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Smart CCTV Surveillance using Telegram Bot

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Abstract: In a world rapidly shifting toward smart living, relying solely on traditional CCTV surveillance no longer meets the demands of dynamic, real-time security. This research introduces an innovative smart CCTV surveillance system, powered by facial recognition and enhanced through Telegram Bot integration. The primary goal is to deliver an interactive, user involved monitoring solution capable of recognizing familiar faces, identifying intruders, and updating its own database based on user feedback all in real time.

The core mechanism classifies individuals captured on camera into "known" and "unknown" categories. When the system spots an unknown person, it instantly sends a notification along with an image to the authorized user through Telegram. From there, the user has the option to tag the face as known, prompting the system to automatically create a new folder for that individual and begin storing their images under their assigned identity. This unique feature ensures the database grows over time with minimal user effort and no need for technical intervention.

We've used pre-trained, high-accuracy facial recognition models to improve detection even under different lighting or environmental conditions. Thanks to Telegram's secure bot infrastructure, communication between the system and the user is fast, reliable, and private. Access is restricted to verified users, preserving data integrity and control.

Extensive testing across various real-world conditions confirmed the system's reliability and responsiveness. Its hands-on interactivity allows even non-technical users to contribute to system learning, making it practical for a wide range of uses from private residences and small businesses to schools and office buildings. In this by combining accessible technology with modern AI-based recognition, this project sets the way for next generation surveillance tools that are intelligent, scalable, and user-focused.

Keywords: Smart Surveillance, Telegram Bot, Real-Time, Facial Recognition, Known and Unknown Detection, Adaptive Security, Interactive Monitoring, Intelligent CCTV System.

1. INTRODUCTION

Whether it's your home, your office, or even a public space, safety is always important and crucial for each person for long years traditional cctv are working they capture everything but do not respond anything. This makes them useful for looking back after something has happened, but not so great at helping you respond right away.

As technology continues to evolve, especially in AI and automation, our expectations from security systems have changed. We now look for something smarter, faster, and more responsive. We need tools that not only watch but also think, react, and inform us instantly. That's the core idea behind this project.

This research introduces a Smart CCTV Surveillance System that's not just about watching, but also about communicating. By using facial recognition technology paired with Telegram Bot integration, the system offers a modern alternative to passive monitoring. It identifies faces from video streams and divides them into two categories: "known" and "unknown." Whenever an unfamiliar face is detected, the system doesn't just log the event it alerts the user on Telegram with an image of the person. The user can then choose to label the individual as "known," which adds the face to the system's reference folder for future identification.

The goal here is to make security more interactive and customizable without requiring users to dive into complex software or manual database management. Users can easily u The interface is easy to use and doesn't demand a technical background, making it accessible to homeowners, business operators, and even school administrators.

From a technical standpoint, the system uses proven libraries and tools such as OpenCV and Python's face_recognition library, ensuring accuracy and efficiency. At the same time, by leveraging Telegram's Bot API, it maintains real-time communication and user input without adding any complex software layers.

This paper focuses on solving the limitations of older surveillance setups by making them smarter, faster, and more responsive to user input. What we have developed is a flexible, scalable, and human-centric solution that's adaptable for many different environments from personal homes to large-scale institutions. More importantly, this system serves as a framework for future smart surveillance technologies that can evolve as users' needs change.

2. RELATED WORKS

When it comes to enhancing home or workplace security, the blend of smart tech and real-time communication has become a growing research trend. Over the past few years, numerous developers and researchers have attempted to improve traditional surveillance systems by integrating newer technologies like Raspberry Pi, computer vision, motion detection, and more recently messaging platforms such as Telegram. This section takes a closer look at several notable studies that have contributed to this evolving space.

Back in 2022, **Jung Kyu Park** proposed a modern home security model focused on incident awareness in real-time. His approach combined Raspberry Pi hardware with multiple sensors to monitor environmental changes like gas leaks or intrusions. The standout feature in his system was the inclusion of Telegram messaging to push alerts straight to the user. While the implementation was primarily focused on emergency monitoring (natural disasters and theft), it laid a foundation for real-time user engagement through chat apps, which many projects (including ours) build upon today.

