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Smart Surveillance System for Monitoring and Detecting Abnormal Human Behaviour

J. Sarala Bai[1], J. Keerthana[2], K. Jyothi[3], Y. L. Malathi Latha[4]
[1, 2, 3]*UG student, Department of Information Technology,*
[4]*Associate Professor, Department of Information Technology, Stanley College of Engineering and Technology for Women, Hyderabad, Telangana, India*

Abstract: ***The increasing demand for real-time video surveillance systems has underscored the need for automated methods to detect abnormal human behaviors, particularly to enhance the safety of individuals, including those living alone. This study presents a deep learning-based framework for identifying anomalous human activities in video data, enabling timely interventions. By leveraging advanced deep CNNs, the proposed framework extracts discriminative features directly from raw video frames, eliminating dependence on manual design features. To mitigate challenges associated with limited labeled training data, transfer learning from large-scale action recognition datasets is employed. The model is trained and rigorously evaluated on a dataset encompassing four critical categories of abnormal behavior: fighting, explosions, robbery, and assault. The project results to show the framework's effectiveness in accurately detecting these activities, contributing to enhanced surveillance and public safety.***

Keywords: Abnormal Behaviour Detection, Video Surveillance, Deep Learning,CNN, Transfer Learning, Anomaly Detection, Human Safety Monitoring, Real-Time Video Analysis, DenseNet201, Action Recognition, Frame-Level Accuracy, ROC-AUC, Confusion Matrix, Home Surveillance, Autonomous Monitoring.

I. INTRODUCTION

Prediction plays a major role in data analysis, enabling the forecasting of future behaviors and supporting timely, informed decision-making. This research focuses on the predictive modeling of abnormal human behavior patterns in surveillance, addressing the limitations of traditional manual monitoring by leveraging AI-powered techniques like CNN. By analyzing patterns in behavioral and environmental data, the study looks to build on a model that identifies and flags atypical activities, enhancing security through proactive responses. Key components explored include methodologies, algorithms, input attributes, and performance metrics essential for robust predictive models. The methodology involves a comprehensive review of studies from prominent databases over the past decade, focusing on high-accuracy approaches. The findings are consolidated in this paper, titled “A Survey on Smart Surveillance Systems for Monitoring and identifying unusual patterns of human activity using CNN,” providing insights into effective practices for real-time abnormal behavior detection in surveillance systems.

II. LITERATURE SURVEY

In this paper [1], the authors present a framework in which they introduce a real time approach to identifying abnormal behaviour in social networking sites making use of user behaviours and their curated profiles with the use of CNN. The proposed framework takes the data through a pipeline of stages: profile verification, one-time password generation and verifying the user using their cookie information. A CNN model learns the

data at a non-linear level by making use semantics, syntax and analysing the data at a token level using Natural Language Processing (NLP). It takes in this data and returns a group of feature vectors. The users are pooled into these vectors that are either labelled as normal or abnormal based on the behaviour. For training, a variety of URLs have been sourced from the internet, like Facebook, Twitter, and malicious URL sites like VirusTotal and PhishTank. This study [2] focuses on utilizing the video data from surveillance cameras to monitor the environment in crowded and uncrowded areas to label any behaviour as normal or abnormal. The study delves into some specific forms of unusual human behavior patterns starting with loitering where there is a set specific threshold of time that dictates whether a person is aimless loitering around. Other abnormal behaviours investigated were falling; using a depth sensor-based model to detect the change in the stature of a person, abnormal patient behaviour, violence, panic, snatching, and sexual abuse.

