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Research Article

Enhancing Motion Detection in Video Surveillance Systems Using the Three-Frame Difference Algorithm

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ABSTRACT

This paper outlines a methodology for motion detection in video surveillance systems, leveraging advanced algorithms and TCP/IP networks for real-time data acquisition and analysis. The primary focus is on the implementation of the Three-Frame Difference Algorithm, which detects moving targets by analyzing the differences between three consecutive video frames. This method significantly reduces redundant data transmission and storage, addressing the challenges posed by limited wireless network capabilities. The surveillance model, designed in MATLAB using SIMULINK, integrates computer vision systems with embedded coders to facilitate effective communication and processing of video data. The results demonstrate the system's capability to detect motion accurately under varying lighting conditions, thereby showcasing its potential applications in diverse fields such as security, robotics, and human-computer interaction.

1. INTRODUCTION

Motion detection technology has become a fundamental aspect of modern video surveillance, transforming traditional video monitoring systems into intelligent solutions capable of real-time environmental analysis and response [1] .

This technology underpins video surveillance systems, allowing them to manage storage and transmission by capturing and transmitting only relevant information when movement is detected, thus conserving storage space and reducing redundant data transmission. This selective data handling is particularly beneficial for wireless networks, where bandwidth may be limited, as it optimizes resource allocation and reduces strain on network capacities [2] .

The current study employs the Three-Frame Difference Algorithm, a method that detects moving objects by calculating pixel differences between three consecutive frames. This approach involves analyzing the current, previous, and oldest video frames, identifying regions with significant changes between them, which typically indicate motion in the monitored area [3] .

The algorithm is advantageous for its simplicity and effectiveness, pinpointing regions in video frames that likely represent movement. This technique enables video surveillance systems to identify moving targets, ensuring video storage and transmission are activated only when motion is detected, thereby minimizing unnecessary data handling [4].

Figure 1illustrates the flowchart of the real-time video acquisition control algorithm. The system initiates by loading the necessary camera drivers to capture video data, configuring the video format, and continuously reading video information until instructed to stop. Throughout the process, the system compresses the acquired video data in real-time, transmitting it to the receiving end over wireless communication channels. By using motion detection algorithms, the system dynamically adjusts storage and transmission settings, activating these functions only when motion is detected within the frame. This approach not only conserves storage space but also reduces the load on network transmissions, highlighting the efficiency and operational benefits of integrating motion detection with real-time video surveillance [5].

Prior research has emphasized the significance of motion detection in enhancing surveillance capabilities. For instance, [3]presented an efficient algorithm for real-time motion detection, focusing on reducing processing times while increasing accuracy.[7] reviewed various motion detection techniques, highlighting their practical applications in video surveillance

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and noting the importance of choosing appropriate algorithms based on specific use cases. Additionally, [8] developed a hybrid motion detection system that combines multiple techniques to improve detection rates in challenging environments. These foundational studies provide context for the current research by showcasing advancements in motion detection technology and their application in surveillance systems. The implementation of the Three-Frame Difference Algorithm, as discussed in this paper, contributes to this ongoing dialogue by offering a practical solution that balances efficiency and effectiveness in real-time video monitoring.