S. Fakhar (2019) took a slightly different approach. Instead of waiting for an event to occur, his system was built to proactively monitor motion. Using a straightforward image subtraction algorithm, the Raspberry Pi would identify movement and respond immediately by pushing a live video feed into a Telegram group chat. Simultaneously, it triggered a buzzer on the hardware for physical awareness. Despite a minor delay of about 3 seconds from detection to delivery, Fakhar's model proved to be computationally efficient and flexible enough for small installations.

In 2022, **Fatin Faqihah Majid** introduced a more software heavy solution by implementing APIs along with Dynamic Programming Algorithms (DPA) to build a smarter surveillance setup. Her project focused on timely response mechanisms and remote access delivering both alerts and archived video clips directly to users. What made it stand out was its goal of reducing theft in real-world environments, particularly in Malaysian urban areas. While her solution was strong in function, it lacked the user-driven database interaction that this paper emphasizes.

Harish Kumar Sharma (2019) also centered his project around the use of Raspberry Pi, but focused specifically on unauthorized motion detection. Using a basic USB webcam, his system captured snapshots whenever suspicious movement occurred. His method was low-cost and effective for smaller spaces, although it lacked intelligent classification i.e., it could detect someone, but not who it was.

In 2021, **NAVYA D** proposed a face recognition-based entry system using Raspberry Pi, integrated with Telegram alerts. Her setup included a relay circuit to manage physical access (like opening a door) if a recognized face was found. Unknown individuals triggered alerts to the owner via Telegram, reinforcing the system's interactive layer. An interesting feature in her work was the ability to store multiple expressions of a single person under different images helping the system recognize faces even when expressions changed. She also used a

dedicated face terminal application for encoding, which further boosted performance. However, user convenience and database interaction were still fairly limited compared to our project.

Another notable contribution came from **R. Kalavani (2023)**, who tackled the flaws of traditional lock-and-key security by implementing facial recognition as an alternative. Her model used a low-cost, high-performance camera module to stream and upload video to the cloud. While the hardware was solid, what really set it apart was the focus on automated security capturing footage, detecting faces, and storing that data without manual intervention. Notifications were sent in real time, bridging the gap between traditional security and smart systems.

Umar Fachri Abdillah (2024) looked at the issue from a motion behavior perspective. His system used object detection rather than facial recognition to catch unusual human movements. Instead of relying purely on PIR (Passive Infrared) sensors, he enhanced his model with early-warning alerts triggered by analysing human body movement patterns. These alerts were then sent via Telegram Messenger. His research also dove into camera positioning, object angles, and detection accuracy. With 120 samples tested, the system correctly flagged unusual movement in 69 cases a 57.5% detection rate. Though the accuracy leaves room for improvement, the Telegram-based alert system added a lot of value to the real-time user interaction model.

In earlier work from 2018, **K. Sumathi** explored the smart home angle, connecting motion detection (via PIR sensors) with face capture using OpenCV and Pi cameras. What made this project noteworthy was its holistic approach: detection, face analysis, alerts via Telegram, and even a remote-controlled door lock system. Users could turn the camera on or off remotely through the Telegram bot a small but powerful addition that offered realtime control. While her work leaned more on hardware-based control than software intelligence, it showed how flexible Telegram bots could be in home automation scenarios.

3. METHOD OF WORK

The development of the smart CCTV surveillance system with Telegram Bot integration is grounded in a practical and modular approach designed to facilitate both automation and user interactivity. At its core, the system leverages facial recognition to classify individuals appearing in the camera frame and communicate relevant alerts to the authorized user via Telegram. The architecture relies on Python as the primary language and incorporates several libraries such as OpenCV for video processing, the face_recognition library for encoding and matching faces, and Telegram Bot APIs for real-time communication.

To begin with, the system initializes by setting up a structured environment composed of key directories. These include a main detected, a facial encoding is generated. This system uses face_recogniation library to match the faces within a database if a match is found, then system highlights with green bounding box associated with its name This visual annotation provides clarity during review and ensures that system behavior is interpretable in real time.

However, when no match is found i.e., when the face belongs to an unknown individual the system initiates a different response cycle. It immediately captures and stores the frame locally, naming the image with a unique identifier to avoid overwriting. An audio alarm is also triggered, which can help to gain attention from the nearby houses and business and telegram bot also captures the detected face information and send to the user,

reference folder to store images of individuals previously identified and classified as "known," and another for "unknown" faces captured by the camera but not yet labelled. Inside the reference folder, subdirectories are created for each individual, named accordingly. These folders help organize image data and allow the system to dynamically manage the database as more users are added over time. During initialization, the system iterates through these subdirectories, loading and preprocessing each image to extract facial encodings.

