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Body worn camera

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Abstract. A body worn camera is small video camera worn on the body, typically used by police officers to record arrests, evidence from crime scenes. It helps preventing and resolving complaints brought by members of the public; and strengthening police transparency, performance, and accountability. The main constants of this type of the system are video format, resolution, frames rate, and audio quality. This system records the video in .mp4 format with 1080p resolution and 30 frames per second. One more important aspect to while designing this system is amount of power the system requires as battery management becomes very critical. The main design challenges are Size of the Video, Audio for the video**.** Combining both audio and video and saving it in .mp4 format, Battery, size that is required for 8 hours of continuous recording, Security. For prototyping this system is implemented using Raspberry Pi model B.

1. Introduction

Body worn cameras (BWC) are mobile audio and video capture devices that allow officers to record what they see and hear. Body worn camera can be attached to various parts of the body, including the head, a helmet, glasses, or to the body by pocket, badge or other means of attachment (such as in-car and on the dash). They have the capability to record officer interactions that previously could only be captured by in-car or interrogation room camera systems. The use of body worn cameras reduces "he said, she said" disputes in an incident, known as an un-biased witness. Law enforcement agencies can also recognize the potential for video footage to assist with prosecuting crimes, promoting accountability, and professionalism [1].

Body worn cameras have many advantages preventing confrontation situations, resolving officer complaints, improving agency transparency, identifying and correcting integral problems within the agency, and improving evidence documentation. Lastly, it helps the officer to remain professional while on duty [2].

The rest of the paper is organized as follows. In section 2, the specifications of the project are given. In section 3 and 4, the block diagram and flowchart is given. In section 5, calculations for the memory is given. In section 6, working mechanism is explained. In section 7 and 8, the conclusion and the future scope of body worn camera is given. In section 8, references are given.

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2. Specifications

In requirements engineering for embedded systems the fundamental functional and non-functional requirements for a system is obtained from the customers or the designers themselves discuss, capture, analyze, validate, and document the requirements [3]. The requirements are the non-technical way of expressing what is needed for the project. With the help requirements, the designers analyze the feasibility, size, power, cost and comes to a conclusion of an optimum solution for the product/project. In the body worn camera the requirement
are as follows: Taking video of 1080 pixels and 30 frames per second which is stored in the format of .mkv file along with the audio; Other features to be included are microphone and battery life lasting for 8 hours and memory storage for storing 8 hours of HD videos; The size of the product is to be comfortable to hold in hand and to be fixed in the front packet [4].

After the analysis of the requirements with respect to the cost, size, power and memory storage, conclusion of specifications are given as follows: Choosing the processor which can handles 8 hours of HD videos is critical. Thus we choose raspberry pi 3 model b. The raspberry pi 3 is a 1.2GHz 64-bit quad-core ARMv8 CPU with 1GB RAM, 4 USB ports, camera interface, display interface and micro SD card slot. Raspberry pi can handle up to 64GB of memory in the SD card. CAMERA – pi-camera with 1080p, 30fps, 5MP. Video will be in .h264 which can be coded in .mkv file along with audio [5]. For microphone, an audio jack is used where the audio are in .wave file. 64 GB micro-SD (class 10) is used for storage. The storage calculations are explained later.

