Using Computer Webcam as a Surveillance Device

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Abstract— *Current line of Surveillance devices aims for ergonomics and hardware features but lack in software intelligence. Many of the current surveillance devices gives support for attaching a storage which are aimed to store the footage for a month or two. when the storage starts to fill the software will also starts erasing the older recording. Which leads to loss of data set aside the inefficient way of storing the data at first place. This project utilizes Python allows user to add several useful features such as motion detection, record on motion detection, intruder alarm, live feed over network, etc.*

Keywords— *Webcam, Computer Vision, OpenCV, Python, Motion Detection, Surveillance System.*

I. INTRODUCTION

The core objective of the study is to create a surveillance system which can perform intelligently in different scenarios. Since the current line of surveillance camera aim towards the hardware features such as night vision and better image quality and not towards the safety and programming capabilities that has been achieved in the recent years, they are easy to fiddle with. This project aims to add intelligent features to those cameras such as tamper detection, intruder alert etc. Since the program is made with python it can be packaged into mobile application, can be used with Raspberry Pi computers or integrated with cloud if need persist.

II. LITERATURE REVIEW

Surveillance system is a crucial part to current requirement for the any business and organization. But there are several scenarios where surveillance system has failed to meet the efficiency many organization and business wants from it. But first let's see what is surveillance and how surveillance system is a necessity in the current human lifestyle. Surveillance is the process of monitoring of behaviour, action, activities for the purpose of information gathering. Surveillance is done in every field of life, from small businesses to health surveillance in case of a pandemic. Surveillance is done for endangered species, cultures of bacteria and viruses in field of microbiology etc. But the most important feature of surveillance even today is the security. A proper Surveillance system provides following benefits in field of security:

- Reduce and prevent mis happenings such as theft.
- Real time video surveillance of suspects or criminals.
- Provides criminal evidences in case of criminal activities.
- Safer environment for women in organizations.
- Monitor high-risk areas.

Surveillance system no doubts provides ample of benefits to the organization and businesses but there are occasions where these surveillance systems fail, some of them are:

- Improper Placement
- Recording Failure
- Obstructed View
- Power Failure
- Communication Failure
- Easy to Tamper
- Current Systems have high cost, low availability and poor security [1].

In article [2], authors have written a detailed article on how we can implement the intelligent surveillance functionality using mobile phone and 3G/4G network. This makes user integrate highly advanced camera system of current smartphones into the work.

Table 1. Table showing video storage Matrix [1]

NTSC Recording @ 20fps	# Days for Hard Disk Capacity	
	1TB	2TB
176 x 120	540	1080
352 x 240	206	412
704 x 480	66	132
1280 x 1024	20	40
NTSC Recording @ 30fps	**# Days for Hard Disk Capacity**	
	1TB	**2TB**
176 x 120	360	720
352 x 240	138	276
704 x 480	44	88
1280 x 1024	14	28

In this Research Paper are discussing about the system which can resolve the some of the mentioned issues with current security system. This can be achieved by creating an intelligent surveillance using the power software programs that can detect or resolve issues. With the emergence of new technology, increasing number of computer vision projects dealing with detection and tracking of human posture have been proposed and developed. An exhaustive review of proposals addressing this field was written by Moeslund and Granum in [3]. They have summarized over 130 research papers analyzed and classified them into taxonomies. Yet, the current surveillance systems only focus on hardware features such as better resolution, night vision, etc.

Some expensive security cameras may provide high-capacity storage. In the Table 1, we can see users can only store for 14 days of footage in 1TB storage capacity if the resolution is set to 1280x1024 (slightly better than 720p) at 30fps. Also, Matthew Ashby made a detailed report in effectiveness of current surveillance system in [4]. Normal camera systems stop recording when the storage gets full or are programmed to delete the oldest footage in order to capture new footage. In above techniques, we are losing important data which might be crucial if needed. The new intelligent surveillance system we have worked upon provides the following features over the current surveillance system:

- Reducing the amount of data stored in storage by analyzing every frame using motion detection, if the motion detected is none or very low then the frames will not be stored in the storage device. Which drastically increase the longevity of amount a data being stored.
- Our system can be installed in systems such as raspberry pi systems and can be placed almost anywhere and can be easily powered. Later in the implantation we can also add the connection cloud service which can add the power of cloud for storing, managing data and notifying the user.
- It can utilize one of many SMS APIs to send notification when a tampering or sabotage is detected by the system.
- Feature of detecting tampering or sabotage.