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The study observed that the CNN model showed improved results other machine learning methodologies in recognizing specific features from the images. Since they used 3D CNN, it performed better than its 2D counterpart due to having extra motion detection capabilities for a 3D environment. The authors wish to further improve their approach by integrating the use of LSTM to incur real time identification and the ability to alert neighbouring people in case of any victim needing immediate help. Khosro Rezaee et al [3] present a strategy for real-time monitoring for abnormal behaviour in crowded spaces with the assistance of transfer learning and drones surveilling the area. The model utilizes deep transfer learning and a modified ResNet architecture which process the frames that are captured by the drone technology and stored in the network. The authors make use of two modified ResNet-18 architectures where one of them consumes the video frames and the other monitors the background frames notifying the congestion of the crowd. They use the UMN and the UCSD datasets with 11 and 48 video samples respectively showcasing various crowded scenarios that might occur in rea life. The model performed well under its testing achieving an accuracy above 90 percent.The study [4] focuses on the use of border supervised DNN to detect unusual human movement from surveillance videos. The proposed method leverages deep neural networks (DNN) to automatically extract abnormal features from time-series data. By utilizing weakly supervised training, the DNN model is optimized through a devised loss function, enabling the detection and quantification of outliers in time-series data, particularly unnatural human motion. The study proposes a DNN training technique with an approach similar to multiple-instance learning for detecting unnatural human motion. Furthermore, the study details the network structure and training process, illustrating in the need of a one-dimensional convolutional neural network (IDCNN) for analysing time-series data. The network consists of multiple phases of repeating 1DCNN, RELU activation outputs higher anomaly scores for data points con abnormalities. The paper [5] introduces a real-time image recognition machine for human behavior in environments, aiming to assist disabled individuals, surveillance, track human behaviour, facilitate computer interaction, and optimize resource utilization proposed system is an Image based Human Recognition (IHAR) system that utilizes images captured by CCTV the images down to enhance the data quality, extraction using PCA utilizes various machine learning algorithms and co their accuracies. The dataset collected comprises 10 d activities, including walking, sitting down, standing u and throw, pushing, pulling, waving hands, clapping and carrying, consisting of 35,530 images. The data divided into different training and testing sets experimental results demonstrating high accuracy rates recognition algorithms. The paper [6] discusses the application of the Long Short Memory (LSTM) method for HAR in videos. It highlights the significance of various fields such as surveillance, gaming, and healthcare and the challenges faced by conventional HAR m including slower recognition and low precision rates. of wearable devices and smartphones equipped with for monitoring human activities is also mentioned. The document emphasizes the need for a more efficient framework to replace high-configured computational vision and operate with minimal data, particularly for real-time recognition in videos. Furthermore, it delves into the methodology, including the use of the UCF-50 dataset, the PSO-LSTM approach for training and testing, and the results obtained, including loss observed during training and accuracy gained during testing.

The research study [7] focuses on patient monitoring through abnormal human activity detection using a CNN architecture. The dataset consists of 192 patient videos, with 23,040 frames, acquired from eight volunteers performing eight different activities. The dataset is partitioned into two ratios: 60% for training and 40% for testing, and 70% for training and 30% for testing. The labelling of the dataset was done using the VoTT annotation tool, adding bounding boxes around the patient and class IDs of the activity. The study employed the YOLO network as the backbone CNN model and achieved an accuracy of 96.8% in abnormal action recognition. The study also discussed the limitations of the YOLO model and proposed future work to handle small objects and multiple individuals in patient monitoring.

The study [8] aimed to develop an Al-based machines detection system based on YOLOv4 Darknet framework for CCTV surveillance in Malaysia. The V6 dataset, comprising over 3000 images, was utilized for training the model. The training involved two sessions: single class and multiple class object detection. The results indicated that the single class object detection achieved an average accuracy of 66.67% to 77.78%, while the multiple class object detection achieved up to 100% accuracy on most input images. The study also highlighted the challenges of recognizing different types of weapons due to variations in shape and size. The study proposed potential improvements for the multiple class object detection model, such as the ability to classify more types of weapons and implementation on microcontrollers for broader use.

The study [9] discusses the development of a intelligent video monitoring system for unusual behaviour. Various methodologies and models are presented, including the use of CNNs, OpenCV, motion influence maps, and YOLOv3 for detecting suspicious activities such as abandoned luggage, gun detection, and unusual human behaviour. Kamthe et al. proposed a semantic approach for defining and detecting suspicious activities, testing the model using CAVIAR (PETS 2004) and PETS 2006 datasets, achieving accuracies of 57% in object detection, 90% in object tracking, 93% in detecting loitering at ATM, and 96% in detecting abandoned bags.