3. Block diagram

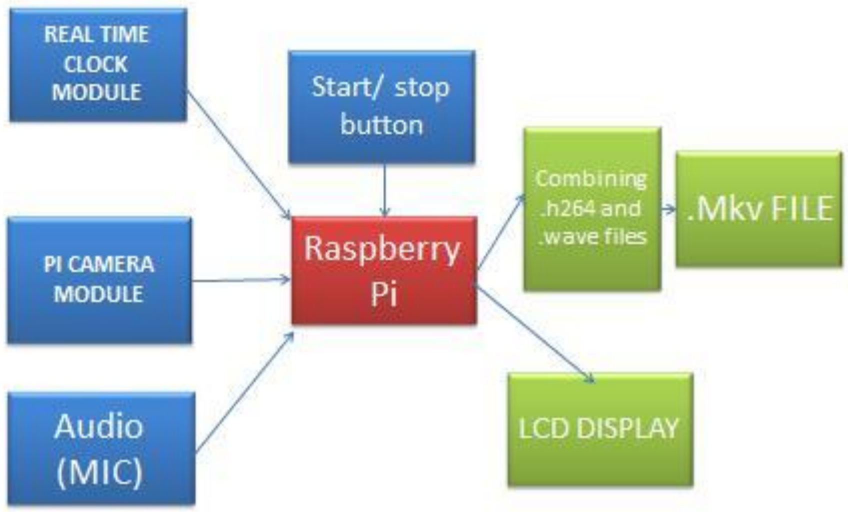

Figure 1. Block diagram of the body worn camera

This block diagram depicts the recording of video and audio and then synchronising them using Raspberry Pi 3 B+. Audio input is taken through Mic which is connected to the sound card reader. Pi camera is used to capture the video. Both Picamera and Sound card reader are connected to

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Raspberry Pi 3. HDMI display is used to display the video. Camera can be switched on/off using the switch. Once both audio and video are recorded then both the files are synchronised using ffmpeg. Time and Date are also displayed on video.

4. Flowchart

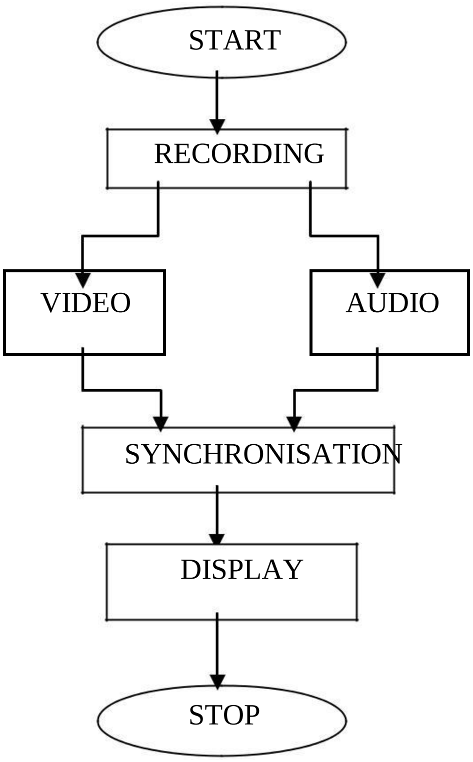

Figure 2. The flow

5. Calculations

Resolution **-** How much data is fitted in a single frame or in two fields (in the form of pixel per inch).The more pixel in the frame , higher the resolution [6].

Frame Size **-** Everything in a computer are numbers. A picture is made up of blocks. Blocks are called pixels (picture elements) and there are millions of pixels.
Example **-** 1920*1080, 1280*720, 576*720 these are the frame sizes and count the number of pixels that makes the frame.

Pixels **-** It is a smallest controllable element of a picture represented on the screen.

R	G	B

Single pixel

Frame Size – W x H

- W= width of frame
- H = height of frame

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CD = colour depth

FPS = frames per second

Video Size (VS) = BR* t

For H264, 1080p30 a high quality bitrate would be 15Mbits/s or more. Maximum bitrate is 25Mbits/s but much over 17Mbits/s won't show noticeable improvement at 1080p30.

Thus considering 17Mbits/s and 8 hours of video BR = 17(Mbits/s)/8 = 2.125 MB/s

And t = 60*60*8 = 28800s

The size of video becomes BR*t = 28800*2.125= 61.2 GB

6. Working

To program this hardware setup python was used as it very easy to learn and use. Raspberry Pi supports both Python 2 and 3. But as python 2 is more stable, it was used to implement this project.

