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Artificial intelligence in video surveillance systems for suspicious activity detection and incident response: A systematic literature review

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ABSTRACT

Artificial intelligence (AI) has proven to be a key tool to improve the efficiency of video surveillance systems, contributing to public safety. This systematic review aims to analyze the contributions of artificial intelligence in this field, in line with Sustainable Development Goal 16 (SDG 16), which promotes peaceful and inclusive societies. 145 articles extracted from major databases such as Scopus, WOS, ProQuest, EBSCO, IEEE Xplore, and ScienceDirect were analyzed. Using PRISMA methodology, inclusion and exclusion criteria were applied, resulting in 42 articles relevant to the review. The findings indicate that the use of advanced AI technologies, such as the internet of things, computer vision, and edge computing, are the most integrated with artificial intelligence, enhancing its capabilities in video surveillance systems. In this framework, deep learning stands out as an essential basis for optimizing these applications. Finally, the results of this review provide a solid foundation for future research on the use of artificial intelligence in video surveillance. The technologies evaluated have the potential to further contribute to the improvement of security and operational efficiency in different contexts and environments.

Keywords: artificial intelligence, video vigilance, deep learning, security, SDG 16.

INTRODUCTION

Citizen safety is a critical issue in managing cities, especially those with high population density and facing socioeconomic challenges. Ensuring citizens' safety involves reducing crime and creating environments in which people can live free from fear and enjoy their daily lives with confidence and peace of mind. Sustainable Development Goal (SDG) 16, promoted by the United Nations, aims to "promote just, peaceful, and inclusive societies". This goal highlights the importance of all people, regardless of ethnicity, religion, or sexual orientation, being able to live free from fear of violence and feel safe in their everyday environment (1).

According to the Inter-American Development Bank (IDB) (2), The security situation in Latin America and the Caribbean faces unique challenges, characterized by high levels of violence and homicide rates that exceed the global average. This situation not only carries a high human cost but also has a significant economic impact, estimated at an average of 3% of regional GDP, a figure that doubles in some Central American countries. The persistent violence has generated a state of social alarm, with 43% of the population feeling a constant fear of becoming victims of crime, making public safety one of the main concerns of citizens.

Along the same lines, in recent years an important tool for human beings, known as artificial intelligence (AI), has been consolidated (3), defining AI as software (and possibly also hardware) systems designed by humans to address complex objectives and operating in both the physical and digital dimensions (4). These systems can perceive their environment by acquiring and interpreting data, which can be both structured and unstructured. This perception capability allows

them to understand different aspects of the environment in which they operate, either through physical sensors in the real world or by capturing digital information.

For this reason, AI has positioned itself as a key tool in public safety, providing unprecedented efficiency in areas such as pattern recognition and decision-making (5). In particular, video surveillance systems have emerged as a fundamental technological solution for city crime prevention and control. The implementation of these technologies, which include video surveillance and geospatial analysis, not only allows us to map crime and understand its dynamics in urban environments, but also to address challenges related to privacy, data storage, and measuring its effectiveness (6).

The use of artificial intelligence in video surveillance not only improves security but can also act as a catalyst for economic revival and productive growth. According to estimates by the Development Bank of Latin America and the Caribbean (CAF) and the Organization of American States (OAS), the use of Artificial Intelligence in video surveillance not only improves security but can also act as a catalyst for economic reactivation and productive growth (6) accelerating the development and adoption of Artificial Intelligence could increase global GDP by up to 14% by 2030, representing an increase of US$16.5 trillion. In Latin America and the Caribbean, the adoption of artificial intelligence has the potential to increase business productivity and boost consumption, thus supporting the goals of the 2030 Agenda for Sustainable Development. This would contribute to the creation of safer and more peaceful environments while boosting economic development (7).

The objective of this research is to analyze the role of artificial intelligence in video surveillance systems for suspicious activity detection and incident response in urban environments in Latin America and the Caribbean. It aims to assess how the implementation of these technologies can contribute to improving citizen security, reduce crime, and foster an environment of trust and tranquility, in line with Sustainable Development Goal 16. In addition, it seeks to explore the economic impact of the adoption of artificial intelligence on business productivity and its potential to catalyze economic growth in the region, thus promoting more just, peaceful, and inclusive societies (8).

METHODOLOGY

Type of study

The systematic literature review (SLR) approach was chosen to conduct this study, given its ability to provide a comprehensive and structured analysis, supporting both practice and policy formulation (9). The PRISMA method was implemented for its recognized value in standardizing processes, reducing bias, and ensuring scientific rigor, as well as providing a transparent presentation of results (10). These aspects are essential to accurately assess the impact of artificial intelligence in video surveillance systems.

Objective and research questions

This study will analyze the impact of the use of artificial intelligence (AI) in video surveillance systems for suspicious activity detection and incident response. Technological advances in this field will be explored, with a focus on how AI improves the accuracy and speed of threat identification in urban and high-risk environments. It will also review how these technologies can contribute to the improvement of public safety, enabling a more efficient response to potential incidents. The research questions are as follows:

- RQ1. Which are the countries with the most research implemented and under development in the use of artificial intelligence technologies applied to video surveillance systems?
- RQ2. What are the main technologies that can be combined with Artificial Intelligence to improve the efficiency and accuracy of video surveillance systems?
- RQ3. What approaches to integrating AI with incident management systems improve critical event response in video surveillance environments?
- RQ4. What are the recent trends in the development of architectures for real-time detection of suspicious activity in surveillance video?
- RQ5. How have detection techniques in video surveillance systems influenced the identification of suspicious activity and incident response?

Search strategy

The data collection method was based on an exhaustive search of reliable sources, for which a review of articles in various databases was carried

out. Specific search terms and literary resources were used, as described in (11). This search strategy identified a total of 145 articles, of which 42 relevant articles were selected by applying inclusion and exclusion criteria, as shown in Figure 1.

For data collection, a search was carried out in the following databases: Web of Science (WOS), ScienceDirect, Scopus, IEEE Xplore, EBSCOhost, and ProQuest. The search strategy included the following key terms, which are shown in Table 1.

Inclusion and exclusion criteria

For the systematic review study, the inclusion and exclusion criteria shown in Table 2 were applied. Figure 2 illustrates the automation process implemented, according to the PRISMA method, which underlines the importance of this approach to provide a clear and transparent evaluation of the reviewed items, detailing the inclusions and exclusions based on the established criteria (12).