These datasets were crucial in training and evaluating the models for detecting unusual human patterns in surveillance videos. The document also outlines future enhancements to further improve the system's effectiveness and broaden its scope, focusing on enhanced security systems and real-time video analysis for more precise detection.

The research [10] presents a study on predicting personality traits using textual data in English and Brazilian Portuguese. It aims to address the scarcity of lexical resources for Brazilian Portuguese and evaluate the feasibility of training models with English textual data to predict personality traits in Brazilian Portuguese. The methodology involved data collection from the my Personality dataset and Twitter, followed by text pre-processing and analysis using. Word Embeddings techniques. Machine Learning models were trained and tested for FFM personality traits recognition. The results showed that the Stochastic Gradient Descent(SGD) model performed satisfactorily for predicting personality traits in Brazilian Portuguese textual data. The study also compared the performance of the proposed method with related works and found that the results were close to those obtained by other approaches.

The paper [11] presents Sig Segment, a novel algorithm designed to address distracted driving by accurately detecting and segmenting abnormal driving events in real-world videos.Tested on a dataset of 210 video clips from 35 drivers engaged in various tasks, SigSegment achieved notable success in spotting distracted driving behaviours. Subsequent developments are planned to improve the algorithm's capacity to identify and evaluate anomalies in driving, which could support advanced driver assistance systems in improving road safety. With more study concentrating on extending its capabilities to detect other forms of driver attention or combining it with current driver assistance systems, SigSegment shows potential in the fight against distracted driving and offers insightful information for future traffic safety measures.

The paper [12] is a Hybrid Guidance-Exploration Model with Scene-Behavior Association Analysis is a unique framework that the authors offer for the detection of anomalies in human unusual behaviour in video data. The method utilizes normalizing flow to guide motion and appearance anomaly detection by merging RGB and skeletal features. To identify abnormalities, a behaviour-scene matching module investigates connections between typical behaviours and scenes. The method's superiority is confirmed by comprehensive implementation and assessment measures, such as ablation studies and comparisons with sophisticated approaches.

The paper [13] notes the growing interest in behaviour modelling for surveillance and human-computer interactions and investigates the use of real-time video surveillance to identify anomalous human behaviour. It assesses current approaches, focusing on techniques for feature extraction, segmentation, and classification. The efficiency of CNNs in video analysis is emphasized. There is discussion of several models and methods, such as object detection and suspicious activity identification. To strengthen security in a variety of contexts, including private properties, banks, offices, and airports, the conclusion highlights the effectiveness of the system and outlines recommendations for future improvements. In summary, the document presents a thorough analysis of aberrant behaviour detection, highlighting its potential uses and importance in improving security and safety in various contexts.

The study [14] has high theft rates and inadequate security measures in Indonesia motivate this study's investigation of the need of surveillance camera video and the YOLO V3 algorithm to identify criminal activities, especially theft, in school settings. Starting with context awareness, the study highlights the stages of data preparation and model training, going into technical details about things like turning on the darknet and configuring parameters. The results show how well YOLO V3 detects human activity, with high accuracy rates-99.1%, in particular. To further improve safety and discourage criminal activity, the study highlights the potential of YOLO V3 to support security measures in educational settings and suggests possibilities for future research, such as object tracking algorithms and integration with current security infrastructure.

In South Korea researchers[15] have created a revolutionary method for identifying child abuse using real-time video surveillance, which is presented in this study article. The program uses a CAD model with attention networks and Multiple Instance Learning for anomaly scoring, and pre- trained C3D models for feature extraction, using a mix of the UCF-Crime dataset and a recently assembled dataset on child abuse. Evaluation metrics like AUC and ROC curves show how successful the deep learning strategy is; it achieved an astounding AUC score of 84.5%, which is 10% higher than earlier models. The program improves the capacity to recognize cases of child abuse in kindergartens and schools, even in the event of misdetections. To counteract the growing number of child abuse incidents, the report highlights the significance of using cutting-edge technologies like deep learning. It also makes recommendations for future improvements, like the incorporation of transformer networks and the extension of datasets, to further improve child safety measures.

