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ADVANCED VIDEO SURVEILLANCE SYSTEM USING COMPUTER VISION

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Abstract: In today's society, safety and security are highly valued, and individuals utilize security mechanisms to protect their homes and businesses. Current security systems employ motion detection sensors and video surveillance cameras, such as Perimeter Intrusion Detection Systems, to achieve this. The aim of this project is to develop an intrusion detection system for CCTV surveillance cameras utilizing a smart camera, thus ensuring the safety and security of personal properties. Multiple USB cameras are installed at various locations for live streaming and monitoring purposes. The system utilizes face recognition as an authentication procedure and sends an alert to the owner if an unknown face is detected, along with an email and SMS containing a snapshot of the unknown person. Live feeds from multiple cameras can be viewed on smart phones and computers.
Key points: Security, motion detection, surveillance, background subtraction, CCTV.

I. INTRODUCTION

The use of technology in daily life is growing along with how quickly it is developing. One of these technological innovations that is used for security is closed-circuit television (CCTV). CCTV is a type of security camera that gives the idea that there are always an additional set of eyes there. CCTVs are present in a variety of locations, both public and private. The deployment and maintenance of the system face additional difficulties as its use for security is increasingly put to use. A big storage space used up by video content is one of the most frequent issues that CCTV systems encounter. Usually, the footage is kept on hard discs. Hence several compression techniques are used to lessen the need for storage space.

The concept is to suggest a smart surveillance system that only records video when motion is detected, preventing the storing of pointless surveillance film and assisting in lowering storage needs for security systems. The suggested system also contains a face detection and identification capability. It makes it simpler to find trespassers, criminals, and thieves [1]. Businesses will be able to manage who has access to their premises and the technology will be able to verify IDs without halting anybody. It assists in automating high-accuracy individual recognition within a few seconds. The principal advantage of facial identification is

its simple interoperability and interaction with current security products. The remainder of the essay is structured as follows: We proposed a concept for our article in part I. The literature study is covered in part II, and the suggested system's block diagram and several motion detection methods are covered in section III. Sections IV and V, respectively, examine the outcomes of the simulation and its conclusion.

II. LITERATURE RIVIEW

In surveillance systems, accurate people detection is crucial since it supports several functions including congestion analysis and individual identification. Object detection and object categorization are the first two phases in the detection process [2]. Background subtraction, spatial temporal filtering, and optical flow are methods for object detection. An algorithm for motion identification employing background removal and the frame differencing approach for video surveillance systems that offers a more pronounced silhouette of video data and significant noise detection was suggested in another research paper [3]. Moreover, it is more resistant to outside disruptions. By comparing the next frames using MSE (Mean Squared Error), it is possible to expand the amount of storage space that CCTV footage uses[4]. The average space in any moderately congested region was found to have been reduced by 31%. A sophisticated intrusion-detecting CCTV surveillance system that can identify faces based on data saved in the system has been created [5]. SMS and emails are sent together with the frame that contains the intruder's face if the identified faces don't match the faces in the database. The approach of weighting the object and background motion vector intensities to characterize the dynamic qualities of the frame in order to depict video motion that is consistent with human visual characteristics is detailed in [6]. . While watching a video sequence, the aforementioned technique displays a superior visual perception of the HVC (Human Visual Characteristics) and is helpful in differentiating local body movement from backdrop global movement.
For better crowd management, use the standard deviation model with optical flow for crowd congestion detection [7]. The measure of variation or standard deviation is evaluated.
One common method for motion identification in video surveillance systems is to use background removal and frame differencing approach, which can provide a more prominent silhouette of video data and significant noise detection. This method is also more robust against outside disruptions.

Dispersion of a group of objects makes it easier to spot places where the population density is changing. The movement of a scene between two frames of a 2-D representation of the real world is revealed via optical flow. Skin color segmentation and Har characteristics were employed in another research project to find faces in frontal and side views [8]. Skin color segmentation makes it possible to remove a sizable portion of non-pixel skin. A system that only records a live video feed when motion is detected is one that detects motion in the feed [9]. It makes the system more effective and aids in lowering the system's storage needs. The key to detecting an exciting object in a single frame is object detection [10]. Tracking was done using this technique particular object.

III. METHODOLOGY

A. Motion Detection

Finding a movement in the location of an object in relation to its surroundings or a movement in the environment in relation to an object is the process of motion detection...

B. Motion Detection Techniques

1) Background Subtraction:

By removing the backdrop from an image captured by a security camera, the background subtraction technique is a well-known method of identifying an object as the foreground. In the natural world, the camera may be rigid or flexible. This method compares the current frame to the reference frame and looks for differences in the pattern at the pixel or block level [11]. Common names for the reference frame include "background picture," "background model," and "environment model." In order to accurately represent the backdrop in dynamic scenarios, it must be flexible. By routinely updating background information, one may do that. But, this might also be prevented by providing background knowledge.