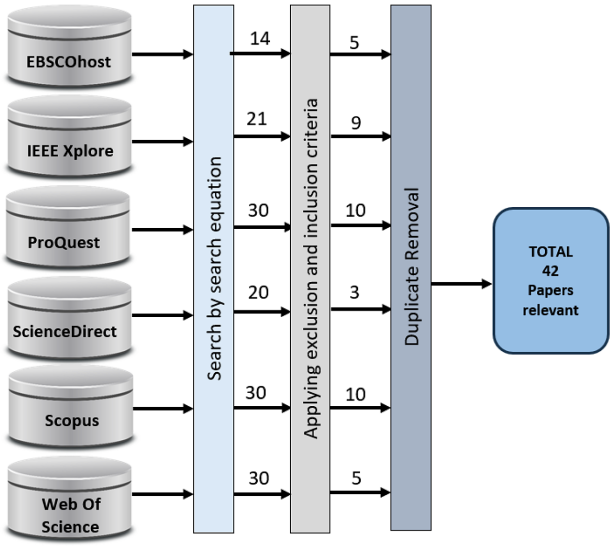

Figure 1. Selection methodology diagram

Table 1. Search strategies

Database	Search terms
Web of Science	”Artificial Intelligence” OR ”AI” AND ”Video Surveillance” OR ”Video Surveillance Systems” OR ”CCTV” OR ”Security Cameras” OR ”Surveillance Cameras” OR ”Surveillance Systems” AND ”Anomaly Detection” OR ”Suspicious Activities” OR ”Threat Detection” OR ”Weapons Detection” OR ”Intrusion Detection” OR ”Perimeter Security”
ScienceDirect	”Artificial Intelligence” OR ”AI” AND ”Video Surveillance” OR ”Video Surveillance Systems” OR ”CCTV” OR ”Security Cameras” OR ”Surveillance Cameras” OR ”Surveillance Systems”
Scopus	”Artificial Intelligence” OR ”AI” AND ”Video Surveillance” OR ”Video Surveillance Systems” OR ”CCTV” OR ”Security Cameras” OR ”Surveillance Cameras” OR ”Surveillance Systems” AND ”Anomaly Detection” OR ”Suspicious Activities” OR ”Threat Detection” OR ”Weapons Detection” OR ”Intrusion Detection” OR ”Object Detection” OR ”Human Detection” OR ”Perimeter Security” AND ”Motion Tracking” OR ”Action Recognition” OR ”Behavioral Analysis” OR ”Incident Response” OR ”Emergency Management” OR ”Real-Time Monitoring”
IEEE Xplore	”Artificial Intelligence” OR ”AI” AND ”Video Surveillance” OR ”Video Surveillance Systems” OR ”CCTV” OR ”Security Cameras” OR ”Surveillance Cameras” OR ”Surveillance Systems” AND ”Anomaly Detection” OR ”Suspicious Activities” OR ”Threat Detection” OR ”Weapons Detection” OR ”Intrusion Detection” OR ”Object Detection” OR ”Human Detection” OR ”Perimeter Security” AND ”Motion Tracking” OR ”Action Recognition” OR ”Behavioral Analysis” OR ”Incident Response” OR ”Emergency Management” OR ”Real-Time Monitoring”
EBSCOhost	”Artificial Intelligence” OR ”AI” AND ”Video Surveillance” OR ”Video Surveillance Systems” OR ”CCTV” OR ”Security Cameras” OR ”Surveillance Cameras” OR ”Surveillance Systems” AND ”Anomaly Detection” OR ”Suspicious Activities” OR ”Threat Detection” OR ”Weapons Detection” OR ”Intrusion Detection” OR ”Object Detection” OR ”Human Detection” OR ”Perimeter Security” AND ”Motion Tracking” OR ”Action Recognition” OR ”Behavioral Analysis” OR ”Incident Response” OR ”Emergency Management” OR ”Real-Time Monitoring”
ProQuest	”Artificial Intelligence” OR ”AI” AND ”Video Surveillance” OR ”Video Surveillance Systems” OR ”CCTV” OR ”Security Cameras” OR ”Surveillance Cameras” OR ”Surveillance Systems” AND ”Anomaly Detection” OR ”Suspicious Activities” OR ”Threat Detection” OR ”Weapons Detection” OR ”Intrusion Detection” OR ”Perimeter Security”

Table 2. Inclusion and exclusion criteria

Category		Criteria
Inclusion	I01	Articles on the use of artificial intelligence in video surveillance systems for the detection of suspicious activities.
	I02	Articles related to the impact of AI-based video surveillance systems on incident response.
	I03	Articles discussing the effectiveness of AI-based video surveillance systems in improving security and emergency management.
	I04	Articles exploring anomaly detection techniques, action recognition, and behavior analysis in video surveillance.
	I05	Articles that partially answer the research questions.
	I06	Articles in English.
Exclusion	E01	Articles not related to the use of Artificial Intelligence in video surveillance systems.
	E02	Articles that do not address the detection of suspicious activity or incident response in video surveillance systems.
	E03	Articles that do not focus on specific AI techniques for safety improvement and emergency management.
	E04	Articles that do not partially answer the research questions.
	E05	Only articles published from 2021 onwards.

