REVIEW OF ANOMALY DETECTION IN VIDEO SURVEILLANCE

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Abstract

Recognizing anomalous conduct in crowded environments quickly and automatically can greatly improve public safety.Real-time surveillance systems are in high demand as urbanization and industrialization spread rapidly. Because of their reliance on artificial intelligence, anomaly identification systems only tackle some of the challenges, mainly overlooking the changing nature of abnormal behavior over time. Anomaly identification techniques also have the additional issue of requiring a training dataset with established normalcy and known error levels. Common methods for spotting anomalies on the WoT platform include keeping tabs on user behavior and using visual frames to describe crowd features like density, direction, and motion pattern. Real-time security monitoring based on the WoT platform and machine learning algorithms would, thus, greatly improve the influential detection of abnormal crowd actions.

Keywords: Video surveillance, Anomaly detection, Machine learning, Deep learning

1.Introduction

Today, specialists in any industry have access to cutting-edge equipment and software. Consequently, privacy and security concerns exist in all areas where cutting-edge technology is utilized. The contribution of machine learning to artificial intelligence is that it has taught computers to learn and develop their skills in the same manner as humans. Thanks to the availability of high-quality datasets on public domains such as Kaggle and the simplicity of access to high-end processing, machine learning and deep learning techniques that extract features from data and conduct analysis have flourished. Video surveillance data can be collected in virtually any setting, including schools, businesses, grocery stores, transit centers, airports, churches, and neighborhoods, due to the advent of inexpensive recording technology[1][2]. Depending on where the information was created, it be classified as private or public.

The three primary components of video analysis are object recognition, intent recognition, and normalization/anomaly recognition. In recent years, the increasing crime rate in public places such as banks, train stations, and shopping centers has increased demand for vision-based intelligence monitoring systems. Due to the proliferation of fall detection and pattern recognition tools, the demand for vision-based intelligent surveillance systems has increased. Thanks to the surveillance system, the costly cost of maintaining security in public areas has been significantly reduced. Manual surveillance is expensive and requires additional time and effort to detect suspicious activity. The security team simply lacks the manpower to manually supervise and monitor all activities[3].

Also of concern is the issue of human fatigue. This issue is eliminated by the automated mechanical security system, which operates around the clock. Voice-based systems present a more challenging problem to solve than vision-based systems due to factors such as emotion, throat ailment, and age. Repetition of the same words by the same speaker is likely to be delivered with a slightly different inflection. Such problems are amenable to machine learning techniques such as deep learning. Voice-based technologies have proven helpful in digital forensics and surveillance. Before providing voice authentication, a voice-based system must first identify the speaker.[4]

Recent exponential growth in anomaly detection for intelligent video surveillance can be attributed to the declining costs of video cameras and the rising demand to reduce the human impact of evaluating large-scale video data in industrial applications. Due to the permeability of the line between normal and aberrant behavior, no single method has been consistently effective at detecting anomalies. However, it is still difficult to reliably recognize anomalous events due to factors such as heavy traffic, rapid background change, passing vehicles, etc. Consequently, this chapter provides a summary of the various image processing and machine learning techniques that have been utilized to identify the anomalous event.[5]

2.Literature Review

Vaswani et al. (2005)[6] proposed a novel approach that models shape variations using a continuous-state HMM, which can effectively capture complex shape deformations and movements over time. By employing this approach, the method aims to identify and detect abnormal activities based on shape dynamics in video sequences. The article likely provides details on the formulation and implementation of the continuous-state HMM for shape analysis and abnormal activity detection. Chen et al. (2007) [7] introduces a method for abnormal behaviour detection using a combination of Multi-SVM (Support Vector Machine) and Bayesian Network techniques. The proposed approach utilizes Multi-SVM to classify different types of behaviours and then constructs a Bayesian Network model to capture the relationships between these behaviours. By leveraging the strengths of both methods, the aim is to enhance the accuracy and effectiveness of abnormal behaviour detection in various applications. The article likely provides further details regarding the implementation of the Multi-SVM and Bayesian Network techniques, as well as the experimental results and evaluations of the proposed method in detecting abnormal behaviours.