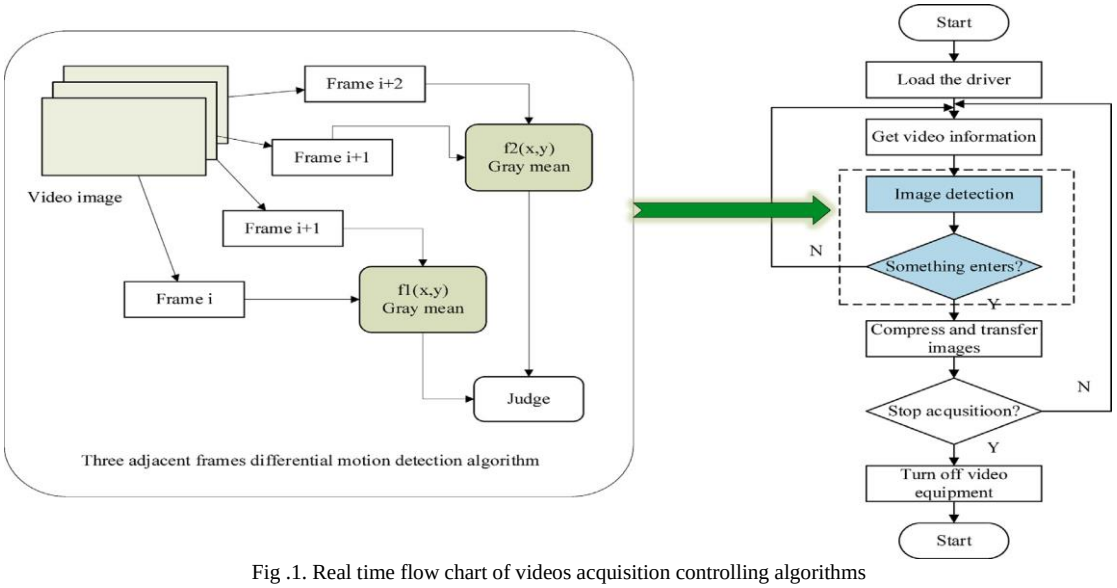

Fig .1. Real time flow chart of videos acquisition controlling algorithms

2. CAMERA SURVEILLANCE MODEL DESIGN IN MATLAB

The videos surveillance model has been design over TCP-IP networks, and examined in MATLABs. This structure show the behavior of every parts in the model with different condition as illustrated in Figure 2 and Appendix 1. The SIMULINK block set in MATLAB provide instruments controlling to sends and received the data over TCP-IP and users data protocols. The user data protocol shows in figure 3 is an another protocols of communications to transmit controlling protocols. These environments are used chiefly to established lower latencies and losses standing among all internets application. The TCP-IP was used to sends and received the information under tests that capture by camera to performs video surveillance. Additionally, through usage embed coders types C6000, the videos surveillances recorded information after DSP platforms process as well. The algorithm of motions detections have implementing and organize to TIC6000 signals processors[9].