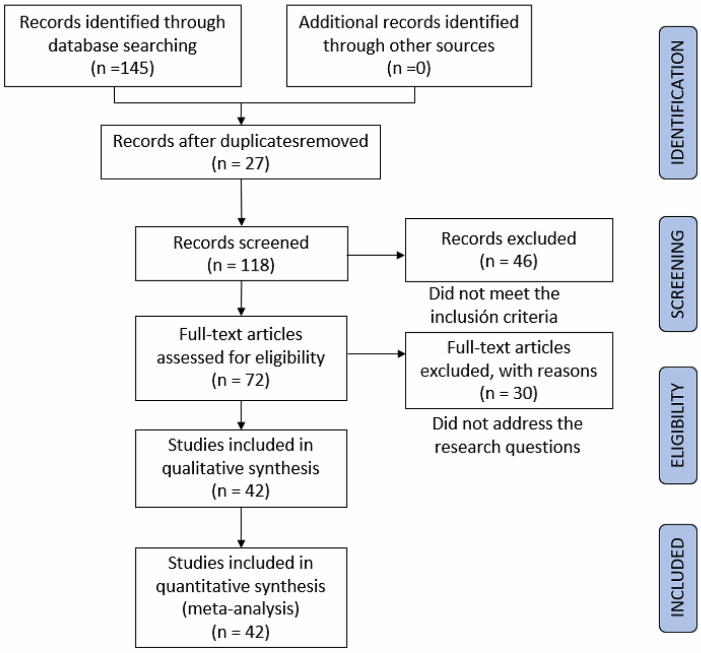

Figure 2. PRISMA methodology diagram

RESULTS

A total of 145 articles obtained from databases relevant to the research topic were examined. After eliminating duplicates and those that did not meet the established inclusion criteria, an exhaustive review was performed. As a result, 46 articles were excluded according to the inclusion and exclusion criteria, and 30 articles that did not answer the research questions formulated were discarded. This resulted in a total of 42 articles selected for the systematic review. The percentage of articles found in each database is shown in the following graph (Figure 3). Figure 4 shows the number of articles found in the databases, analyzed by year of publication.

VOSviewer is a specialized software for visualizing scientific networks, widely used in bibliometrics. It helps analyze co-authorship, citation networks, and relationships between authors, institutions, and keywords in scientific publications. Known for handling large bibliographic datasets, it effectively identifies collaboration patterns, thematic trends, and research impact. With its user-friendly interface, VOSviewer simplifies the creation of maps to visualize and communicate complex bibliometric analyses (13). The following graphs provide a more comprehensive and

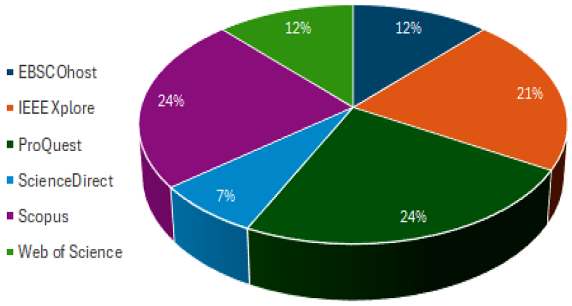

Figure 3. Articles by database

objective perspective of current literature, allowing for the identification of knowledge gaps and a deeper understanding of the research landscape in a particular field. Based on this, visualization maps were created, as illustrated in Figures 5 and 6.

Figure 6 shows a network visualization based on the bibliometric analysis of articles related to the field of artificial intelligence applied to video surveillance systems for public safety and SDG 16 compliance. The terms are organized into six clusters, highlighting key research areas:

Cluster 1 (Red, 11 elements): This cluster focuses on security and real-time interactive systems. It includes terms such as "edge computing", "network security", "real-time systems", "interactive computer systems", and "violence detections". It highlights the need for fast and efficient responses, especially in video surveillance and real-time security systems scenarios, such as the monitoring of violent activities.

Cluster 2 (Green, 10 elements): This group focuses on anomaly detection and anomalous event