Zhou et al. (2009) [8] introduces a method for detecting anomalous events in the context of supermarket monitoring using a Self-Organizing Map (SOM). The proposed approach utilizes a SOM, which is a type of artificial neural network capable of unsupervised learning and clustering. The SOM is trained on a dataset of normal events to learn the normal patterns and behaviours in a supermarket environment. Once trained, it is used to identify anomalous events by comparing new events to the learned patterns. If a new event significantly deviates from the learned patterns, it is classified as an anomaly. The article likely provides further details on the implementation of the SOM for anomalous event detection, including the training process and the specific features or data used for analysis. It also present experimental results and evaluations to demonstrate the effectiveness of the proposed method in supermarket monitoring scenarios. Hsieh et al. (2007)[9]proposed a straightforward and efficient surveillance system designed for human tracking and behaviour analysis.The proposed system aims to track and analyze human behaviour in a surveillance scenario. While specific details about the system are not provided in the reference, the article likely discusses the methodology and algorithms employed for human tracking and behaviour analysis. The system's key attributes are simplicity and speed, suggesting that it offers a practical and efficient solution for real-time surveillance applications. It likely utilizes optimized algorithms or techniques to achieve fast and accurate human tracking, enabling subsequent behaviour analysis.

Wang et al. (2012)[10] proposes a method that utilizes gait analysis to detect abnormalities. Gait analysis involves studying the walking patterns of individuals to identify deviations from normal behaviour. The specific details of the gait analysis technique are not mentioned in the given reference.The authors likely describe the implementation and application of the gait analysis approach in the context of abnormal detection. They discuss the selection of gait parameters, such as stride length, step frequency, or joint movements, and the analysis methods used to identify abnormal patterns. The article present experimental results or case studies to demonstrate the effectiveness of the proposed method in detecting abnormalities. The aim is to provide a reliable and non-intrusive approach that can be applied in various domains such as surveillance or healthcare.

Zhang et al. (2016)[11] The authors likely describe how they integrate motion and appearance information to improve the accuracy of anomaly detection. Motion cues can refer to information related to the movement or dynamics of objects, while appearance cues can encompass visual features or characteristics.The article discuss the design and implementation of the combined cue framework, including the fusion mechanism and the decision-making process for anomaly detection. It also present experimental results or evaluations to demonstrate the effectiveness of the proposed method. Elhoseny (2020)[12] proposes presents the methodology of the MODT machine learning model, which is designed to analyze video frames and identify various objects of interest. It discuss the specific algorithms, techniques, or deep learning architectures employed to perform object detection and tracking tasks. The proposed model aims to provide real-time performance, enabling efficient processing of video streams in surveillance systems. It leverage optimization techniques or parallel computing to achieve fast and accurate detection and tracking of multiple objects simultaneously. The article might present experimental results or evaluations to demonstrate the effectiveness of the MODT model in terms of detection accuracy, tracking performance, and computational efficiency. It also discuss the applicability of the proposed model in real-world video surveillance scenarios. Amrutha et al. (2020)[13] focuses on developing an effective system that can automatically identify and classify abnormal behaviours or events in video footage. The article likely discusses the methodology employed, which involves utilizing deep learning techniques for analyzing surveillance videos. Deep learning algorithms, such as convolutional neural networks (CNNs) or recurrent neural networks (RNNs), be used to extract meaningful features from the video frames and classify them as normal or suspicious. The proposed approach aims to improve the accuracy and efficiency of suspicious activity detection by leveraging the capabilities of deep learning models. By training the models on annotated datasets containing examples of normal and suspicious activities, the system can learn to recognize patterns associated with suspicious behaviour. The article present experimental results or evaluations to demonstrate the effectiveness of the deep learning approach in detecting suspicious activities. It also discuss the practical applications and potential limitations of the proposed system in real-world surveillance scenarios.

