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DEEP LEARNING-BASED CLASSROOM ANOMALY DETECTION USING OBJECT-CENTRIC TEMPORAL MODELING

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Abstract: Detecting the unusual patterns in video footage plays a crucial role in ensuring safety by alerting authorities to potential risks. In many real-world scenarios, delayed identification of abnormal events such as fights or suspicious behavior can lead to serious consequences. This project focuses on developing an automated video anomaly detection system using deep learning and computer vision techniques. The system processes video footage by extracting frames and detecting foreground objects using the YOLOv8 algorithm. Relevant spatial features are extracted using a ResNet-based convolutional neural network, and temporal patterns are learned using a Bidirectional Long Short-Term Memory network. The extracted features are analyzed to identify abnormal activities using statistical methods such as Z-Score-based anomaly scoring. When an abnormal event is detected, the system generates real-time alerts by displaying warning messages, triggering an alarm sound, and sending an email notification to the user. The proposed system is implemented using Python and integrated with a Streamlit-based web interface for visualization. This approach improves real-time montoring, reduces response time, and enhances the effectiveness of surveillance systems.

Keywords: Video Anomaly Detection, Deep Learning, YOLOv8, BiLSTM, Temporal Analysis

I. INTRODUCTON

Classrooms need to be monitored regularly to ensure Student safety and maintain discipline. However, watching CCTV footage manually is difficult, time- consuming, and can lead to mistakes, especially when there are many hours of video to check. Because of this, important events like fights, or unusual behavior may sometimes be missed, which can create safety issues. With the help of artificial intelligence and computer vision, it is now possible to monitor videos automatically. These technologies can continuously analyze video footage and detect activities that are different from normal classroom behavior without the need for human supervision.

The main aim of this project is to develop an automatic classroom anomaly detection system using CCTV footage. The system detects students and important objects in video frames using the YOLOv8 algorithm and extracts useful features using a deep learning model. It then analyzes how activities change over time using a Bidirectional Long Short-Term Memory network to identify unusual behavior. When any abnormal activity is detected, the system gives real-time alerts by showing warning messages, playing an alarm sound, and sending an email notification. This helps in taking quick action and improves classroom safety.

II. OBJECTIVES

AI-Based Classroom Video Anomaly Detection System

The main objectives of this project are explained below in simple student-level language.

1. Automatic Detection of Abnormal Activities

The first objective of this project is to automatically detect unusual activities such as fights, aggressive behavior, or abnormal movements in the classroom using CCTV cameras. The system analyzes video footage and identifies such activities without the need for manual monitoring.

2. To monitor classroom using Artificial Intelligence

Another objective is to use Artificial Intelligence to continuously monitor classroom activities. The system detects students and tracks their behavior to identify any unusual or suspicious actions.

3. To analyze and detect abnormal behavior using advanced techniques

The system detects students and important objects in video frames using the YOLOv8 algorithm. It further analyzes how activities change over time using a BiLSTM model and identifies abnormal patterns. Statistical methods such as

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Z-score are used to detect deviations from normal classroom behavior.

4. To generate real-time alerts

When an abnormal activity is detected, the system sends alerts through email, alarm sound, and on-screen messages. This helps in informing authorities or staff immediately.

5. To analyze behavior over time

The project aims to study how student behavior changes over time using deep learning techniques. This helps in identifying patterns that are not visible in a single frame.

6. To use existing CCTV infrastructure

Another objective is to utilize already installed CCTV cameras in classrooms. The system processes existing video footage, making it cost-effective without requiring additional hardware.

7. To improve classroom safety

The final objective of the project is to improve safety and discipline in the classroom by detecting abnormal activities early and enabling quick response.

III. SYSTEM ARCHITECTURE

The proposed classroom anomaly detection system consists of multiple components that work together to monitor classroom activities and detect abnormal behavior.

First, CCTV cameras are used to capture live video footage from the classroom. The captured video is continuously processed by the system for further analysis. The video is divided into individual frames so that each frame can be analyzed efficiently.

Next, the object detection module uses the YOLOv8 algorithm to detect students and other important objects in each frame. This helps the system focus only on relevant activities present in the classroom.

After object detection, the feature extraction module extracts important visual features from the detected objects using a deep learning model such as ResNet. These features represent the appearance and spatial information of the objects.

The extracted features are then passed to the temporal analysis module, where a BiLSTM model is used to analyze how activities change over time. This helps in identifying unusual patterns or abnormal behavior that cannot be detected from a single frame.

Once the temporal patterns are analyzed, the anomaly detection module uses statistical methods such as Z-score to identify deviations from normal behavior. If the calculated anomaly score exceeds a predefined threshold, the system classifies the activity as abnormal.

Finally, when an anomaly is detected, the alert module generates real-time alerts. The system sends email notifications, triggers an alarm sound, and displays warning messages on the screen. This ensures that immediate action can be taken to handle the situation.