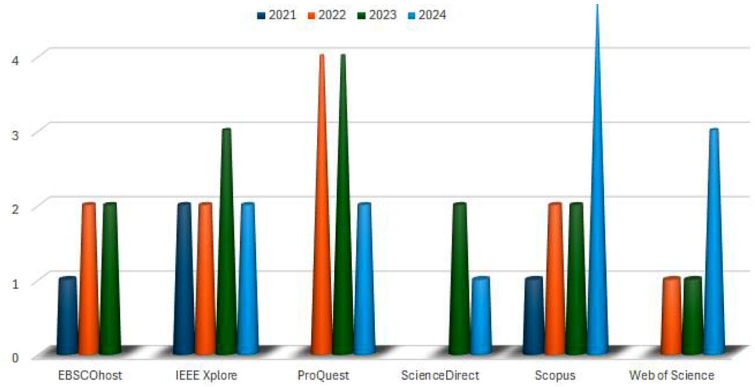

Figure 4. Articles by year and database

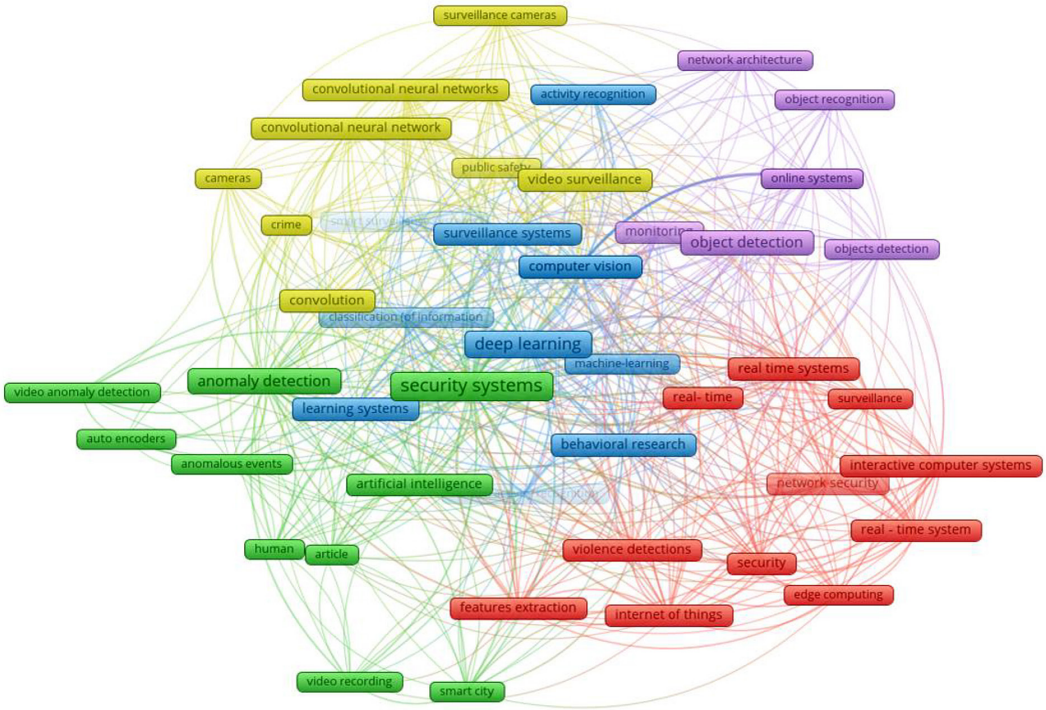

Figure 5. Network visualization for bibliometric data analysis

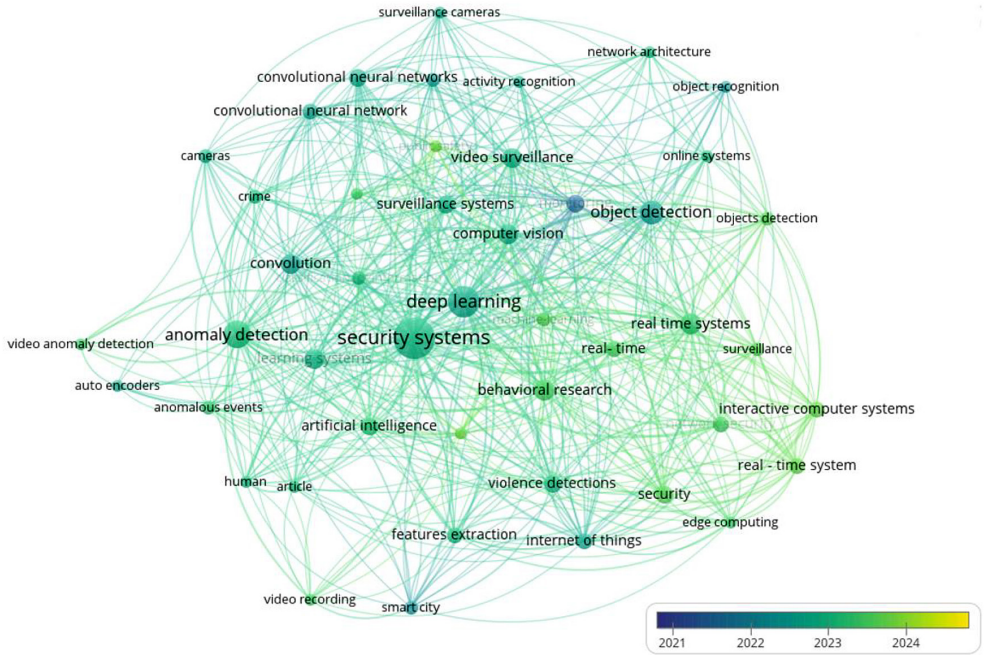

Figure 6. Overlay visualization of bibliometric analysis by year

analysis, with terms such as "video anomaly detection", "autoencoders", "anomalous events", and "artificial intelligence". It highlights the importance of identifying suspicious behavior using AI and machine learning systems, which improve surveillance in smart cities.

Cluster 3 (Blue, 10 elements): This cluster includes topics related to activity recognition and advanced machine learning, highlighting terms such as "activity recognition", "deep learning", "computer vision" and "classification of information". The focus here is on improving the accuracy of human activity detection through the use of AI and computer vision techniques.

Cluster 4 (Yellow, 9 elements): Related to video surveillance and neural networks, this cluster groups terms such as "video surveillance", "convolutional neural networks", "crime", and "convolution". The focus is on how convolutional neural networks and other AI technologies are being applied to improve public safety systems and surveillance.

Cluster 5 (Purple, 6 elements): This group focuses on object detection and network architectures for video surveillance. Terms such as "object detection", "network architecture", and "online systems" highlight advances in AI infrastructure, enabling better detection and automated tracking of objects.

Figure 7 presents a word cloud generated from the keywords of the articles that were analyzed using the R Studio software, version 2024.06.15, as part of this bibliographic review. Notable terms include "security systems", "deep learning", and "anomaly detection".

Figure 8 shows the tree structure with the percentages of the most repeated words according to the bibliographic analysis.

DISCUSSION

In this systematic review of the scientific literature, we analyze the impact of artificial intelligence (AI) on video surveillance systems for suspicious activity detection and incident response. We identify the most advanced technologies, the most widely used implementation tools, as well as the sectors with the largest amount of research, all in order to answer the questions posed in this study.

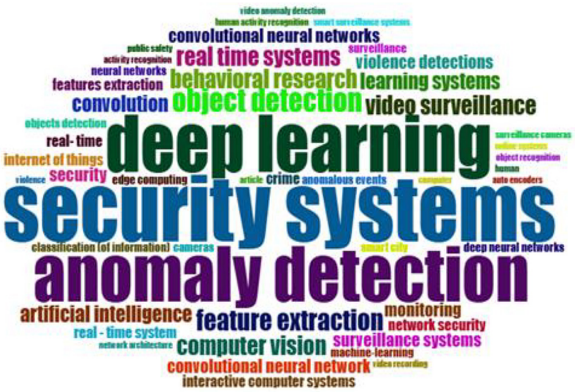

Figure 7. Overlay display of documents: word cloud

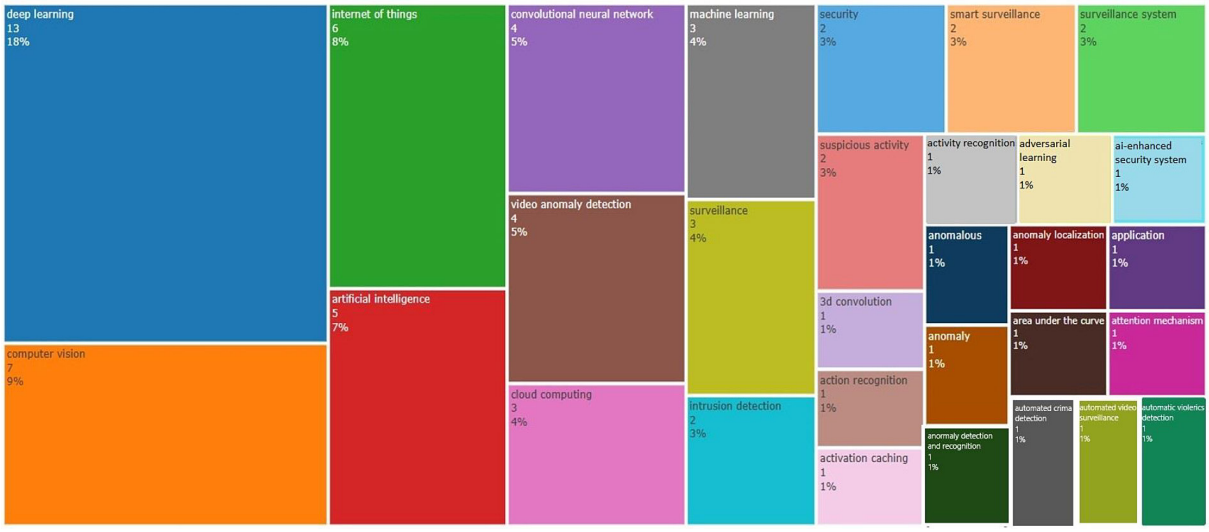

Figure 8. Visualization of documents based on bibliometric analysis

RQ1 Which are the countries with the most research implemented and under development in the use of artificial intelligence technologies applied to video surveillance systems?