This study [16] aims to detect and monitor unusual and suspicious behaviour among individuals in crowded locations. The authors utilize a deep learning methodology to remotely identify and track actions that deviate from the norm, providing accurate information regarding the location, time of occurrence, and potential identification of perpetrators. The proposed system leverages the advanced YOLOv8 model for real-time detection of weapons, with a focus on ensuring swift performance by quantizing the model's weights.

Upon completion of the study, the authors achieved a precision rate of 92.6%. To train the model, the study amassed a dataset comprising 2986 images of weapons sourced from various platforms such as Google and YouTube, which were then meticulously annotated using the Roboflow website.

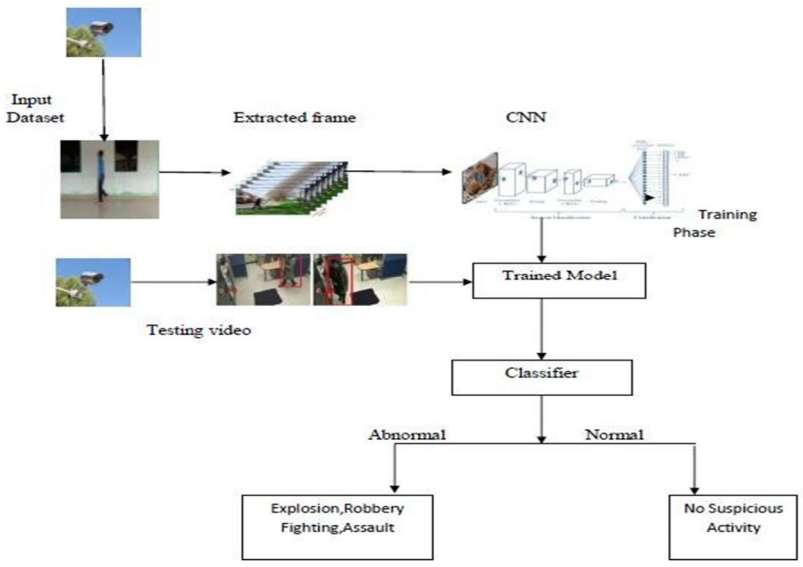
This research paper [17] focuses on autonomously monitoring and analyzing crowd behaviour in real-world settings to facilitate efficient crowd management in various public areas like transportation stations and streets. The researchers found a idea-based crowd area monitoring framework named V3Trans-Crowd, which processes video data to extract meaningful insights for categorizing crowd behaviour. This model integrates spatial and temporal considerations to analyze videos depicting crowd movement, enabling the classification of crowd behaviour based on the derived analysis. Additionally, the study employs an enhanced hierarchical transformer tailored for multi-modal tasks. The model is trained using the Crowd- 11 dataset, achieving an accuracy of 63.32%.

This study [18] delves into the rising instances of disruptive and offensive behaviours directed towards individuals, particularly women. It introduces a machine learning algorithm known as Darknet 53. The aim of this algorithm is to identify patterns indicative of such behaviours in real- time, distinguishing irregularities from typical behaviour and filtering out inconsistencies from the norm.

This paper [19] introduces an automated system designed to recognize improper human patterns noticed by CCTV cameras in public spaces.To ensure accuracy, the dataset underwent thorough annotation to filter out noise, facilitating precise localization of anomalies within the video footage. The human-related dataset, comprised of real crime scenes, was then compared against other cutting- edge techniques like Pseudo 3D and ResNet 3D. Through these comparisons, the system achieved an high rate of accuracy that is 97.39%. The experiments were conducted on the UCF-Crime dataset, a widely recognized benchmark video dataset for anomaly detection. This dataset includes large number of datasets the number of 1900 surveillance videos, including 950 unedited real-world surveillance recordings featuring clear anomalies, and normal videos to prevent class imbalance.