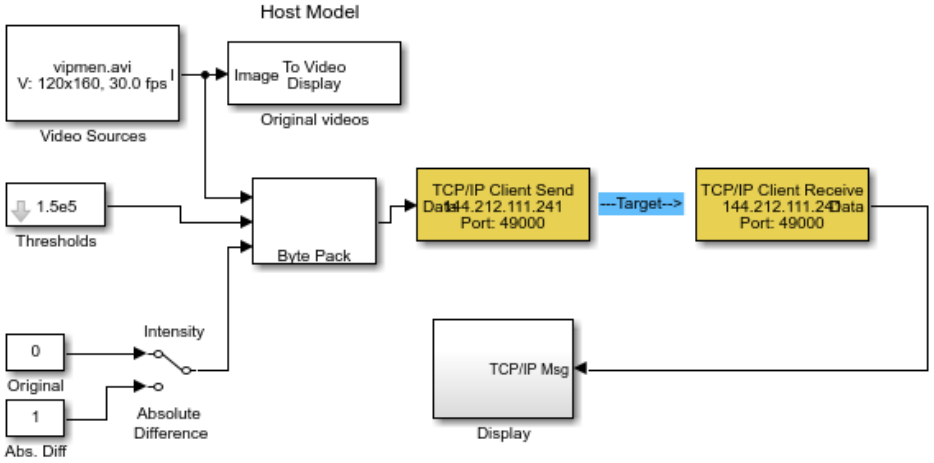

Fig. 2. Surveillance model thru usage of SIMULNK in MATALBs

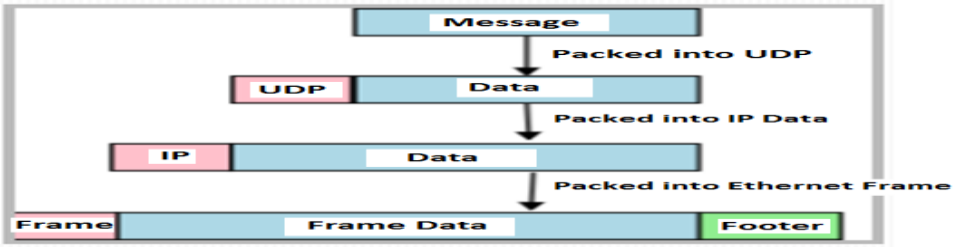

Fig. 3. Programming of Java user data protocols

The computers vision systems and DSP systems are integrates with embed coders in order to runs this model. The algorithms model show in figure 4 is use to runs the host machines and communicating with the targets thru charging TCP-IP sender and receiver block. By the blocks model, the TCP-IP blocks is configured to sends and receives the information under tests. The surveillance model is executing on the targets under algorithm of surveillance systems as showing in figure 5.These algorithms are implement through DSP systems toolboxes, in SIMULINK block set and embed coders that is convert to C language coders figure 6 show the motions display models.

