streaming applications. One of the papers describes the live video streaming through Raspberry Pi 2 using python programming that uses a Pi cam to capture the video and process the data and transfers to the wireless network for streaming video through mobile clients [1].

Another research states that use of Raspberry pi for Surveillance system that supports motion detection of objects using python programming which uses a motion sensor for detecting the objects and a pi cam connected to the Raspberry Pi for video streaming [2].

Another paper that describes the live video streaming along with the audio using Raspberry Pi that uses a microphone and a pi cam to record audio and to capture video these video and audio data is processed using python and terminal commands and transmitted to the wireless network using a VLC codec for streaming of video with audio through the web browser in any device [3].

Other studies, researches and many papers mainly focused on surveillance system for live video streaming from anywhere in the world using any devices that supports web browser for live video streaming. These researches mainly contribute to the security purposes for home security and where the human eye is beyond reachable in sensitive areas for surveillance to rescue the sensitive areas using live video streaming [4].

3. System Architecture

The system architecture is shown in Fig.1. The architecture makes use of a Raspberry Pi, Pi Cam, PIR Motion sensor and a USB microphone. The Pi cam connected to Raspberry Pi can
be used to capture video and USB microphone is used to record audio, the captured video and audio are processed and compressed using VLC, Python and terminal commands so that the user can stream video and audio from a web browser or any android device. The PIR motion sensor detects the objects and stores the captured image on the desktop automatically with the written Python program.

The system is an embedded system that achieves video and audio streaming and motion detection of objects using Raspberry Pi and other devices uses following processes as are as follows:

A. Audio Streaming

To implement an audio streaming through server there must be a device that should cable of recording audio but Raspberry Pi does not have an audio input port. So, to achieve this an external audio device or converter is used to record the audio through USB. The captured audio is then live streamed using RTP (Real-Time Transport Protocol) protocol through any web browser with video.

B. Video Streaming

The video streaming process also starts when the Pi Cam module connected to the Raspberry Pi capturing video takes place. The operation and protocols used for video streaming uses a different standard than that used in audio streaming, the main protocol used is HTTP (Hypertext Transfer Protocol).

C. Motion Detection Algorithm

The motion detection algorithm for detecting the objects is developed using a python script and the built-in pi camera library, which makes it very simple to control the camera. To control the GPIOs, the gpiozero library is used that contains classes for most popular components like pushbuttons, LEDs, motion sensor, etc.

The Python script for motion detection, detects objects whenever there is a movement detected by the motion sensor. The system uses PIR motion sensor for detecting the objects, it can be used as a burglar detector. The overview of the motion detection Python Script is as follows:

1. Initialize the Pi Camera.
2. Capture a photo by the camera when the PIR motion sensor detects movement.
3. Save the photos captured by the pi camera in a manually created folder.
4. Naming the captured photos incrementally so that to know what order they were taken in.
5. Stop the camera with pushbutton pressing using python script.

The basic flowchart for motion detection is shown in Fig.3 using Python script.

![Fig. 1. System architecture](image1)

![Fig. 2. Operational flowchart](image2)
The proposed system used hardware and software components are as follows:

D. Software Used
1) Raspbian OS
Raspbian is an operating system based on Debian optimized for the Raspberry Pi hardware. Raspbian comes with pre-installed with plenty of software for education, programming and general use. It has Python, Scratch, Sonic Pi, Java and more. An operating system is the set of basic programs and utilities that makes the Raspberry Pi microcontroller run.

This system used Raspbian NOOBS V.3.0.0. one of the new Raspbian released 2018 was installed. This operating system was chosen because it’s very compatible OS with the Raspberry Pi.

2) VLC media player
The VLC media player is a free and open-source cross-platform media player software and streaming media server, which is a portable media player developed by the VideoLAN project. It also supports various network streaming, and supports separate video and audio ports streaming at the same time.

E. Hardware Used
1) Raspberry Pi
The proposed system uses Raspberry Pi 3B+ model single board computer and some of the key features are:
- Broadcom BCM2835 SoC processor with 700MHz ARM1176JZF-S core.
- It comes with 512MB RAM.
- Videocore 4 GPU supports up to 1920x1200 resolution.
- 5Mpix Camera module capable of full HD video @ 30fps.
- MicroSD card slot, 10/100Mbps Ethernet port, 4 x USB 2.0 ports, HDMI, audio/video jack, GPIO header, microUSB power port, DSI and CSI ports.
- Dual step-down (buck) power supply for 3.3V and 1.8V.

2) Pi camera
The Pi camera used is a 5MP camera module that capable of 1080p video and still image, and it can connect to Raspberry Pi directly with CSI (Camera Serial Interface). And then boot the latest version of Raspbian and we are good to go with the camera. It’s a fixed focus 5MP sensor capable of 2592x1944 stills, but also 1080p30, 720p60 and 640x480p60/90.

3) Motion Sensor
The motion sensor used in this system is PIR motion sensor which is operated using the 5V pin.

4) Monitor Display:
To deal with the Raspberry Pi through it.

5) USB Microphone
That works as the audio input recording device.

6) USB Power Adapter
Power supply for the Raspberry Pi.

7) Mouse
To deal with Raspberry Pi Desktop screen.

8) Keyboard
Used to write the commands.

4. Implementations and Results
Install the Raspbian OS into the SD card and insert the SD card into Raspberry Pi board and upgrade the system. Connect the camera to the Raspberry Pi board and then enable the camera and install all the software required and then reboot the system and follow the steps as follows:

Firstly: Initialize the Raspberry Pi board and connect it to monitor, keyboard and mouse.
Second: Connect the Raspberry Pi to the Network.
Third: Connect the USB microphone to the USB port.
Fourth: Write the audio code in terminal.
Fifth: Audio input devices start recording audio as soon as the code runs.
The below figure shows the code running and displays different parameters of audio recording during execution of codes.

Sixth: Write the video code into python terminal.
Seventh: The video will be captured by the Pi camera as soon as the python script runs.

Similar to the audio code, the video code also starts functioning and the shows the camera captured view. The below figure shows the video capturing command while running.

Eighth: Open any web browser from android device or laptops and type the IP address as web address.
Ninth: The video server is now working.
Similar to the video code, the motion detection python script is written into the python terminal, which will save the images on the desktop whenever movement is detected by the PIR motion sensor.

The hardware setup of the raspberry Pi board connecting to the Pi camera, motion sensor and USB microphone is shown in the below Fig. 6.

The screenshot of video streaming form an android web browser is shown in fig. 7.

The system achieved a video and audio server with a very simple method using Raspberry Pi. The proposed system used a 16GB memory card only nearly 8GB of the total memory was used including the operating system and all the software requirements.

The output of the proposed system fulfilled approximately 80% of the objectives as it was a low cost budget system, the whole audio and video server achieved with some lags, but the motion sensor detects the sensitive and small moving objects but it can overcome in future using perfect threshold values for motion detection algorithm and as well as motion sensor.

5. Conclusion

Live video streaming and surveillance system is available with various features. Selection of the system is based on the factors such as cost, video quality etc. The proposed system is cost effective and user friendly. It has applications in different fields like military, house, office, education, defenses, and environment monitoring. The proposed system can be enhanced by using face detection and recognition to follow a particular person and reducing the audio delay recording by using long range advanced wireless microphones.

References

[1] Video Server, techopedia.com