The paper [20] discusses the rapid evolution of society, marked by increasing urbanization and population density, which in turn raises concerns regarding safety such as accidents and potential terrorist threats. To address these challenges, there's a growing reliance on intelligent video systems (IVMS) for surveillance, particularly to detect unusual behaviour, like students engaging in misconduct on escalators. The study proposes the need of an OpenPose deep learning network to streamline the process of identifying and analyzing abnormal behaviour by reducing redundant information from human bone facial features during feature extraction. The extracted human skeleton features are then classified using a graph convolution neural network, aiming to minimize the computational complexity of behaviour identification algorithms. Additionally, a sliding window voting method is employed to enhance the accuracy of behaviour classification in practical scenarios. The experimentation involves the utilization of a self-constructed student trajectory dataset alongside the INRIA dataset, resulting in an outstanding accuracy rate of 99.50 percent in diagnosing and classifying abnormal behaviour among students under video surveillance.

III. DESIGN



It Compile a variety of datasets that show human behavior, including both typical and unusual actions. To guarantee representative samples for efficient anomaly identification, preprocess the data by standardizing formats, addressing missing values, and supplementing datasets.

Start the selected pre-trained CNN model without any classifying layers to apply transfer learning. Utilize the previously acquired information to leverage the model's weights as you fine-tune it based on human behavior data to capture domain-specific elements that are essential for anomaly identification.

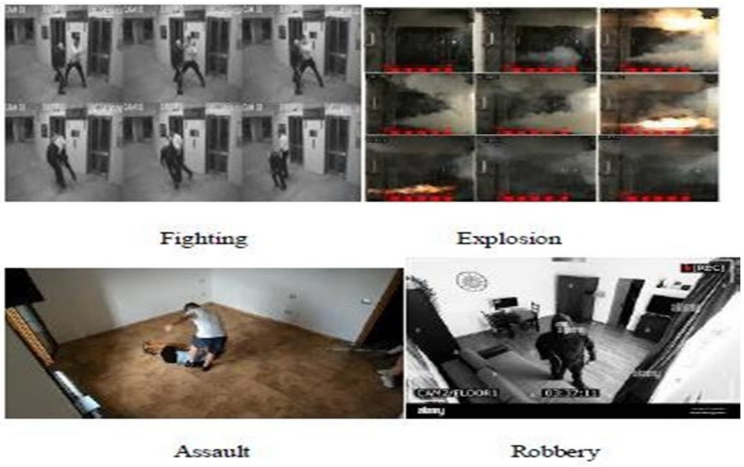
Apply the modified CNN layers to extract complex characteristics from data on human behavior. These characteristics must encompass temporal and geographical patterns. The major part of the modified CNN architecture, add an anomaly detection layer that is intended to spot departures from typical behavior patterns. This layer allows the model to efficiently identify instances of abnormal behavior. It typically consists of dense neural network components with suitable activation functions. Utilize labelled datasets of human behavior that have been divided into training, validation, and testing sets to train the model. Throughout the training process, keep an eye on the model's performance and use validation measures to adjust the hyper parameters and avoid overfitting.