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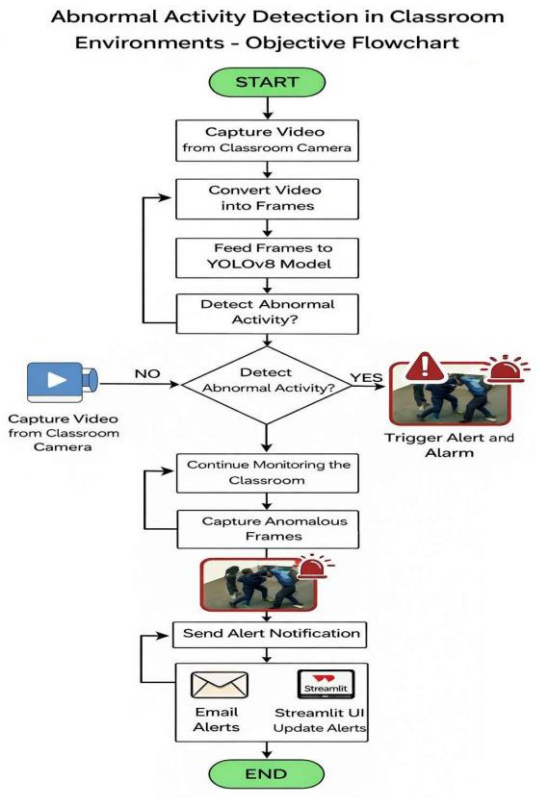

Fig 1.1 Architecture of proposed video anomaly detection system

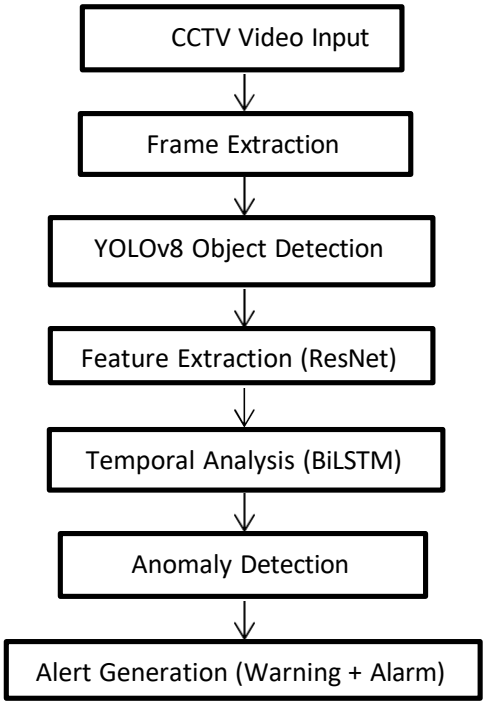

Fig 1.2 Data Flow

IV. METHODOLOGY

The proposed system works in a series of steps. First, the system takes video input from CCTV cameras in the classroom. The video is then divided into frames so that each part can be analyzed easily.

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Each frame is processed using the YOLOv8 model to detect students and important objects. After detection, the system studies how these objects move and behave across multiple frames.

The system then analyzes these patterns over time using a deep learning model to identify unusual behavior such as fights or sudden movements. If the behavior differs from normal patterns, it is considered an anomaly. Once an abnormal activity is detected, the system immediately generates alerts. It sends an email notification, triggers an alarm sound, and displays a warning message on the screen.

This approach helps in continuous monitoring and ensures quick response to maintain classroom safety.

V. PROPOSED SYSTEM

This section explains how the classroom anomaly detection system is designed and how it work step by step. The system uses video input and analyzes student behavior to detect any unusual activity and generate alerts.

System Design Overview: The design of the system is divided into several stages that work together to detect classroom abnormal activities and generate alerts.

Video Capture Stage

In this stage, CCTV cameras installed in the classroom capture live video. This video is given as input to the system for further processing.

Frame Processing Stage

The captured video is converted into frames because the system works on images. Each frame is processed one by one for analysis. **Object Detection Stage**

Here, the YOLOv8 model is used to detect students and other important objects in each frame. This helps the system focus only on useful information.

Feature Extraction Stage

After detecting objects, the system extracts important features using a model like ResNet. These features help the system understand the visual details of the objects.

Behavior Analysis Stage

The system then observes how students behave across multiple frames. It studies movements and patterns to understand what is normal and what is unusual.

Anomaly Detection Stage

The system checks for abnormal activities such as:

- Sudden aggressive movements
- Fighting between students
- Unusual actions
- Irregular behavior

If such activities are found, the system marks them as anomalies.

Alert Stage

When an abnormal activity is detected, the system immediately sends alerts. It sends an email, plays an alarm sound, and shows a warning message on the screen.

Modules of the System

The system is divided into different modules to make the process simple and organized.

Video Input Module

This module captures video from classroom cameras.

Functions:

- Capture live video
- Provide input to system

Frame Extraction Module

This module converts video into frames. Functions:

- Split video into frames
- Prepare frames for processing

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Detection Module

This module detects students using YOLOv8.