Apart from that our intelligent system will also be able to transfer the stream over the network to virtually any computer device running the driving program or we can utilize this like how Zoltan Balogh and Martin Magdin have done in [5]. Or use to enhance the road safety as described by Chaudhary and J.L. Raheja in [6]

III. BASIC REQUIREMENT

Basic Requirements for the procedure are two computer system, one as an input device which has to be connected to the camera and a continuous internet connection; and another is the receiving device which has to be connected to first device with a high bandwidth internet connection. Software requirements for both devices include:

- First System connected with a webcam:
- Python 3.7
- PyCharm Community
- NumPy 1.20
- OpenCV 2
- PyZMQ 17.1.0
- Pypi3
- At least 5mbps internet connection.

Second System which is going to receive the live network feed

- Python 3.7
- PyCharm Community
- NumPy 1.20
- Internet connection with at least 5mbps speed.

IV. RESEARCH METHODOLOGY

System 1 will be used to capture/process the feed.

- **Record:** It will use to OpenCV to Capture concurrent frames.
- **Motion Detection:** The difference after cascading in the concurrent frames will be used to define motion.
- **Live Feed over internet**: ZeroMQ will be used to create a connection to the target device.

- **Tamper Detection:** When the difference between concurrent frames reaches a set threshold (say 90%) it will trigger a tampering alarm. E.g.: Covering of the camera, no input from webcam etc.

System 2 or the target system will get the feed when once connected.

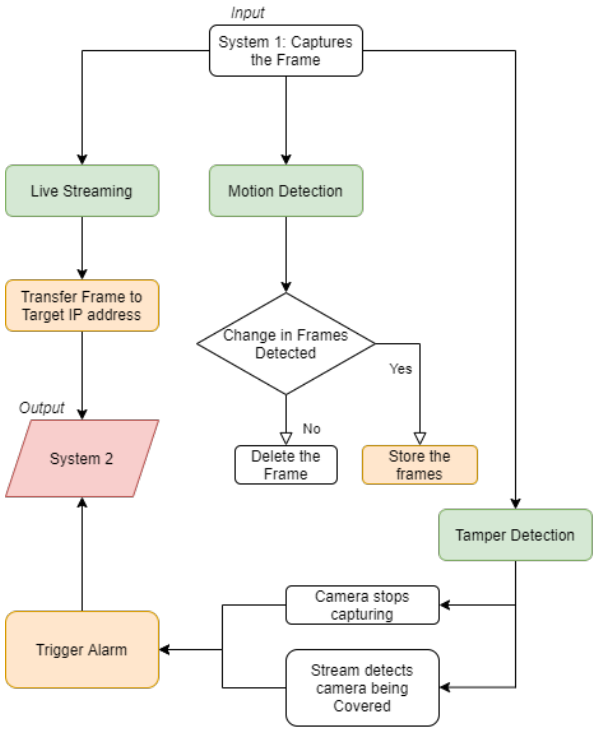


Fig.1: General Project Flow Diagram

Let's See each of the feature individually.

A. RECORD

Before going directly into the procedure lets make some clarifications. A video is a sequence of fast-moving images. When it states the video is in 23fps it means in a single second a total of 23 images are sequenced. In terms of python an image is technically called as a Frame, hence Frames-per-second(fps) is used.

In order to record the video in python we are going to use OpenCV Library. OpenCV is a library of programming aimed mainly at computer vision. It allows user to easily Capture, Record and Store frames in the system. In OpenCV, Cameras are defined by the numbers. Camera attached to system is passed by '0' and suppose if we have another camera connected to the system then it is passed by '1'.