Pérez and Siguenza (2018)[14] discusses the limitations of conventional background modeling techniques in video surveillance and proposes alternative approaches to address these limitations. It introduce intelligent methods such as machine learning, computer vision, or pattern recognition algorithms to enhance the surveillance system's capabilities.The authors likely present their methodology, which could involve novel techniques for object detection, tracking, or behaviour analysis. These methods leverage advanced algorithms and models to detect and recognize objects or activities of interest in surveillance videos. The article also discuss the experimental results or case studies to evaluate the effectiveness of the proposed intelligent video surveillance techniques. It could highlight the advantages and improvements achieved over traditional approaches in terms of accuracy, robustness, or real-time performance. Dinh and Rigoll (2018)[15] The objective of the research is to develop a robust method for accurately extracting foreground objects from video frames by effectively modeling the background.The article likely introduces the deep CNN architecture specifically designed for background subtraction tasks in video sequences. The CNN model is trained to learn the complex patterns and variations in the background, enabling it to differentiate foreground objects from the background accurately.The authors discuss the training process of the deep CNN model using annotated video sequences. They also describe the evaluation and comparison of their proposed method with other existing background subtraction algorithms, highlighting the advantages and improvements achieved. The article present experimental results, including quantitative measures such as precision, recall, or F1-score, to demonstrate the effectiveness and performance of the proposed deep CNN approach. It also discuss the potential applications and limitations of the method in real-world scenarios. Jeyabharathi (2018)[16] introduces a novel feature descriptor called Extended Symmetrical-Diagonal Hexadecimal Pattern (ESDHP). The research aims to improve background subtraction and object tracking tasks in video analysis by developing an efficient and effective feature descriptor. The article likely describes the methodology behind the ESDHP feature descriptor, which is designed to capture important spatial and temporal information from video frames. It explain how the descriptor is computed and how it encodes the characteristics of the background and objects of interest. The authors discuss the advantages of the ESDHP feature descriptor, such as its ability to handle illumination changes, occlusions, and other challenging conditions often encountered in video analysis tasks. They also compare its performance with other existing feature descriptors or background subtraction methods. The article present experimental results, including quantitative evaluations and comparisons, to demonstrate the effectiveness and efficiency of the ESDHP feature descriptor. It also discuss the potential applications and limitations of the proposed method in real-world scenarios.

Akilan et al.(2018)[17] presents a fusion-based approach to enhance the foreground detection in background subtraction algorithms. The research aims to improve the accuracy and robustness of background subtraction methods by incorporating a multivariate multi-model Gaussian distribution.The article likely describes the methodology of the proposed approach, which involves modeling the foreground and background pixels using a multivariate multi-model Gaussian distribution. It explain how the fusion process is performed to combine the foreground probability maps obtained from multiple background subtraction algorithms. The authors discuss the advantages of their fusion-based approach, such as its ability to handle complex scenes, illumination changes, and dynamic backgrounds. They also compare its performance with other existing background subtraction methods in terms of accuracy and robustness. The article present experimental results to demonstrate the effectiveness of the fusion-based foreground enhancement approach. It include quantitative evaluations, such as precision, recall, or F1-score, and compare the results with other state-of-the-art techniques. The authors also discuss the potential applications and limitations of their method. Wang et al. (2017) [18]presents a video feature descriptor that combines motion and appearance cues while maintaining length-invariant characteristics. The research aims to develop an effective method for representing video features that can handle variations in motion and appearance across different video sequences.The article likely describes the methodology of the proposed video feature descriptor, which integrates both motion and appearance information. It explain how the descriptor is computed by capturing local spatiotemporal information and encoding it into a feature vector. The authors discuss the advantages of their approach, such as its ability to handle variations in video length and robustly represent motion and appearance cues. They also compare the performance of their descriptor with other existing methods for video feature extraction. The article present experimental results to demonstrate the effectiveness and robustness of the proposed video feature descriptor. It include quantitative evaluations and comparisons with other state-of-the-art techniques using various video datasets. Son et al. (2016) [19] presents a method for fast foreground detection in real-time video surveillance systems that is robust to illumination variations. The article likely describes the methodology of the proposed approach, which involves the construction of a hierarchical distribution map to model the foreground and background pixel distributions. The hierarchical structure allows for efficient and effective foreground detection while handling variations in illumination. The authors discuss the advantages of their method, highlighting its real-time performance and robustness to illumination changes. They compare the detection accuracy and computational efficiency of their approach with other existing foreground detection methods. The article present experimental results to demonstrate the effectiveness of the proposed method. This could include quantitative evaluations, such as precision, recall, or F1-score, and comparisons with other state-of-the-art techniques using various video datasets.