IV. IMPLEMENTATION

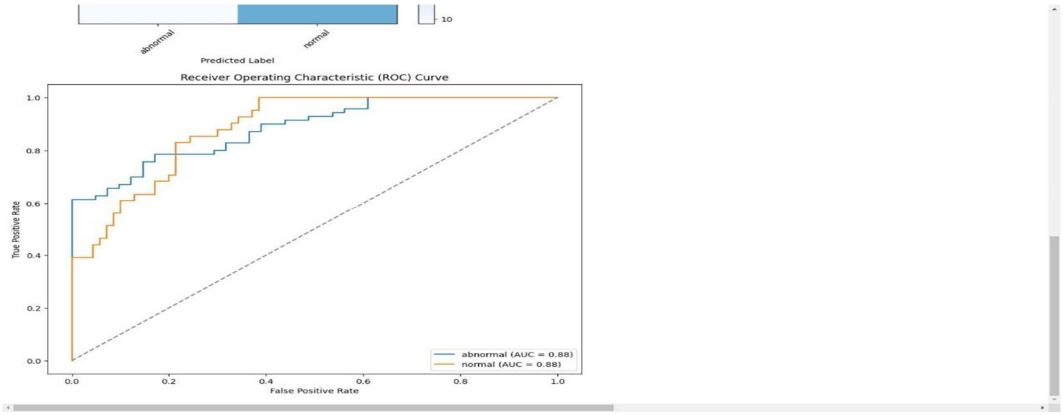
A. Datasets

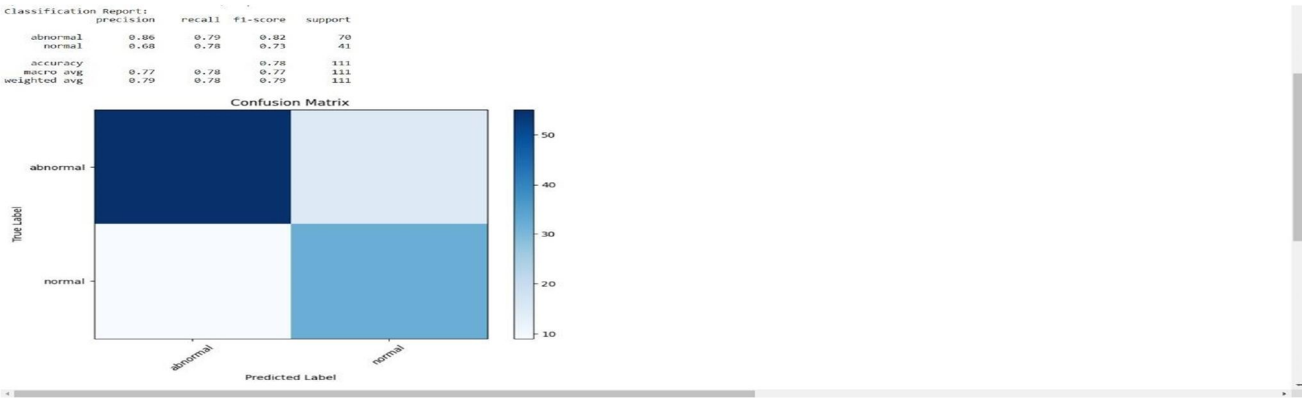
The UCF Dataset is an invaluable resource that includes a wide range of criminal activities captured in videos from various regions of the United States. The dataset includes pictures taken from video frames of the UCF crime Dataset.This Kaggle dataset provides information on a variety of actions, such as assault, explosion, fighting, robbery. .Each class represents a specific type of behavior or activity depicted in the videos, with important applications in surveillance, law enforcement, and safety. In total, there are 1,000 Training and 1000 Testing images used spanning across 4 classes namely Assault, Explosion, Normal, Robbery,Fighting. Overall, every 10th frame of the videos present in the UCF- dataset have been maintained.

Size: Each image is in the size of 64 *64 .png format.



B. Results and Analysis





V. ANALYSIS OF EXISTING APPROACHES

PaperTitle	Author	Data sets	Algorithm	Remarks
Vision-BasedSurveillancefor Monitoring Vehicles andHumans	ReubenA. Farrugia	Identifying vehiclesand human	Classificati on ,SVMObject detection	97% accuracyin classifying humans and vehicles
AReviewofCrowdAnalysis Techniques	Waleed Albattah	Mall, UCSD PedestrianDataset:	Object Detection Algorithm Tracking Algorithm	Scalability Behavior Analysis
UnusualEventDetectionUsing Gaussian Mixture Models	Mariem Gnouma	UCSD Anomaly DetectionDataset	Gaussian Mixture Models (GMM):	effective for modeling normal behavior
HumanDetectionand SegmentationBasedonposture analysis	Mikel D Rodriguez	COCO(Common Objects in Context) Openpose	Convolutio nal Neural Networks (CNNs): Recurrent Neural Networks (RNNs):	Real- Time Processing Evaluation Metrics
MultipleInstanceLearning for AnomalyDetection	Waqas Sultani	Mammography Dataset	Deep Learning Approaches SVM	Labeling Challenge
Real-TimeActivity ClassificationUsingOpenCV	SunilMal viya	OpenPose, Kinetics, Activity Net:	Convolutio nal Neural Networks (CNNs), RNN.	Real-time activity classificio nrequires efficient algorithms