Figure 9 presents the percentage distribution of articles on implementation and projects under development by continent in the field of artificial intelligence in video surveillance. Europe and the Americas stand out with 100% of the articles focused on implementation, suggesting a total focus on the practical application of these technologies. In Asia, between 60% and 80% of the articles refer to implementations, while the rest are oriented towards projects under development. On the other hand, Africa presents a range of 60% to 70% on implementations, indicating that a significant part of the research on the continent also focuses on practical applications, while the remainder corresponds to projects in the development phase.

Asian countries, such as China, Japan, and South Korea, are leading the way in the adoption of AI in video surveillance systems due to a combination of technological, political, and social factors. This is evidenced by (14), this article analyzes investment in AI in various countries, highlighting that Asia, especially China, is leading the way in terms of investment and technological development. It mentions that China has made significant investments in AI, with a particular focus on surveillance, although exact amounts are not specified. For its part, the World Economic Forum (15) indicates that the Chinese AI market is forecast to exceed $61 billion by 2025, with a total investment of approximately $120 billion in its AI ecosystem, which includes video surveillance systems. In comparison, AI investments in Europe are highlighted to be significantly lower, with Germany initially allocating €3 billion for the 2019-2025 period. Regarding generative AI an IDC report (16),

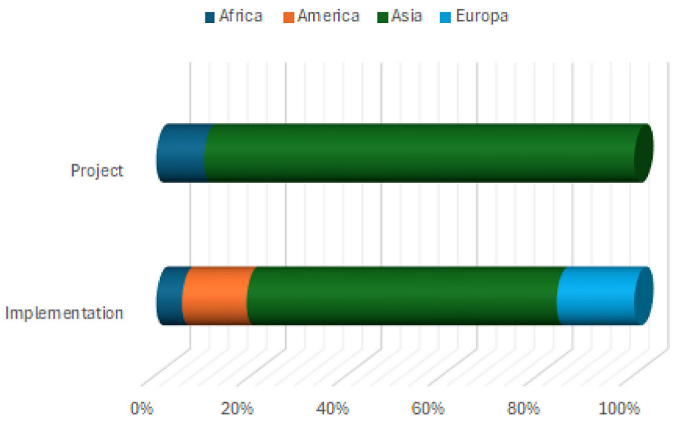

Figure 9. Percentage of continents with implementations or projects

highlights that Asian countries are leading the way in technology investment and have a proactive stance toward new technologies, including applications for surveillance systems, some Asian governments are promoting surveillance policies to strengthen security and manage large urban populations, which facilitates the implementation of these systems on a large scale. Cultural acceptance of the use of advanced technologies in everyday life and increased tolerance of state surveillance have also contributed to the rapid expansion of AI video surveillance in the region.

Meanwhile, in Europe, the adoption of AI surveillance has been slower due to strict data privacy regulations. The European Union places great emphasis on balancing technological progress with privacy rights, as seen in its General Data Protection Regulation (GDPR). While the UK has deployed AI surveillance in cities such as London, the EU generally focuses more on ethical standards and public trust, investing around €7 billion through programs such as Horizon Europe to explore the potential of AI, while maintaining privacy protections (17) (18).

Table 3 presents a comparison of the number of articles related to projects and implementations between different continents, as well as intercontinental collaborations. In the Asia-America category, one article focused on implementation has been identified. On the other hand, in the Europe-Asia collaboration, a total of four articles addressing this topic of implementation are registered.

Figure 10 shows that India and South Korea lead the research in the field of artificial intelligence applied to video surveillance systems, with 10 scientific publications. China contributes with five studies, while Saudi Arabia presents four research in this area. These countries stand out for their growing interest and participation in the development of AI-based intelligent video surveillance technologies.

Figure 11 reveals a diverse panorama in terms of video surveillance technology implementation and projects. South Korea stands out as the country with the highest number of implementations, with 7 items, in addition to having 3 projects under development. It is followed by India, with a balance of 6 implementations and 4 projects, indicating a remarkable effort in both the implementation and planning of new technologies. China is also well positioned, with 4 implementations and only 1 project, reflecting a more hands-on

Table 3. Table on cross-continent projects or implementation and collaborations

Continents and collaborations	Implementation	Project under development	Articles
Asia	19	9	(19) (20) (21) (22) (23) (24) (25) (26) (27) (28) (29) (30) (31) (32) (33) (34) (35) (36) (37) (38) (39) (40) (41) (42) (43) (44) (45) (46) (47) (48) (49) (50) (51)
Africa	2	1	(52) (53) (54)
America	4	0	(55) (56) (57) (58)
Europa	2	0	(59) (60)
Asia - Europa	4	0	(20) (44) (46) (48)
Asia - America	1	0	(21)