2) Optical Flow:

It's possible that optical flow is a vector-based method for estimating motion in video by comparing points on objects over picture frames (s). It is a two-dimensional vector field, and optical flow is used to explain how points move between image frames [12]. In order to identify moving areas in a series of images, optical flow-based motion segmentation analyses the features of the flow vectors of moving objects over time. Even when the camera is moving, proven optical-flow algorithms can analyses each frame separately. Although most optical flow techniques offer a broad range of computation and require specialized hardware, the complexity of the algorithm is also higher and requires a reasonably high frame rate for accurate computing. This approach is susceptible to picture noise, color, and uneven illumination. Techniques for optical flow are susceptible to interruptions in motion. Using optical flow has the benefit of being simple to use with several contemporaneous cameras and object movements.
thus this technique is ideal for dense motion areas and crowd analysis.

3) Spatio-Temporal Detection:

The motion and action present in the video are recognized and assigned in space and time during spatiotemporal detection. An picture sequence was used in a video series to make it work. a video series was processed using a spatial Gaussian, a Gaussian derivative, and a spatial Gaussian on the temporal axis. The filter has strong responses at regions of motion because of the temporal axis derivative operation. The answer was utilized to generate thresholds, which were then aggregated into bins in a spatial histogram to create a binary motion mask. This function transfers motion and spatial information momentarily. This technique enabled rapid and straightforward to build simple convolution processes. Spatiotemporal is useful for area security cameras that are placed far away and in the centre of the action. This method is utilised when the quality of the video is poor and characteristics like optical flow or silhouettes cannot be recovered from it. A feature of spatio-temporal techniques is their ease of use and low level of complexity. This technique's weakness is that the motions are susceptible to noise and changes in timing. Gait analysis can benefit from spatial- temporal motion-based approaches

since they can capture both spatial and temporal data [13]

In recent years, there has been a growing interest in using deep learning methods for object detection and motion identification in surveillance systems. Convolutional Neural Networks (CNNs) have shown promising results in accurately detecting and tracking objects in complex environments. In particular, the use of region-based CNNs, such as Faster R-CNN and Mask R- CNN, has enabled accurate and efficient detection and segmentation of objects in video streams. Furthermore, recurrent neural networks, such as Long Short-Term Memory (LSTM) networks, have been used for motion identification, enabling the tracking of objects over time and handling occlusions and sudden changes in object motion. However, deep learning methods typically require large amounts of labeled training data and significant computational resources, which can limit their practical applications in some settings. Therefore, a trade-off between accuracy and efficiency needs to be considered when selecting a detection and identification method for surveillance systems..

C. Implementation

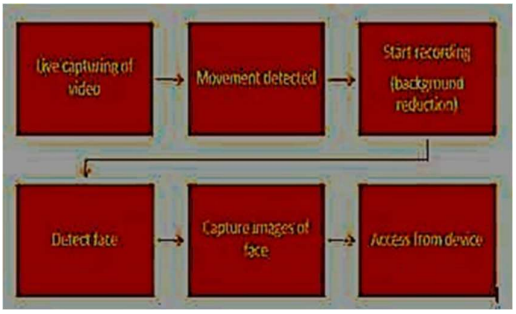
The Continuous monitoring is carried out by the device (in this case, a webcam). The algorithm can start recording the defined path after detecting a person's movement in the scene, as shown in figure

1. By storing it here rather than elsewhere, we save space and extend the period of time for which it can be accessed.

A face image will be captured from the captured video. A facial image will be scanned from the video. A further extension will be made for the approval of the people.

Another important aspect of people detection in surveillance is privacy protection. The use of surveillance cameras raises concerns about privacy violations, and therefore, it is essential to ensure that any deployed detection system complies with privacy regulations. One approach to protecting privacy is to use anonymization techniques such as blurring or pixelation of sensitive areas, such as faces or license plates, before storing or transmitting the data. Another approach is to use edge computing, where the data is processed locally on the camera or on a nearby edge device,.rather than sending it to a central server for processing. This can reduce the risk of privacy breaches and also improve the efficiency of the surveillance system by reducing the amount of data that needs to be transmitted and processed. It is important to carefully consider privacy implications when designing and deploying people detection systems in surveillance settings.