We used raspbian Jessie operating system on pi. It is a flavor of Debian 8, specifically made for pi. It comes with preinstalled python 2 and python 3 IDE. And extensive support is provided for it by Raspberrypi.org, and various Raspberry Pi forums [7].

For ensuring the safety and transparency in the system we are providing only two buttons on the system-

1. To start the video recording
2. To stop the video recording

These buttons are connected to the GPIO pins of the Raspberry Pi.

To access these hardware buttons from Python script we need a python library called RPi GPIO library. On the latest raspbian updates this library is preinstalled. If not then it can be installed used command “Install python-rpi.gpio” from the pi terminal in super user mode [8].

But to use GPIO pins from the hardware, you need root access. That is user must be in super user mode to used gpio by python script.

To record the picamera is used. To access this camera an interface library python-picamera is written by Dave Jones.

To install this library “install python-picamera” command can be used in super user mode from pi terminal. Along with it, an HDMI display is used to preview what is being recorded. The picamera library provides functions start preview and stop preview for starting and stopping the preview.

We can also change the various settings of the camera. The list of configurations and there default values are as follows and we have set the video resolution to be 1080p.

The main disadvantage of using raspberry pi for this application is that is does not have any audio in. It has hardware support to play a recorded video but it does not have hardware required for recording the audio, but it does has four usb ports. Thus an external USB mic was used to record the sound of the video

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```
camera.sharpness = 0
camera.contrast = 0
camera.brightness = 50
camera.saturation = 0
camera.ISO = 0
camera.video_stabilization = False
camera.exposure_compensation = 0
camera.exposure_mode = 'auto'
camera.meter_mode = 'average'
camera.awb_mode = 'auto'
camera.image_effect = 'none'
camera.color_effects = None
camera.rotation = 0
camera.hflip = False
camera.vflip = False
camera.crop = (0.0, 0.0, 1.0, 1.0)
```

Figure 3. Block diagram of the body worn camera

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A raspbian comes with alsa libraries preinstalled. Now as we need to record from external mic and play it using pi hardware, we do not need to change any alsa-base configuration file. To record audio alsa provides with the command “arecord”. We just need to make sure, we give correct sound card number to the command. We have used “arecord -D plughw: 1,0 -f cd audio.wav” , here the 1 represents the number of the external sound card. By default the number „0‟ is given to the internal sound card of the Pi. The alsa project is well documented, from there one can easily learn how to use alsa commands [9].

The python scrip is written such that when start button is pressed, Video preview, video recording and audio recording starts at the same time. And when stop button is pressed, it all stops.The next step is to combine both audio and video files and save it as one video file.

The video recorded above is saved in H.264 format and to audio on .wav format, we have used ffmpeg.

ffmpeg is a cross platform solution to combine audio and video files. But the installation of it on raspberry pi is bit tricky as FFmpeg is not supported on debian Jessie and has to be backported. Thus we installed a static binary of the ffmpeg to ensure the proper installation.

The video is saved with name as current date and time, and is stored in the root folder. Thus to access it, user must have access to the root folder, or must be a super user.

7. Conclusion

This paper involves the design and implementation of the product body worn camera where different problems are addressed in designing. The various problems in designing of body worn camera are storage of the videos and transparency. These problems have been addressed in this paper and successful implementation of the body worn camera is done.

8. Future scope

In future, we can encrypt the recorded video. Also there will be few questions such that „who will have access to those videos? How will they be used? For how long the videos will be saves? How the backup of these videos is taken? How the privacy of people in these videos is protected?" needs to be answered.

Also technically, device is going to run on battery power thus work needs to be done on optimizing the battery and charging time.

As the system captures 1080p HD videos, along with a separate audio recording, the system is also memory constrained. Thus memory utilization must also be optimized.

Features like night recording, flash light, remote camera activation, officer down activation, data offloading, pre-event capture, weather resistance can also be added to make it more useful and productive.

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