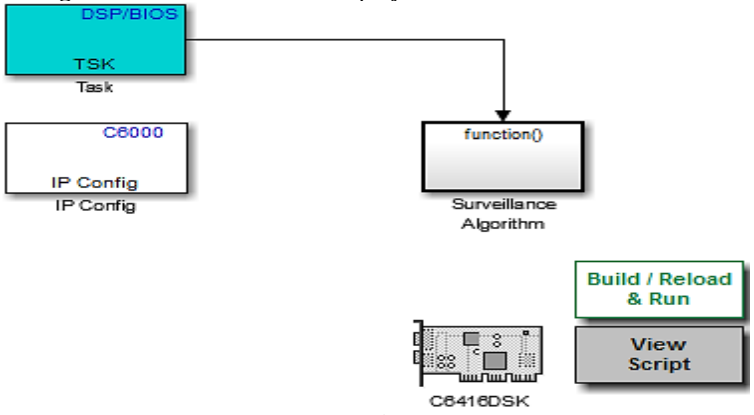

Fig. 4. Model of Targeted side

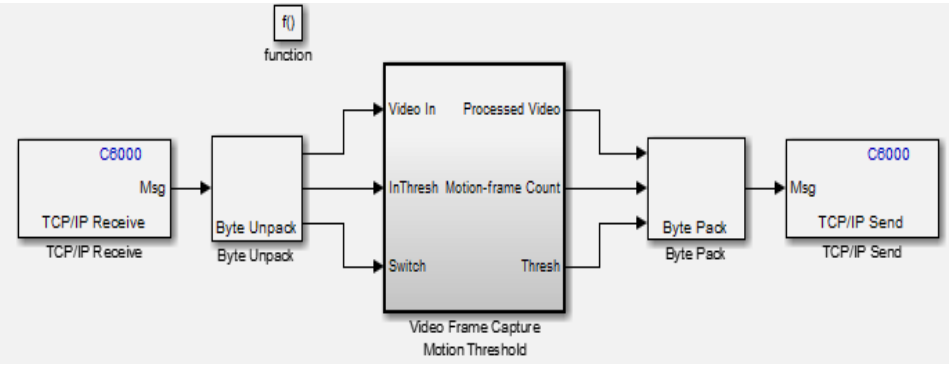

Fig. 5. Model of Surveillance algorithm

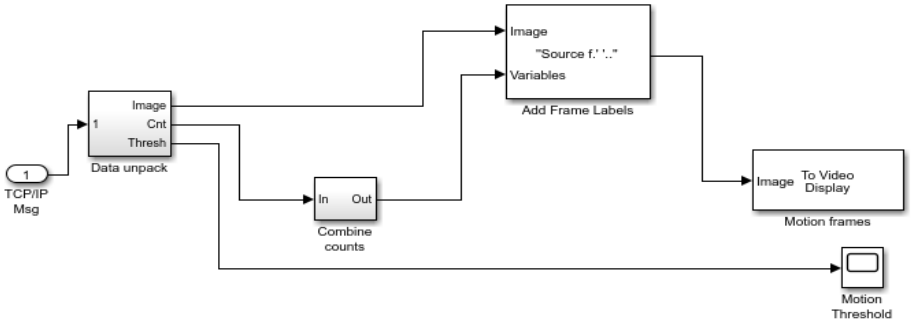

Fig. 6. Model of Motions displays

This image appeared from the implementation of the program code in the MATLAB language to monitor the movement during the day and night in The Diwan of the Anbar Province in The researcher's workplace. Where a motion in a day and night environment was tracked, analyzed, and transmitted in real-time, this is required. The attached images show accurate motion detection in all lighting conditions. , whether bright in the daytime or low in the dark. Our advanced system is used to accurately identify objects and analyze their movement in successive frames of video thanks to the technology used in image processing and motion detection as shown in figures 7 , 8 , 9 and 10.

Fig. 7. Video surveillance with motions at night

Figure 7 is taken at night shows additional challenges as a result of limited lighting and poor contrast. With these challenges, we note the identification of frames around the detected movement.

Fig. 8. Video surveillance without motion at night

We notice from figure 8 that there is no movement in the image taken at night. The consecutive frames do not include boxes or signs of movement of objects.

Fig. 9. Video surveillance without movements during the day

Figure 9 shows that there is no movement in the image taken during the day, as the successive frames do not include boxes or signs of movement of objects.

Fig. 10. Video surveillances with movements during the day

Figure 10 is captured in daylight when applying a motion tracking algorithm that uses successive frames of video to identify and track a moving object. Animated objects feature target frames that are drawn around them to define their movement in real time.The technique of object motion tracking from video is considered an important tool for understanding, studying, and analyzing motion. It allows for precise monitoring of object movements over time, enabling researchers to gain insights into patterns, trajectories, and behaviors. By analyzing the motion data, valuable information can be extracted, such as velocity, acceleration, and interaction between objects. This technology finds applications in various fields, including computer vision, robotics, surveillance, sports analysis, and human-computer interaction. The ability to accurately observe

and analyze motion enhances our understanding of dynamic systems and facilitates informed decision-making in numerous domains.

3. VIDEOS MONITORING

The increasing security concern will quicken the demands for incessant videos surveillance and a numbers of camera install in rural area, private buildings, airports, seaport and industry facility will kept rising. The numbers of camera increased and the technical challenge in manage this different quantity of data will keeps researcher and practitioner demanding in develop feasible solution to sustains this development. Many solution have been push forwards affected the greatest numerous systems component. Though, this solution is often in contrasts with each other. The new compress algorithm will decreased the bandwidths require per video streams which will likely increased the process powers require for compress and decompress the videos. In addition, the user will keeps ask for high resolutions to achieve more detail videos frame. Further than that, the networks bandwidths and process powers is the other important designing constraint and researches topics involved videos analytic and automatic videos analysing which aims at decrease the labors components in video surveillance. Because of the continuous demands for more video stream and high resolutions, larger scales video surveillances will perhaps be amongst the application that will drive greatest demands for more process capability and bandwidths. In this thesis, the aspect is analyse in details, mainly focus on videos surveillances over TCP/IPs. The whole review of the main IP-base technology is carrying out in this work. In addition, we existing a simpler methodologies to designing and measurement an IP-base video surveillances systems.

Depend on the video traffics characterizations, we develop a set of rule to verifying the video surveillances systems that will capable to supporting the largely bandwidths demands. Lastly, we describe the case study of video surveillances installations in the wireless network technologies. This approach is extend and apply to dimensions the networks in presences of wireless link.