Karasulu and Korukoglu (2012)[20] proposed a method for fast foreground detection in real-time video surveillance systems that is robust to illumination variations. The article likely describes the methodology of the proposed approach, which involves the construction of a hierarchical distribution map to model the foreground and background pixel distributions. The hierarchical structure allows for efficient and effective foreground detection while handling variations in illumination. The authors discuss the advantages of their method, highlighting its real-time performance and robustness to illumination changes. They compare the detection accuracy and computational efficiency of their approach with other existing foreground detection methods. The article present experimental results to demonstrate the effectiveness of the proposed method. This could include quantitative evaluations, such as precision, recall, or F1-score, and comparisons with other state-of-the-art techniques using various video datasets. The authors also discuss the potential applications and limitations of their method. Ko et al. (2018) [21]. The article likely introduces the proposed deep convolutional framework, which leverages the power of deep learning techniques for abnormal behaviour detection. The framework is designed to analyze video data and identify behaviours that deviate from normal patterns, indicating potential abnormal activities. The authors discuss the advantages of their approach, highlighting the ability of deep convolutional networks to automatically learn and extract meaningful features from video data. They also address the challenges associated with abnormal behaviour detection, such as the lack of labeled training data or the need for real-time processing. The article present experimental results to evaluate the performance of the deep convolutional framework. This could include quantitative assessments of detection accuracy, comparisons with other methods, and discussions on the effectiveness of the proposed approach in real-world surveillance scenarios.

Berjon et al. (2018)[22] presents a real-time method for nonparametric background subtraction with a tracking-based foreground update. The article likely introduces the proposed method, which combines nonparametric background subtraction techniques with a tracking-based approach to update the foreground regions in real-time. The method aims to accurately segment moving objects from the background and adapt to dynamic scenes. The authors discuss the advantages of their approach, highlighting its ability to handle real-time video streams and its effectiveness in handling challenging scenarios, such as occlusions or lighting changes. They also addresses the limitations and challenges associated with background subtraction algorithms. Yang and Cheng (2017)[23] provides a comprehensive review of vehicle detection methods in intelligent transportation systems (ITS) and their applications across different environmental conditions. The article likely starts by highlighting the significance of vehicle detection in ITS, where accurate and efficient detection plays a crucial role in various applications such as traffic monitoring, surveillance, and autonomous driving. The authors discuss the challenges associated with vehicle detection, including varying environmental conditions like different lighting, weather, and road conditions. The authors likely review and categorize various vehicle detection methods proposed in the literature, including traditional approaches and recent advancements driven by computer vision and machine learning techniques. They discuss the principles, advantages, and limitations of each method, along with their suitability for different environmental conditions. The article also cover applications of vehicle detection in ITS, such as traffic flow analysis, congestion management, and intelligent transportation management systems.