				thatcan process video frames quickly.
Survey of Anomaly DetectionTechniques	AlishaAhi r	Yahoo S5,YahooWebsc ope	Machine Learning Algorithms Deep Learning Approaches :	Domain-Specific Considerat ions Imbalance dataset
Deep Learning for Facial RecognitioninSurveillance	DayanaR .	LFW (Labeled FacesintheWild)	Convolutio nal Neural Networks (CNNs): FaceNet:	Accuracy and Robustnes s Privacy Concerns
SmartVideoSurveillance Framework	M.H.Sedk ay	CAVIARDataset: UCF Crime Dataset:	Object Detection Algorithm Multiple Object Tracking (MOT):	Scalability and Deployme nt Data Annotatio n Challenge
Abnormalbehaviourdetection in Daily Living.	Andrew Beng JinTeoh, Tee Connie.	FallDatasets(frontfall ,back fall,leftfall,right fall) dailyactivities(sleep,watchingtv, eating , kitchen relatedactivites).	Convention al approch, deep learning, Hybrid	Computati onalcost, & Computati onalTime.
HumanActivityRecognition System for Elderly Care	ZafarA.K han	dailyactivities relatedtoelderly people, 400 residents,	Machine learning & Deep learning	Monitor Health & Reduce CareGiver Workload.
		Twomarried people, Agroupof residents.		
SmartsafetyOcean(Detects abnormal behaviour of passengers)	Yehojung	normaland abnormal Walking,Lean-railing,Sit-down.	Faster- RCNN	Overall Safety Concerns.
AReviewofMachineLearning ModelsforAbnormalBehavior Detection	T.Ashraf, F.Saeed, A.Akbar	Example frames fromthehumanto human interaction datasets like handshake,punch,d ance.	Frequency analysis ,classifying humans,ML	Good Detection & Adaptive Lighting .
Pedestriananomolybehavior Detection.	Caijian Hua	IITBcorrider dataset (bag exchange,walking, cyclingsuspicious object,playing),	YOLO- ABD, Small object detection.	SVM achieve 85% Accuracy.

AbnormalHumanBehavior DetectioninVideoSurveillance	LeiWang	videos,vechilesan d human images.	object classificatio n model, motion detection,	Security Prone.
HumanActivityRecognition	Mohamed F.A. Abdalla	Differentmotion images of Humans.	Clustering algorithm.	Adaptive envirnmen t.
ReviewofAbnormalBehavior DetectioninActivitiesofDaily Living.	A.Abdar, R. Ghaffar	Daytoday routinesof humans.	Convention al approch,dee p learning,Hy brid.	Adaptive envirnmen t.
Abnormal human activity detectionbyconvolutional recurrentneuralnetworkusing fuzzy logic	Manoj Kumar	Statistical collectionofday to day activities.	Deep learning, Fuzzy logic.	Model achieves 95.04% and 49.04%.
UnsupervisedLearningMethod s for Human Abnormal BehaviorDetectionin SurveillanceSystems.	Abhinav Bhatia,	Collectionofreal-timecctvfootage.	Clustering, K-Means algorithm.	Reduces usageof sensors.

VI. CONCLUSION

This project presents a robust framework for abnormal behavior detection aimed at enhancing the safety of individuals living alone. By leveraging advanced deep learning architectures, particularly DenseNet201, and employing transfer learning, the model effectively identifies critical abnormal behaviors like fighting, explosions, robbery, and assault in real-time video surveillance. This approach demonstrates high accuracy and computational efficiency, supporting timely interventions and strengthening autonomous monitoring capabilities. Future enhancements could further optimize the system's effectiveness and broaden its applicability. Refining the current deep learning models and incorporating spatial and temporal analysis would enhance the system's accuracsy in recognizing complex behavioral patterns over time. The integration of advanced techniques, such as video-based visual transformers, could provide greater insights into abnormal behavior contexts and improve anomaly management. Expanding the scope to include real-time detection for sensitive scenarios, such as patient monitoring and naturalistic video analysis, could also amplify the system's value in diverse applications. These advancements would not only improve the system's robustness and adaptability but also establish it as a versatile tool for ensuring the safety of vulnerable individuals in both public and private settings.