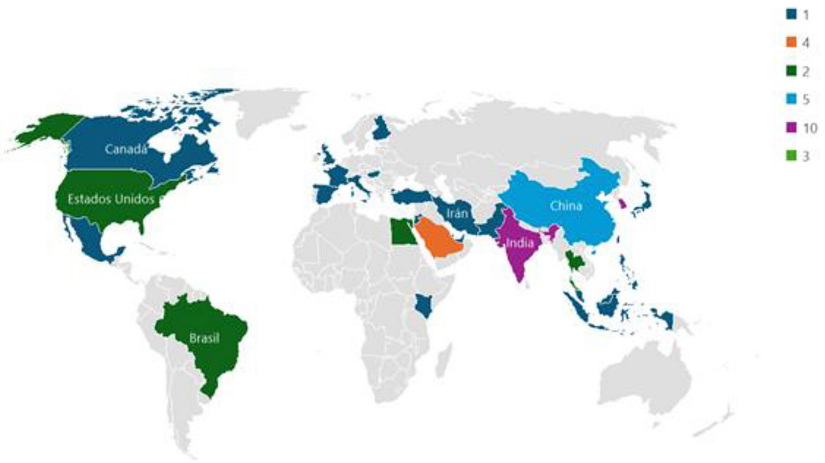

Figure 10. Articles analyzed by country

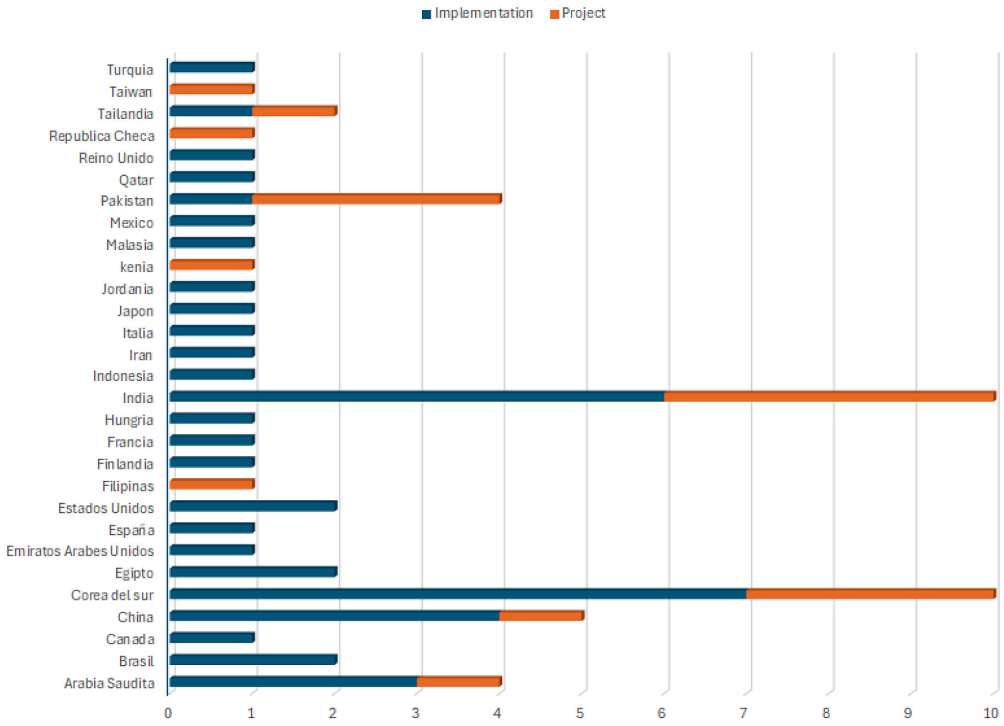

Figure 11. Implementation or project by country

approach to implementation. In contrast, Pakistan has a reverse trend, with 1 implementation and 3 projects, suggesting a more advanced stage of planning than implementation. Thailand shows an exact balance, with 1 item in each category.

On the other hand, countries such as the United States, Egypt, and Brazil present 2 implementations each, with no additional projects, which could indicate a direct focus on the application of existing technologies. Finally, most of the remaining countries have only 1 implementation recorded, while a few, such as Taiwan, and Kenya, have 1 project article, evidencing a lower development compared to the leading nations.

RQ2 What are the main technologies that can be combined with Artificial Intelligence to improve the efficiency and accuracy of video surveillance systems?

According to Figure 12 illustrating the frequency of various technologies integrated with artificial intelligence in video surveillance systems, the internet of things (IoT) stands out as the most mentioned technology, with a frequency of 10, underlining its fundamental role in real-time data collection. It is followed by video management systems (VMS) with a frequency of 9, which are essential for video organization and analytics. Other technologies, such as computer vision and edge computing, feature frequencies of 8 each, while cloud computing is mentioned with a frequency of 2. Big data and sensors both have a frequency of 1, suggesting that their direct integration in this context is less prominent. Although the graph does explicitly mention deep learning and machine learning, these techniques are fundamental subtopics of artificial intelligence and are used in almost all the articles reviewed. Therefore, their relevance is considered to be implicit. Taken together, these technologies have been used as complements to leverage artificial intelligence, thus improving efficiency and accuracy in video surveillance systems.

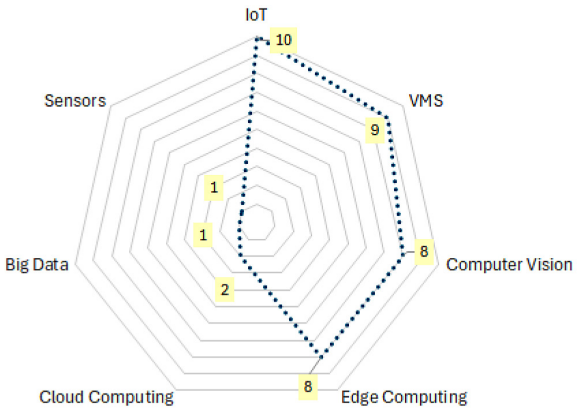

Figure 12. Frequency of technologies integrating with AI

Figure 13 shows how technologies are integrated in video surveillance research with artificial intelligence to improve the efficiency and accuracy of the systems. Each number in the matrix reflects the number of articles that combine two technologies simultaneously. The most prominent combinations include machine learning and deep learning (16 articles), indicating that these technologies are central to advances in intelligent video surveillance. In addition, technologies such as edge computing and IoT (8 and items both) are being integrated with artificial intelligence to optimize processing power and real-time connectivity, contributing to faster detection and response in video surveillance systems.

Important relationships between deep learning and computer vision are also observed (7 papers), where computer vision is used to automatically interpret images captured by security cameras, thus improving the accuracy in detecting suspicious objects or behavior. The combination of VMS with deep learning (8 papers) suggests that artificial intelligence is helping to improve the management and analysis of large volumes of video data, enabling more efficient and accurate monitoring.