Functions:

- Detect students and objects
- Draw bounding boxes
- Identify object positions

Feature Extraction Module

This module extracts important features from detected objects.

Functions:

- Extract visual features
- Represent object information

Anomaly Detection Module

This module identifies abnormal behavior. Functions:

- Analyze behavior patterns
- Detect unusual activity

Alert Module

This module generates alerts. Functions:

- Send email notification
- Trigger alarm sound
- Display warning message
- Show detected anomaly frames in the system interface.

System Flow Diagram:

Start □ Capture classroom video □ Convert into frames □ Detect objects □ Extract features □ Analyze behavior □ If anomaly detected □ Send alert □ Display warning □ Stop

VI. FRONTEND IMPLEMENTATION

The frontend of the system is developed using simple tools such as **stremlit,** which helps in creating an easy-to-use interface. The main purpose of the frontend is to display video output, detected results, and alert messages in a clear and understandable way.

Main Functions

a. Display Classroom video

The frontend shows the classroom video on the screen. The video processed by the backend system is displayed so that the user can monitor classroom activities easily.

b. Show Detected Objects

When the system detects students and objects using YOLOv8, the frontend displays bounding boxes around them in each frame. This helps the user understand how the system is identifying and tracking activities.

c. Display Anomaly Alert

If any abnormal activity is detected, the frontend shows a warning message on the screen. The alert is clearly visible so that the user can quickly notice it.

Example:

i. Abnormal Activity Detected
ii. Unusual Behavior in Classroom

d. Display Anomaly Frames

The system also shows the frames where abnormal activity is detected. These frames are displayed in the interface so that the user can visually understand the situation.

e. Alert Sound Notification

Along with the warning message, the system plays an alarm sound to grab immediate attention when an anomaly is detected.

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Frontend Workflow of the System

The backend system processes the classroom video.

1. Object detection and anomaly detection are performed.
2. The Processed results are sent to the frontend.
3. The frontend displays the video with detected objects.
4. If an anomaly is detected, a warning message and frames are shown, along with an alert sound.

VII. ALGORITHM FOR ANOMALY DETECTION ALGORITHM

AI-Based Classroom Anomaly Detection System

Input: Classroom CCTV Video Stream
Output: Anomaly Alert Notification
Step 1: Start the system.
Step 2: Capture video stream from classroom CCTV camera.
Step 3: Convert video into frames using computer vision techniques.
Step 4: Apply object detection model using YOLOv8 to detect the students and relevant objects in each frame.
Step 5: Extract all important features from detected objects using a deep learning model (ResNet).
Step 6: Organize extracted features into sequences of frames.
Step 7: Analyze behavior patterns using BiLSTM model.
Step 8: Calculate anomaly score using statistical method (Z-score).
Step 9: Check the anomaly conditions:

- Sudden aggressive movements.
- Fighting between students.
- Unusual or irregular behavior.
- Significant deviation from normal patterns.

Step 10: If anomaly is detected:

- Mark the frame as abnormal.
- Display warning message.
- Show detected anomaly frames in the interface.
- Trigger alarm sound.
- Send alert message via email.

Step 11: Continue monitoring the video Stream.
Step 12: End.

VIII. RESULTS AND DISCUSSION

The proposed system was tested using classroom video samples that included both normal and abnormal student activities. During the testing, the object detection model YOLOv8 was able to detect students clearly in different situations.

The system analyzed student behavior across multiple frames and identified the unusual activities such as sudden movements or aggressive actions. When such behavior was observed, the anomaly detection logic sends alerts.
The alert system worked properly by showing warning messages on the screen, playing an alarm sound, and displaying the frames where the abnormal activities occurred. The email notification system also worked successfully by sending alert messages to the given email address.

These results show that the system can effectively monitor classroom activities and detect the abnormal behavior at right time. This is helps in reducing the delay in identifying problems, and supports the quick action.

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Fig 1.3 Output of Classroom Anomaly Detection System

For demonstration purposes, a general fighting video was used during testing. Still, the system is designed to detect abnormal activities in classroom environments.

Observations:

- Abnormal activities are highlight with warning messages.
- Detect anomaly frames are shown in the interface.
- Alarm sound is triggered during abnormal events.

IX. CONCLUSION AND FUTURE WORK

This project presents a simple and effective system for detecting the unusual activities in video using deep learning and computer vision. The system analyzes video frames, detects objects using YOLOv8, and understand behavior patterns using spatial and temporal models. It is able to identify abnormal activities and send alerts in real time through warning messages and alarms. This reduces the need for continuous manual monitoring and helps in faster response. Overall, the proposed system improves surveillance efficiency and can be used environments like classrooms where safety and monitoring are important.

In the future, the system can be improved by using more advanced models to increase accuracy in complex situations. It can also be extended to work with different environments such as public places, offices, and smart city applications. Integration with IoT devices and cloud platforms can help in real-time data sharing and large-scale monitoring. A mobile application can also be developed to send instant alerts to users, making the system more practical and user-friendly.

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