4. RESULTS ANALYSIS AND EVALUATION

The result of errors correction mechanism provide figure comparative to the algorithms performances of the videos transmissions systems. Examination of two type of video with lower motion and higher motion contents have been done properly. The video is encoded with MJPEG compress with the options of restarting markers enable. In all case we examine the robust of the transmissions and errors corrections algorithms in term of increased in the receive video SNRs, when 6% of the packet are random losses.

This examination reveal how packets losses could affected the value of the receives videos. The scenarios involve 6% missed packet in lower motions video as show in figure 11that present errors measurement on the receive and reconstruct videos. There are an clear improvements of the videos quality achieve by the corrections schemes when the missed packet. Same effect have also been observe in the case of 3% and 10% packets losses.

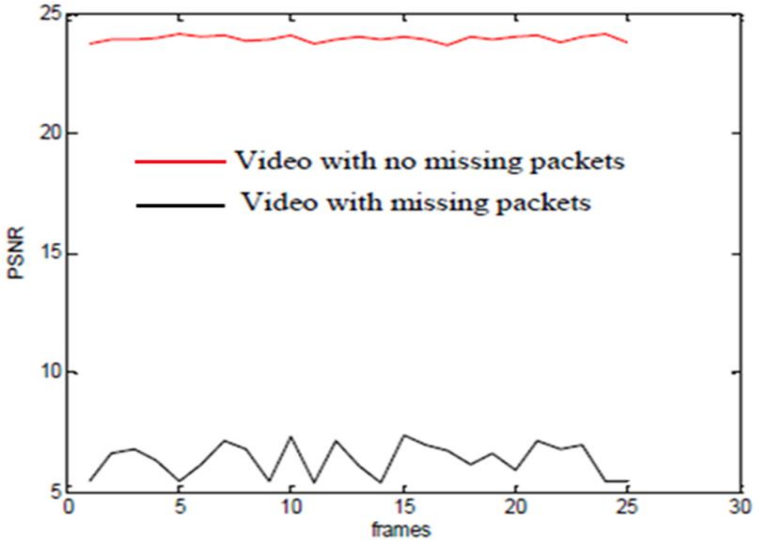

Fig. 11. Reconstructions performances with low motions

figure 12shows the examination of the receive video quality in case of there is significant motions. The quantity of motions are measures in term of frames-to-frames bits differences. The implements errors concealments algorithms perform well in

the situation of increasing the motions. The motions of the videos are not deeply reflect on the qualities of the reconstructing images in term of the peaks signals to noise rations . The peak signal to noise ration value tends to follow the motions activities but not to the same extends. The reasons for these effects are the errors concealments algorithms attempt to reconstructs the missed frames, it use as references the last correct receive frames. Difference cause by motions leads to low qualities of the reconstructed frames.