Table 4 systematizes the technologies that are integrated with artificial intelligence in video surveillance systems, highlighting their frequency of appearance in the literature. This presentation allows a quick visualization of the relevance of each technology in improving efficiency and accuracy in incident management.

RQ3 What approaches to integrating AI with incident management systems improve critical event response in video surveillance environments?

Figure 14 presents a bubble chart illustrating the frequency of approaches integrated with artificial intelligence in incident management systems to improve critical event response in video surveillance

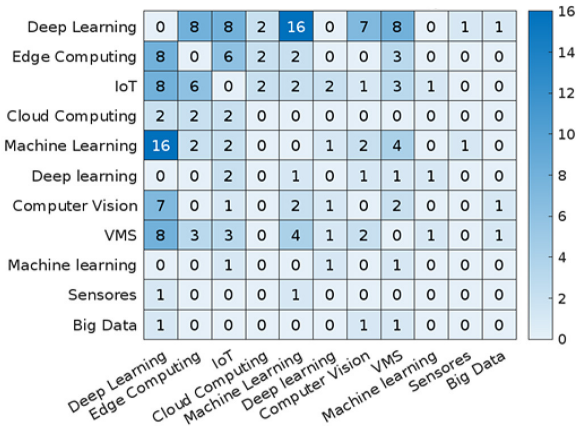

Figure 13. Combined technologies that are integrated with AI

environments. The categories represented include early warning systems, real-time detection and response, predictive analytics, anomalous pattern recognition, and response automation. It is noted that Real-time detection and response is the most documented approach, suggesting a strong interest in proactive incident detection. Overall, the graph indicates that the literature focuses on the importance of technologies that enable fast and effective responses, highlighting how AI integration improves incident management in video surveillance.

Table 5 systematizes artificial intelligence integration approaches in incident management systems, highlighting their frequency of appearance in the literature. This presentation allows a quick visualization of the relevance of each approach in improving critical event response in video surveillance environments.

RQ4 What are the recent trends in the development of architectures for real-time detection of suspicious activity in surveillance video?

Figure 15 reflects a wide variety of neural architectures used in the articles, where

Table 4. Systematization of items based on other technologies integrated with AI in security systems

Technologies	Quantity	Articles
Big data	1	(19)
Cloud computing	2	(20) (21)
Computer vision	8	(19) (52) (22) (23) (24) (25) (26) (27)
Deep learning	42	(26) (28) (29) (55) (30) (56) (31) (32) (33) (34) (53) (35) (36) (37) (38) (39) (40) (41) (42) (43) (44) (45) (46) (47) (59) (57) (58) (48) (49) (50) (54) (51) (60)
Edge computing	8	(20) (21) (57) (44) (40) (53) (55) (30)
IoT	10	(20) (21) (23) (57) (44) (40) (55) (47) (59) (46)
Machine learning	18	(22) (27) (40) (30) (47) (59) (50) (58) (45) (42) (36) (39) (38) (49) (32) (34) (31) (29)
Sensors	1	(32)
VMS	9	(19) (22) (57) (44) (53) (47) (38) (49) (31)

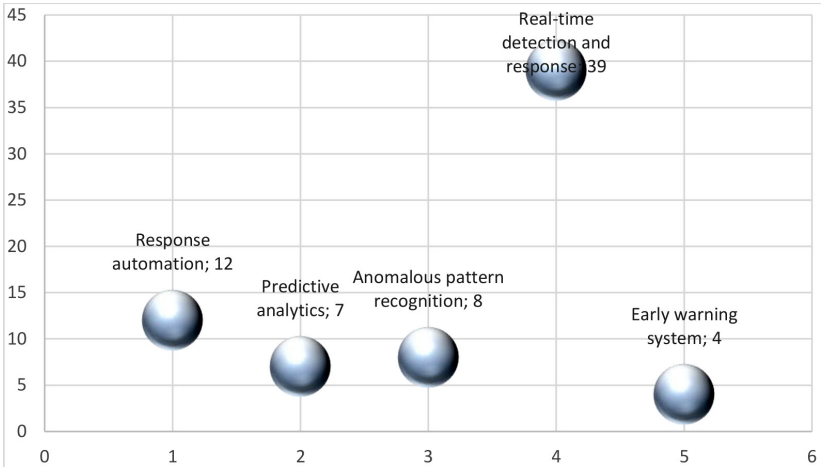

Figure 14. Frequency of approaches integrated with AI

Table 5. Systematization of articles based on AI integration approaches with security systems

Integration Approaches	Quantity	Conclusions	Articles
Predictive analytics	7	Facilitates the identification of incidents and future patterns by analyzing large volumes of historical data. This enables organizations to anticipate likely events and take preventive measures to minimize risks, optimize planning, and reduce the occurrence of unforeseen problems in sectors such as safety and health.	(21) (27) (28) (55) (43) (59) (57)
Response automation	12	AI enables fast and accurate management of events once they are detected. By eliminating or reducing human intervention in certain response processes, organizations can react more efficiently and avoid human error, especially in emergency or high-demand situations, which is essential to protect both people and systems.	(21) (25) (31) (32) (36) (38) (39) (41) (45) (47) (57) (50)
Real-time detection and response	39	Enables continuous monitoring of critical systems, facilitating instant identification of threats or incidents. This capability is essential in sectors where immediacy is crucial, such as IT security and surveillance, as it allows a threat to be stopped quickly before it causes significant damage.	(19) (20) (21) (52) (22) (23) (24) (25) (26) (27) (29) (55) (30) (56) (31) (33) (34) (53) (36) (37) (38) (39) (40) (41) (42) (43) (44) (45) (46) (47) (57) (59) (58) (48) (49) (50) (54) (51) (60)
Anomalous pattern recognition	8	AI identifies variations or atypical behaviors that could indicate problems or threats. This ability is valuable for detecting fraud, supply chain problems or security risks. By focusing on the unexpected, AI helps to uncover situations that might go unnoticed by humans, thus improving the safety and reliability of systems.	(19) (56) (33) (34) (35) (37) (54) (51)
Early warning system	4	AI-powered early warning systems strengthen the ability to react to potential risks by issuing warnings before problems fully develop. This enables organizations to implement proactive responses, reducing the likelihood of damage and increasing resilience to adverse events.	(23) (56) (53) (40)

convolutional neural networks (CNN) and their combinations with long short-term memory (LSTM), and other networks, such as recurrent neural networks (RNN), ecosystem status networks (ESN), and autoencoders, stand out as the most common bases in video surveillance systems. Although they do not represent recent emerging trends, their recurrent presence indicates that these base architectures remain fundamental to the development of suspicious activity detection models. This suggests that traditional architectures still provide a solid framework for improving the accuracy and efficiency of today's systems.