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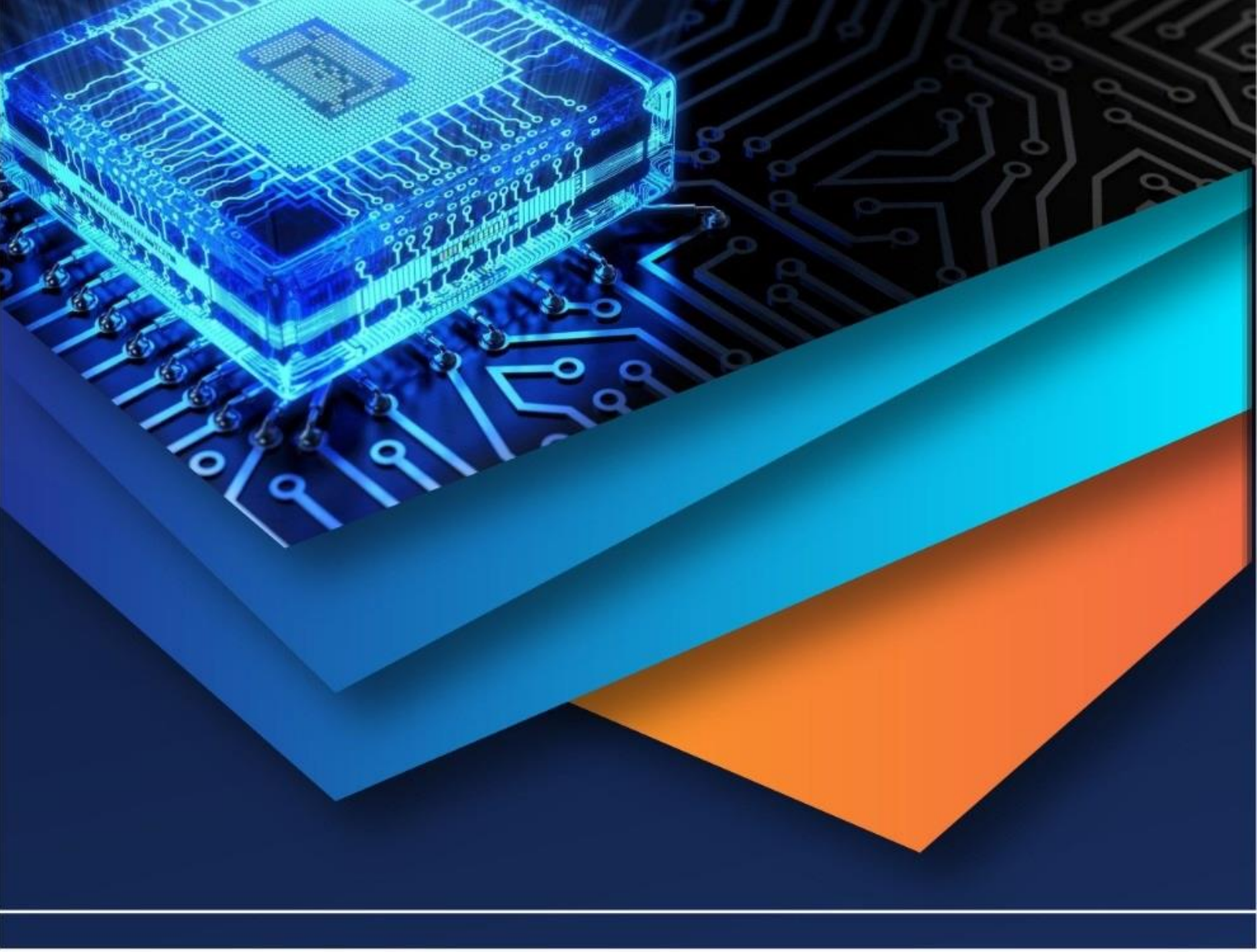

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