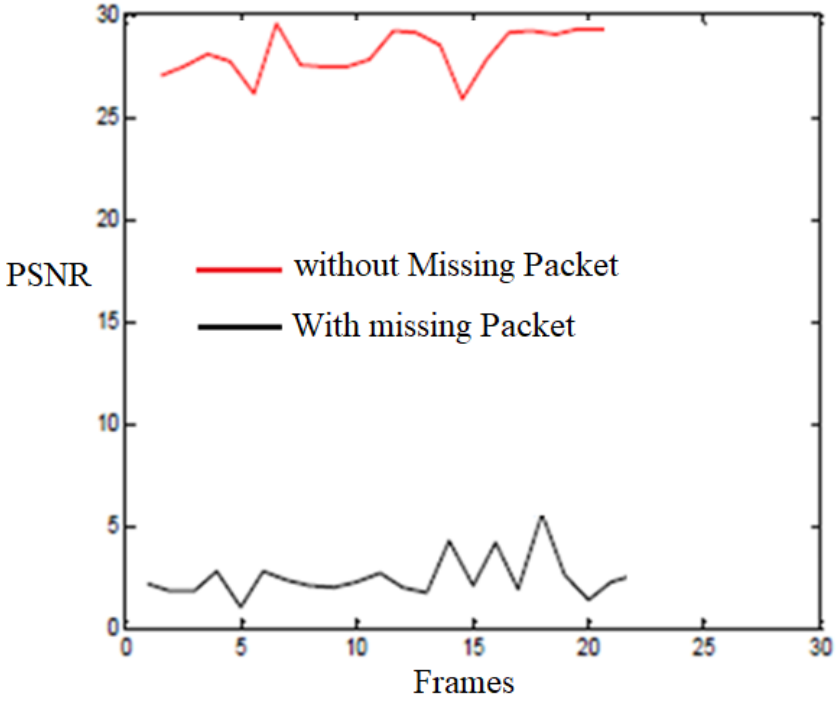

Fig. 12. reconstruction with the mtion preformances

In term of processed the videos, the systems is capable to supporting broadcastings of full size image. Additionally, two user could be requested for zooming part of the occupied cameras images resolution in transmitter at frames rates as illustrated in figure 13.

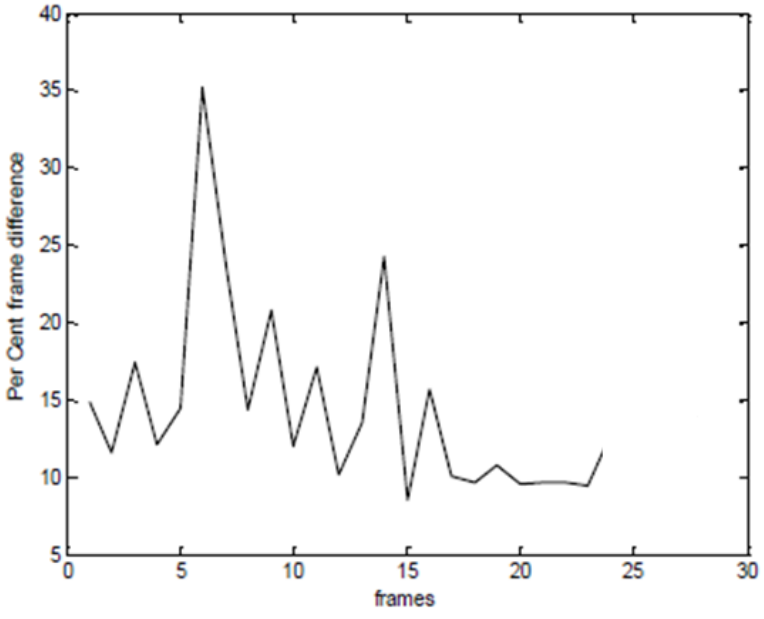

Fig. 13. Percentage change in the bits steams

The system presentation need to be sensibly checking with the options of objects and motions detections and track, since the tracked algorithms could slows down its operations. Further exactly, the executions time on the digital signal processing and the computers are illustrated in table 1This result is worked toward the improvements of the complete systems performances. The key focusing in this thesis is to reduces the process times of the objects detections algorithms and the sections of the great impacts on the complete systems performances.

TABLE I. RESULTS OF MOTIONS SURVEILLANCE ALGORITHMS

Object detection	On server (on Matrox DSP)	On client (on custom PC)
Estimated time for full-sized images	0.07s	0.13s
Frame rate (for full-sized images 1280 x 780 x 24bit/pixel)	~13fps	~7fps
Frame rate (for ROIs 800x600x24bit/pixel)	~20 fps	~11 fps

Through current year, IP cameras technologies has overtaken analogy ones and now they fit to all requirement and specification. Besides, IP performance exceed analogy cameras performance due to their new function. Specifically, analogy cameras is a carrier of mono-directions signal ending on the DVR devices and levels of process, whereas IP cameras is bi-direction and integrate itself with the other part of a systems, up to the higher levels, in given scalable environments. IP cameras communicate simultaneously with numerous application in order to performs many task, such as moving and sending various videos flow table 2 shows a comparisons of characteristic among analogy and IP camera throughout videos surveillance systems performances.