B. MOTION DETECTION

In order to understand Motion Detection, we need to first get acquainted with a term called Background Subtraction. This is one of the most prominently used approach for Motion Detection in videos recorded from a steady camera. Basically, to find the moving objects, the difference between reference frame and the current frame are taken What remains are the contours of moved part in current frame, this procedure is described in detail by Piccardi [7] and by Yao and Marc Odobez in [8]. We will use this as a procedure for Motion Detection in our process. We are going to pick the first static frame of the captured frames as our Background and then use Background Subtraction Technique to detect the motion in consecutive frame.

But we also have to consider the natural changes that may occur during whole process such as day/night cycle, weather change or change in lightning condition. Small movement or environmental change caught by camera will be enough to trigger our motion detection algorithm, surely, it's impossible to tune it to perfection but we can somewhat minimize these effects by mounting the camera in steady position and in a controlled and stable light environment.

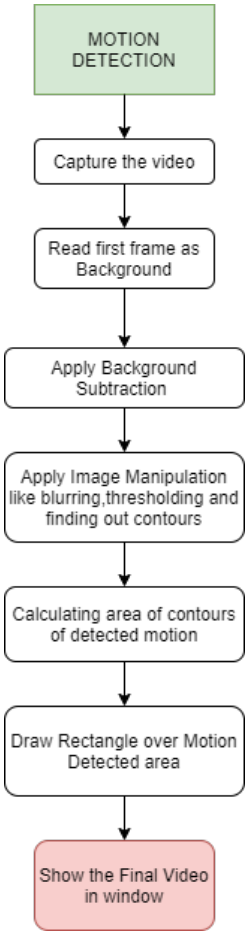


Fig. 2: Steps in Motion Detection Algorithm

C. LIVE FEED OVER THE NETWORK

In order to transfer the live feed over the network we will be using ZeroMQ library for Python. It is an asynchronous messaging library aimed at use in concurrent or distributed applications.

ZeroMQ has to be installed on both device in order to send and receive video frames over internet. We will be transferring the frame to the IP address of the Target system so in order to work target system also needs to run the python program which will allow the device to efficiently get the data being sent from the first system. In [9], authors worked on similar feature but used Linux and HTML protocol as a base.

D. TAMPER DETECTION

Camera tampering, also known as Camera Sabotage, is defined as "deliberate physical actions on a video surveillance camera which compromises the captured images", by Ali Saglam in [10]. Tampering can be of many types but mainly include defocused camera view, turned camera view or camera being covered.

Not much research has been done to counter these sabotages. Sabotages can vary in extent from being normal cover to complete vandalism of the camera system.

Motion detection techniques can be used to detect tamper if we can optimize it for tamper detection. So, in our process we have created a threshold value which calculates the number/percent of pixel changes to detect this as tampering a normal motion detection can trigger a false alarm.

The high numbers of false alarms result in less trust in the system by the operators which will eventually lead to lower system effectiveness. Hence, the systems are expected to have low false alarm rate [11]. In order to reduce the false alarm, we can set the pixel change threshold to a very high level so when the frames captured are drastically different from the background it will trigger and alarm of tampering.

In Order to send the notification, python has to be integrated with third party service like cloud web services or it can use APIs such as SinchSMS which allows user to send SMS to mobile phones.

(a)

(b)

(c)

Fig. 3: (a): Security camera view where a prisoner is preparing to cover the camera view (b): Security camera view where a prisoner starts covering the camera view. (c): Security camera sabotaged by the prisoner.

V. USE CASES

Several uses cases for this project includes:

- Monitoring System during online classes, exam, and interview.

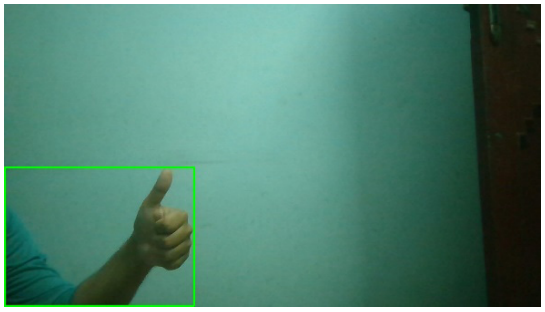
- Monitoring of suspects in custody
- Security System for home, office and business.
- Surveillance system in government restricted zones.