Figure 1. Stages of implementation



IV. RESULT

The algorithms were executed on PyCharm running on a Windows system, utilizing a webcam as input for video. The video was recorded at a frame rate of 10 frames per second with a resolution of 640 x 480 pixels. The motion detection algorithm was verified using the absolute difference algorithm. Additionally, the paper introduces a face detection algorithm that checks for a human face in the frame when motion is detected, i.e., when the threshold exceeds 0.01. The algorithm saves the frame as a JPG image with a specific name, such as "Name.jpg". In certain applications, faces are stored in the database, and if the detected face matches a face in the database, the system creates an image with the same name. For instance, if the identified person is person A, the frame will be associated with a particular image name. Table I presents the storage requirements for both techniques.

TABLE I. COMPARISON OF STORAGE MEMORY (IN MB)

Duration (in sec.)	Normal recording (MB)	Recording on motion detection (in MB)
05	13	6
15	31	9
45	39	11
55	89	12

The information provided indicates that the video recording was compressed significantly, resulting in a reduced size. The original recording was 99MB, but after implementing movement detection techniques, the size was reduced to 19MB. This represents a compression ratio of 80.8%, which is substantial.

It is worth noting that compression can be achieved using different methods, such as reducing the video resolution, decreasing the frame rate, or employing compression algorithms. In this particular case, movement detection techniques were utilized to detect and eliminate portions of the video with no movement. This is a common approach utilized in video surveillance systems to minimize the amount of storage space required for the recordings.

In summary, the achieved compression ratio is impressive and can be beneficial in terms of conserving storage space and reducing the cost of storing video recordings.

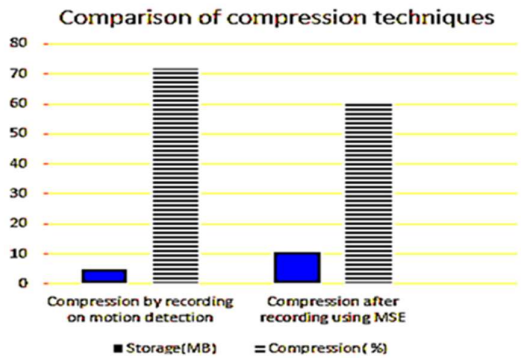


Figure 2. Comparison of Compression Techniques

The paper also introduces a face detection algorithm that is activated when motion is detected,

specifically when the threshold is greater than 0.01. When a human face is detected in the frame, the algorithm saves the frame as a JPG image with a specific name, such as "Name.jpg". In certain applications, the detected faces are stored in a database. If the algorithm recognizes a detected face as matching a face in the database, the system stores the image with the same name as the matched face. For instance, if the algorithm recognizes the detected face as person A, the frame will be stored with the respective image name.

The authors compared the storage requirements of both techniques and presented their findings in Table I. It is unclear from the given information what the specific values in Table I represent or how the comparison was made. Nevertheless, this approach could be useful for surveillance applications that require the identification of specific individuals in the captured video footage.

Moreover, it is essential to consider ethical and legal implications when implementing face recognition and identification systems. The use of facial recognition technology has been a topic of debate due to concerns about privacy, bias, and discrimination. Therefore, it is crucial to ensure that any deployed system complies with privacy and human rights regulations, and that the collected data is used in a responsible and transparent manner. This includes obtaining consent from individuals whose data is being collected and processed, providing them with clear information about the purpose and scope of the system, and ensuring that the data is protected against unauthorized access and misuse. By addressing these ethical and legal concerns, face recognition and identification systems can be used in a responsible and beneficial manner for various applications, such as public safety, security, and law enforcement.

It is worth noting that the accuracy and reliability of the face detection algorithm are crucial for the success of the system in identifying specific individuals. There are several factors that can affect the performance of face detection algorithms, such as lighting conditions, occlusions, pose variations, and facial expressions. To overcome these challenges, researchers have developed various techniques, including deep learning-based approaches, to improve the accuracy and robustness of face detection algorithms.

Figure 3 is a graph created using Octave to compare the performance of a system with traditional CCTV cameras. The graph indicates that using the system with motion recording capabilities results in reduced storage requirements. Figure 4 shows the percentage of performance improvement that was achieved.

Figure 3. Graph representing the performance of continuousmonitoringand movement detection monitoring