TABLE II. CHARACTERISTICS COMPARISON BETWEEN ANALONG AND IP CAMERA THROUGH OUT VIDEOS SURVEILLANCES SYSTEM PERFORMANCES.

	Scenario with analog cameras	Scenario with IP cameras
Camera resolution	from 420 to 700 TV lines, 4CIF resolution	from 1 MPixel to 8 MPixel
Cabling (Video and Power)	coaxial to each camera and DVR, additional power cables	Cat 5e, Power over Ethernet (PoE)
The average cable length	100 m/camera (video) 65 m/camera (power)	65 m/camera (Cat5 with PoE)
Power	Power for cameras	PoE
Switches	to all types DVR	PoE switch
Server / memory	Mid-end DVR (H.264 compatible with memory)	PC (standard) with memory
Software	on the DVR (H.264 compatible)	AXIS Camera Station
Monitors	standard high resolution monitors	standard high resolution monitors

5. RESULTS COMPARISON

Table 3: show the results comparison with the literature. Clearly the PSNR of proposed techniques show better performance compared with another and existing approaches by around 10%.

TABLE III. RESULTS COMPARISON IN TERMS OF PSNR

Parameters	**Konstantia Moirogiorgoul ,et al[8]**	**LalChand Bishoni ,et al [10]**	Proposed technique
PSNR without missing packets	24	27	29
PSNR with missing packets	5	5	5

6. CONCLUSION

The research presented in this paper successfully demonstrates the effectiveness of motion detection algorithms in video surveillance systems. The application of the Three-Frame Difference Algorithm allows for efficient processing and transmission of video data, minimizing storage requirements while maintaining high accuracy in motion detection. The integration of DSP systems with MATLAB and TCP/IP protocols enables seamless data communication, ensuring low latency and reliability in surveillance applications. The findings highlight the system's adaptability to different environments, confirming its utility in both day and night scenarios. This work paves the way for future developments in smart surveillance technologies, emphasizing the importance of real-time data processing in enhancing security and monitoring systems.

Conflicts Of Interest

The author's disclosure statement confirms the absence of any conflicts of interest.

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References

[1] Ahmed and M. Hossain, "A Survey of Motion Detection Techniques for Video Surveillance Systems," International Journal of Computer Applications, vol. 975, pp. 1-6, 2020.

[2] Z. Liu and Y. Wang, "A Comprehensive Study on Video Surveillance and Motion Detection Algorithms," IEEE Transactions on Circuits and Systems for Video Technology, vol. 29, no. 12, pp. 3650-3663, 2019.

[3] A. Raj and R. Gupta, "A Review of Motion Detection Techniques and Their Applications in Video Surveillance," Artificial Intelligence Review, vol. 53, no. 2, pp. 811-828, 2020.

[4] M. A. Hossain and M. Mahmud, "An Overview of Motion Detection Techniques in Video Surveillance," Journal of Information Engineering and Applications, vol. 9, no. 4, pp. 1-8, 2019.

[5] N. Srivastav, et al., "Hybrid object detection using improved three frame differencing and background subtraction," in 2017 7th International Conference on Cloud Computing, Data Science & Engineering-Confluence, 2017, pp. [Insert page numbers].

[6] A. Karam and N. Ayyub, "An Efficient Algorithm for Real-Time Motion Detection in Video Surveillance Systems," International Journal of Computer Science and Information Security, vol. 15, no. 3, pp. 1-7, 2017.

[7] A. M. Abood, et al., "Design and simulation of video monitoring structure over TCP/IP system using MATLAB," Indonesian Journal of Electrical Engineering and Computer Science, vol. 24, no. 3, pp. 1840-1845, 2021.

[8] K. Moirogiorgou, et al., "A Real-Time System for HDTV Video Transmission Over IP Networks," Department of Electronic and Computer Engineering, Technical University of Crete, Chania, Greece, 2017.

[9] L. C. Bishnoi, et al., "Simulation of Video Transmission over Wireless IP Network in Fedora Environment," IP Multimedia Communications, Special Issue from IJCA, 2011.