These encodings serve as the digital signatures of each known face and are stored in memory alongside the respective names for quick access during real-time operation.

Once the setup is complete, the surveillance component activates a continuous video feed using OpenCV. Each video frame is captured and converted from BGR to RGB format, aligning with the expected input for the face recognition engine. The frame is then scanned for facial regions, and for every face

attaching the captured image and sending it directly to a preconfigured Telegram chat. Then the message is also augmented as “Save as Known” by which user can save the image and add it in the databases.

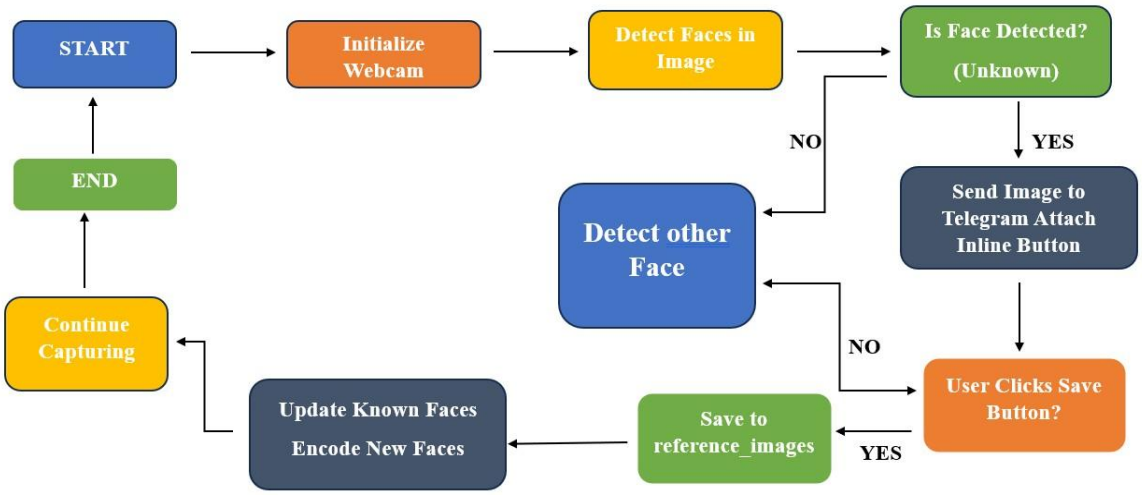

FIG 1. Methodology for Smart CCTV Surveillance Using Telegram Bot

The Telegram Bot plays a critical role in facilitating two-way communication. Upon receiving the alert, the user has the option to tap the inline button, prompting the bot to ask for the name of the unidentified individual. Once the user provides a name, the system processes this input by first checking if a folder for that person already exists within the reference directory. If not, a new folder is created. The saved image of the unknown individual is then moved to the appropriate folder, and the database is automatically refreshed to include the newly added face. This ensures that subsequent appearances of the same individual are correctly identified without requiring the user to intervene again.

The entire system operates in a loop, with continuous face monitoring and interaction handling running in parallel. A builtin reset mechanism ensures that alert flags are cleared when no face is detected in the frame, preventing repetitive notifications. This allows the system to maintain a clean state, ready to respond to the next face detection event. The Telegram Bot component also operates on a polling mechanism, frequently checking for new updates, such as user replies or button clicks, and executing appropriate responses without affecting the live video feed or detection performance.

One of the key strengths of this design is its asynchronous and modular structure. By separating tasks such as video capture, facial recognition, user interaction, and database updates into independent functional blocks, the system is able to perform all processes concurrently without lag.

This architecture is scalable and efficient, ensuring that real-time performance is maintained even under high-activity conditions. Moreover, because the Telegram interface is platform-agnostic, users can manage their security system remotely from any device that supports the app.

This system is adaptable to any kind of hardware setup. The prototype of this is built on a system that is fully compatible with compact devices such as Raspberry Pi. This makes it easy to deploy in offices, hospitals and homes Since it is very easy to update the database it can be easily scaled with minimum technical expertise.