VI. EXPECTED OUTPUT

Since this project aims to provide the suite of feature to the surveillance system, there are several expected outputs which includes:

- A live feed of the webcam on the device connected over internet. Since the program is controlled from side of the receiver, receiver can connect to the surveillance system and watch live feed. Other features won't be affected if the receiver is currently viewing the stream or not.
- Efficient storage algorithm thanks to Motion Detection, the program is set to store only those frames in which Motion has been detected along with the time stamps. This will greatly enhance the longevity of the system as only important frames are being stored.
- Feature of tamper detection will let the owner get the notification immediately when the sabotage alarm is tripped through the SMS service such as SinchSMS or Way2SMS.

(a)



(b)

Fig. 4: (a) Image showing Background (First Frame). (b) Image after motion detection algorithm is applied.

Output for the live stream is shown below as well,

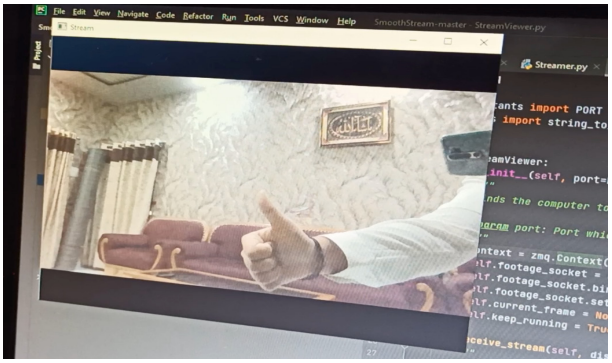


Fig 7.1 Live Stream over Internet

VII. RESULT

After running the StreamViewer module we were able to receive the stream over the internet. Some key features includes that the video was lossless which means there was no degrade in quality of the frames. But this also led to little bit slower stream playback as the it required more internet speed to cope with frames getting streamed. The video quality of the was 1080p so we can say the streaming part was successful in what it was designed for.

Output from motion detection came out to be way more promising than we thought of. The algorithm is design to store the frames only if motion is detected along with the timestamp. For a motion of about 15 seconds total of 16 Frames were captured each being the size of around 2 MB. We compared this with a normal CCTV camera connected to a storage device. We put both of those system in an artificially lit environment for about an hour the result was:

- Normal Camera: 1920x1080 @ 30fps video file: 2.9GB
- Webcam Surveillance Device: 1920x1080 images, total of 1.1GB

VIII. LIMITATION

There are also some limitations which we found while implementing the program are listed below:

- Camera needs to be placed in static and light controlled environment, failing to this may result in inefficient results from Background Subtraction algorithm which in turn result in false alarms and unnecessary data getting stored.
- The efficiency of the system is also dependent upon the quality of camera attached to system. The better the camera - the precise the result.

IX. CONCLUSION

This project can allow users to use their spare laptops or old phones to make a sophisticated surveillance system. The project is easy to setup and can provide user with salient surveillance features which may or may even not be present in expensive surveillance systems. This project can use any camera as base so even high-quality CCTV cameras can also be integrated in the system and since the project is based on OpenCV, Python addition of more features in future is also possible. In future we can add features such as cloud connection or we can use several face detection techniques to make this whole system more sophisticated. We can make this project job specific by adding only specific features required for those job, increasing its use case.

X. FUTURE SCOPE

Several useful features can be added to this project in the future such as:

- Facial Recognition system: This feature will allow this program to recognize faces, this alone can have multiple implication such as in the occasion of Online Exam or in Bank Counters.
- Connection to Cloud: This feature can allow the organization to implement this security in their cloud infrastructure making the whole infrastructure safer for workers or officers.
- This program is currently not implemented with network of camera so there is huge opportunity to optimize this program to make it cover every camera installed in its network.
- It can also have object recognition capabilities to recognized specific items such as knives, guns or even gun fires, this it will become intelligent to identify any crime that is about to happen.
- Ability to blur the faces in order to be complaint with the privacy of the person who is being captured.

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