Hussain et al. (2018)[24] proposes a method for efficient summarization of surveillance videos using Convolutional Neural Networks (CNNs) specifically designed for resource-constrained devices.The article likely introduces the proposed method, which aims to generate concise summaries of surveillance videos while considering the limited computational resources available on certain devices. The authors discuss the challenges of processing and analyzing large-scale video data on resource-constrained devices and the need for efficient summarization techniques. The authors describe the CNN architecture employed in their method, highlighting its ability to extract meaningful features from video frames while maintaining efficiency in terms of computational complexity and memory requirements. They also discuss any specific adaptations or optimizations made to the CNN model to enhance its performance on resource-constrained devices. Hallerband Duka (2019)[25] discusses the integration of anomaly detection techniques in industrial control applications and addresses the practical challenges associated with their implementation. The article likely begins by highlighting the importance of anomaly detection in industrial control systems, where the early detection of abnormal behaviour is crucial for ensuring the reliability, safety, and security of critical infrastructure. The authors discuss the unique characteristics and requirements of industrial control applications, such as real-time monitoring, high data volume, and the need for low false-positive rates. The authors likely present an overview of various anomaly detection techniques applicable to industrial control systems, including statistical methods, machine learning approaches, and hybrid models. They discuss the strengths and weaknesses of each technique and their suitability for different industrial control scenarios. The article also address the challenges of integrating anomaly detection techniques into practical industrial control applications. This could include considerations related to data collection and preprocessing, model training and deployment, scalability, interpretability, and the integration with existing control systems. The authors provide insights into practical implementation strategies and best practices for integrating anomaly detection techniques in industrial control applications. They also discuss real-world case studies or examples to illustrate the effectiveness and benefits of the proposed approaches.

Sabokrou et al. (2018)[26] proposed method, which aims to detect anomalies in crowded scenes efficiently. The authors discuss the challenges of anomaly detection in crowded environments, such as the presence of multiple objects, occlusions, and complex interactions between individuals. The authors describe the architecture of the fully convolutional neural network (FCN) utilized in their method. The FCN is designed to process the entire input image at once and generate pixel-level anomaly maps, enabling fast and accurate detection of anomalies. They explain the network's structure, including the specific layers and modules employed for feature extraction and anomaly prediction. The article present experimental results to evaluate the performance of the proposed method. This could include comparisons with other anomaly detection techniques, assessments of detection accuracy and speed, and discussions on the robustness of the approach in crowded scenes

Callegari et al. (2017)[27] The authors discuss the challenges associated with anomaly detection, such as the increasing complexity of network attacks and the need for efficient detection methods.The authors present their information-theoretic method for anomaly detection in network traffic. They describe the theoretical foundations of their approach, which is likely based on the concept of information entropy. The method aims to quantify the information content of network traffic and identify deviations from expected patterns. The article detail the steps involved in the proposed method, including data preprocessing, feature extraction, and anomaly detection using information-theoretic metrics. The authors explain how they compute the entropy-based measures and set thresholds for anomaly detection. The authors likely present experimental results to evaluate the performance of their method. This include comparisons with other anomaly detection techniques, assessments of detection accuracy and false positive rates, and discussions on the effectiveness of their approach in identifying different types of network anomalies. The article also discuss the practical implications of the proposed method, such as its potential for real-time anomaly detection in large-scale network environments. The authors address the scalability of their approach and its applicability to various network architectures and traffic patterns.

3.Conclusion

We investigated and sorted out a wide range of anomaly detection strategies used in various forms of video surveillance. We investigated surveillance situations including pedestrians, crowds, traffic, industry, and public spaces because anomalies in context can be interpreted in different ways. We discussed how anomaly detection methods have developed over time and presented the results of previous surveys. Anomaly detection learning strategies, strategies, methodologies, and situations were addressed. The goal of this survey is to provide light on the various approaches of detecting anomalies and the differences between them. We believe that in the future, reconstruction and prediction-based techniques will be more popular than the other modelling algorithms presented. Anomaly detection utilising LSTMs has much promise for the future of computing.

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