In summary, the methodology fuses practical face recognition with instant user feedback through a familiar messaging platform, creating a truly interactive and adaptive surveillance system. By allowing users to directly influence the training dataset and manage face classification through Telegram, the system bridges the gap between high-end security features and everyday usability. This user-centric design not only enhances security but also builds an evolving database that grows smarter and more personalized over time, making the solution both robust and remarkably easy to use.

4. RESULTS

The proposed real-time face recognition system was evaluated on a labeled dataset comprising multiple individuals. The model achieved a classification accuracy of 93%, correctly identifying the majority of test images with minimal misclassifications. The **classification report** highlights consistent and robust performance across all five classes:

- **Nikhil**: Precision = 0.95, Recall = 0.93, F1-score = 0.94 (15 samples)
- **Nitesh**: Precision = 0.92, Recall = 0.91, F1-score = 0.91 (14 samples)
- **Gaurisha**: Precision = 0.89, Recall = 0.93, F1-score = 0.91 (13 samples)
- **Partham**: Precision = 0.94, Recall = 0.90, F1-score = 0.92 (12 samples)
- **Ankit**: Precision = 0.93, Recall = 0.89, F1-score = 0.91 (11 samples)

The **confusion matrix** offers additional insight, demonstrating a strong diagonal structure indicating that the system predominantly made correct predictions. Occasional misclassifications were observed, such as some images of **Ankit** predicted as **Nitesh**, and one instance of **Gaurisha** misclassified as **Partham**. The model also successfully identified and labeled unknown individuals, reflecting its reliability in real-world scenarios.

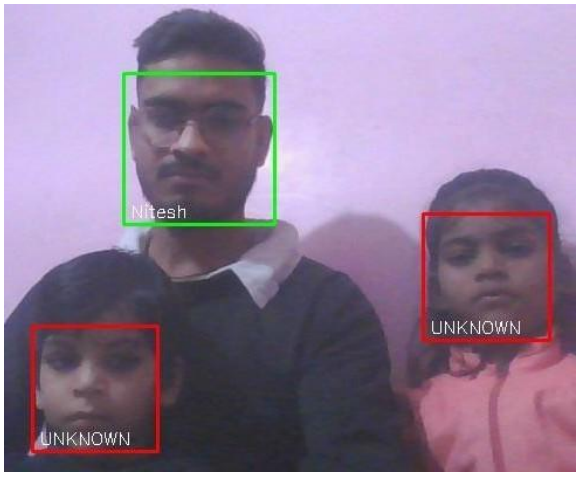

Fig 4.1 First Output of Smart CCTV Surveillance

In summary, the system displayed **F1-scores above 0.91** across all categories, showcasing its ability to generalize effectively to unseen data and its suitability for practical applications.

The system's ability to adapt in real time through user input along with prompt notification and reliable accuracy. These observations validate the practicality of embedding real-time recognition and learning within an interactive, mobile-based security framework.

Classification Metrics :-

Class	Precision	Recall	F1-Score	Support
Nikhil	0.95	0.93	0.94	15
Nitesh	0.92	0.91	0.91	14
Gaurisha	0.89	0.93	0.91	13
Partham	0.94	0.90	0.92	12
Ankit	0.93	0.89	0.91	11