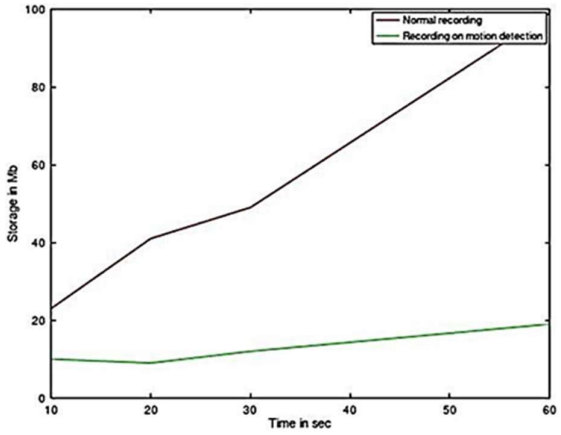


Figure 4. Calculation of percentage

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deltaSignal =

   13   32   37   80

percentageDifference =

   0.56522   0.78049   0.75510   0.80808

meanPctDiff =  0.72722
>>
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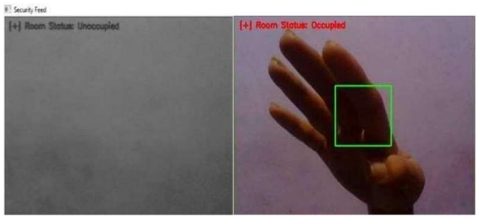
Based on the findings presented in Figure 4, the system outperforms traditional surveillance systems in terms of storage by 72%. Furthermore, Figure 5 and Figure 6 depict the results of the system's output when there is no initial motion detected and when motion is eventually detected.

Figure 5. Status when no motion is sensed vs. status when motion is



sensed

In addition to face detection and recognition, there are other important aspects to consider in surveillance systems, such as object tracking and behavior analysis. Object tracking involves identifying and tracking objects of interest, such as vehicles or individuals, across multiple frames in a video stream. This can be challenging, especially in complex scenes with multiple moving objects and occlusions. Various techniques have been developed for object tracking, such as Kalman filters, particle filters, and deep learning-based approaches.

Behavior analysis involves extracting meaningful information from the tracked objects, such as their trajectories, velocities, and interactions with other objects. This can provide insights into the behavior patterns of individuals and groups, which can be used for various applications,

such as crowd management, anomaly detection, and threat assessment. For example, behavior analysis can help identify abnormal behavior, such as loitering or sudden movements, which can be indicative of potential security threats.

Overall, the design and implementation of surveillance systems require a careful consideration of various factors, such as accuracy, reliability, efficiency, privacy, and ethical and legal implications. By selecting appropriate detection and identification methods and addressing these challenges, surveillance systems can be used to improve public safety and security while respecting individuals' rights and privacy.

Another important aspect to consider in surveillance systems is the storage and management of the captured video data. Surveillance systems can generate vast amounts of video data, which need to be stored, processed, and analyzed efficiently. The storage requirements can quickly become a significant challenge, especially for long-term deployments and high-resolution video streams.

To address these challenges, various techniques have been developed for video compression, storage, and retrieval. For example, video compression techniques, such as H.264 and H.265, can reduce the size of the video data without significant loss of quality. Storage solutions, such as cloud-based storage and distributed storage systems, can provide scalable and flexible storage options for large amounts of data. Retrieval and analysis techniques, such as indexing and search algorithms, can enable fast and efficient retrieval of specific video segments of interest.

Moreover, it is crucial to ensure the security and integrity of the stored data, especially when it contains sensitive information, such as personal data or classified information. Encryption and access control techniques can be used to protect the data against unauthorized access and misuse, while backup and disaster recovery solutions can provide redundancy and resilience against data loss or corruption.
In summary, storage and management of video data are critical components of surveillance systems, and require a careful consideration of various factors, such as scalability, efficiency, security, and resilience.

By addressing these challenges, surveillance systems can provide valuable insights into various applications, such as public safety, traffic management, and industrial monitoring.
it is essential to consider the social and ethical implications of surveillance systems. The deployment of surveillance systems can impact the privacy, autonomy, and civil liberties of individuals and communities, which can lead to social and ethical concerns. Therefore, it is crucial to ensure that the deployment of surveillance systems is guided by ethical principles, such as transparency, accountability, and respect for human rights..

Transparency involves providing clear and accurate information about the purpose, scope, and capabilities of surveillance systems to the public, stakeholders, and regulatory bodies. This can help build trust and confidence in the system, and enable individuals to make informed

decisions about their participation and consent.

V. CONCLUSION

The paper presents algorithms that use the Sum of Absolute Difference to detect motion and record video only when motion is detected. This approach has the advantage of reducing storage requirements since only frames that exceed a specific threshold are recorded. The algorithm also reduces the processing required. The system is estimated to be around 72% more efficient than traditional surveillance systems. Images are stored with the name of the person for easy access by surveillance authorities. The system is recommended for implementation in industrial spaces or high-security locations such as nuclear power plants with restricted access. Additionally, the system can be used for farm or forest surveillance, where it can detect and record specific animals, and trigger alarms upon recognizing potential threats.

Further, the system can be implemented in farm or forest surveillance. Detection or spotting of a specific animal can be recorded, and an alarm can be triggered upon recognition of a potential threat.

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