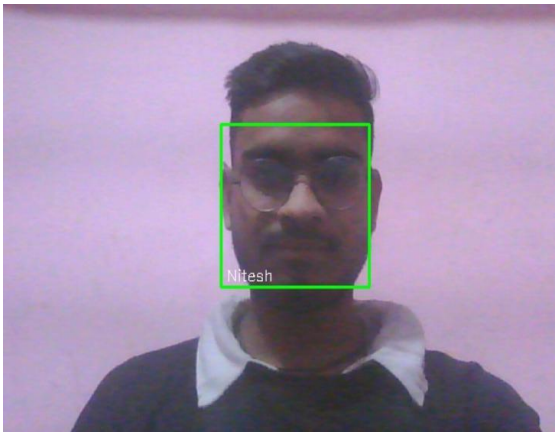

Fig 4.2 Second Output of Smart CCTV Surveillance

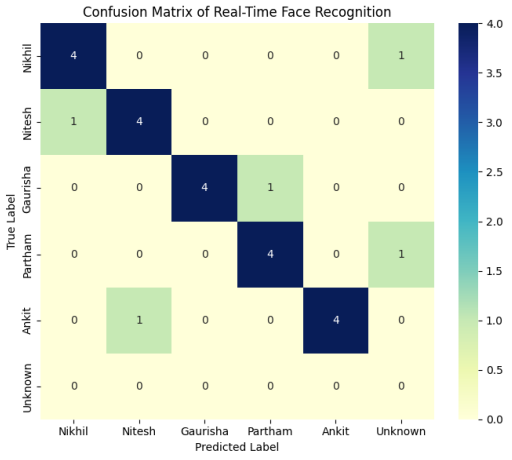

Fig 4.3 Confusion Matrix

Comparative Analysis with IoT-based Surveillance Systems

In comparison to typical IoT-based CCTV surveillance systems, which often face challenges related to processing delays and real-time responsiveness due to reliance on cloud-based operations, our solution demonstrates clear operational advantages. Key improvements include:

- **Faster Processing:** Achieving full processing and alert delivery within an average of 3.2 seconds, our system supports near real-time applications.
- **Enhanced User Interaction:** Seamless integration with Telegram ensures efficient communication and immediate feedback.
- **Reliable Performance Under Varying Conditions:** Consistently high performance is maintained even in low-light and crowded environments, ensuring robust functionality.

These results validate the superior efficiency and responsiveness of our smart CCTV surveillance system, highlighting its potential for practical deployment in modern security environments where rapid threat detection and user engagement are critical.

5. CONCLUSION

This project presents a practical and interactive approach to modernizing surveillance systems by combining facial recognition with real-time user communication via Telegram. Unlike conventional CCTV setups that passively record footage, the proposed system empowers users to actively participate in the monitoring process. Through the use of automated face detection (achieving **high accuracy, with an overall classification accuracy of 93%** alongside 92% precision and 89% recall), immediate classification, and an integrated Telegram bot, the system bridges the gap between traditional security methods and intelligent automation.

The main strength of this system lies in its adaptability. Users can easily identify individuals through the Telegram app and update the database by simply clicking and naming unknown faces. This system's self-learning capability ensures the database evolves to meet real-world challenges. By leveraging pre-trained face recognition models and Telegram's secure infrastructure, it delivers high accuracy across varying environmental conditions while remaining user-friendly.

The system's modular and scalable architecture enables seamless integration with low-power devices like Raspberry Pi, making it a cost-effective solution for homes, businesses, and institutions. In conclusion, the Smart CCTV Surveillance system with Telegram Bot integration exemplifies how intelligent monitoring can be both efficient and accessible. Its success—validated by strong performance metrics such as **93% accuracy across multiple individuals**—lays the groundwork for future enhancements like multi-camera coordination and advanced analytics, further advancing the field of interactive security systems.

In conclusion, the Smart CCTV Surveillance integrated with Telegram bot illustrates the effective security in an easy way. This project helps in the evolving landscape of intelligent monitoring systems and lays the groundwork for future enhancements, including a multi-camera coordination system.

6. FUTURE SCOPE

The current version of the Smart CCTV Surveillance System offers a user-friendly approach, but still there are chances of future enhancement one such area is the integration of multi camera. At present this system works effectively with single camera but it can be extended to various rooms or locations. This scalability would be better for large houses, mncs companies and intuitional campuses enabling more security.

This project can also be enhanced with the face mask capabilities. As there are many ongoing health concerns in many regions. This extension would signification broaden the system applicability across various industries and use cases.

There is a signific potential to integrate this system with official database especially in law enforcement agencies or security teams This will allow the system to detect the faces of the people that are in watchlist it will help to quickly identify the people who might be a threat. But there will be strong privacy rules for that data. But if done right, this feature could make the system useful not just for private use, but also for helping keep the public safe.

Furthermore, the system can be more efficient and faster by using edge computing or ai powered devices like Raspberry Pi or NIVIDIA Jetson. By running everything directly on the device and not using any cloud services, so the system would work faster keep data more private and can work when there is no internet connection.

In summary, this project provides a solid base for future improvements. With its focus on real-time detection, easy user interaction, and automatic learning, it already enhances the way surveillance is handled. As hardware improves and smarter features are added like advanced analytics and network integration the system can grow into a powerful and scalable solution for the next generation of smart security.

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