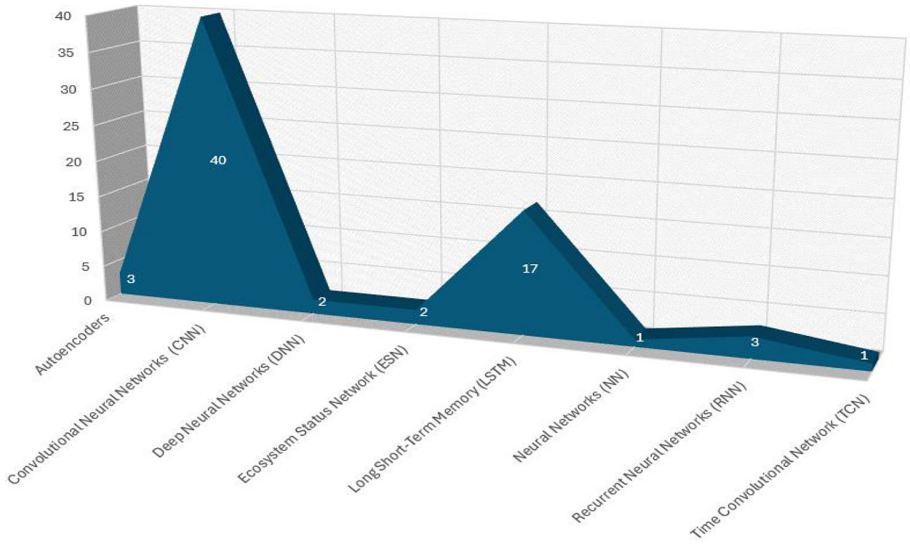

Figure 15. Base architectures used

Figure 16 shows the recent trends in neural network architectures used in systematized articles for real-time detection of suspicious activities in surveillance videos. The most mentioned architectures are 3D convolution network (3D CNN) with 13 articles and 2D convolution network (2D CNN) with 8, indicating a clear preference for the use of convolutions for image and temporal sequence analysis. YOLO also stands out with 6 articles, underlining its relevance in real-time detection. Other architectures, such as ConvLSTM and vision transformer, with 3 and 2 articles respectively, reflect emerging approaches that are gaining interest in this field, while the rest of the architectures are less represented, indicating a greater specialization in their application.

Table 6 systematizes recent trends in the development of architectures for real-time detection of suspicious activity in surveillance video, highlighting the most commonly used architectures and their frequency of appearance in current research, the most prominent being: 3D CNN, 2D CNN, and YOLO with 12, 8, and 6 investigations respectively.

RQ5 How have detection techniques in video surveillance systems integrated with Artificial Intelligence influenced the identification of suspicious activity and incident response?

Figure 17 shows the distribution of detection techniques used in video surveillance systems, according to the articles collected, where 45%

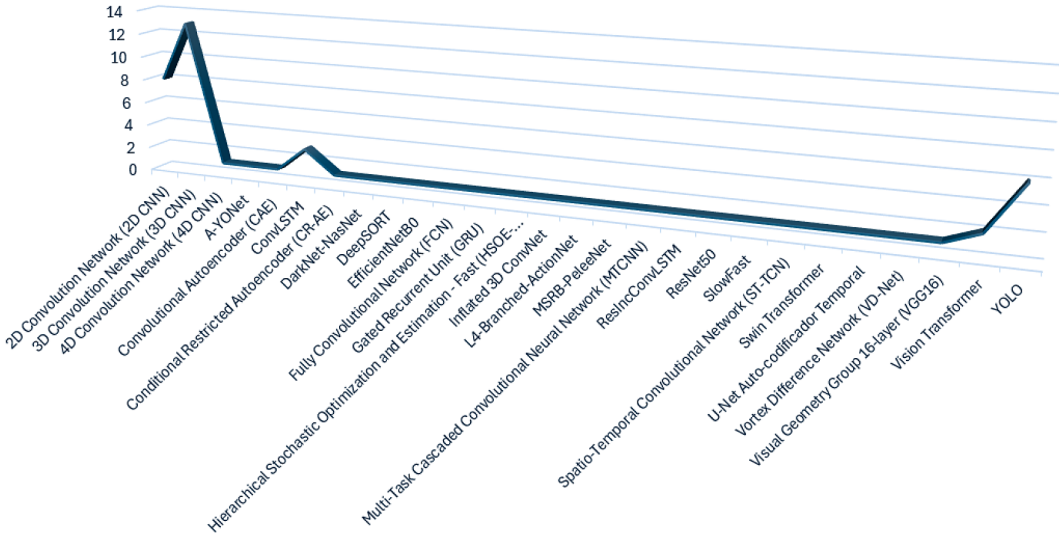

Figure 16. Trends in architecture development

Table 6. Systematization of articles based on trends in architecture development

Architecture	Quantity	Articles
2D CNN	8	(53) (36) (40) (41) (47) (57) (58) (51)
3D CNN	12	(52) (26) (28) (33) (38) (39) (46) (59) (57) (58) (48) (51)
ConvLSTM	3	(21) (37) (54)
Vision transformer	2	(48) (60)
YOLO	6	(20) (24) (55) (31) (34) (35)

focus on the detection of behaviors and actions, allowing the identification of suspicious activities such as unusual movements through pattern analysis and posture recognition; 36% is dedicated to anomaly detection, which identifies out-of-the-ordinary events based on machine learning models that learn the normal behavior of the environment; and 19% is oriented to object and threat detection, using computer vision algorithms to recognize dangerous or prohibited items, such as weapons or vehicles in restricted areas, which improves the ability to respond to possible incidents.

Figure 18 presents the number of articles reviewed about three detection techniques integrated with artificial intelligence in video surveillance systems: anomaly detection, behavior and action detection, and object and threat detection. Behavior and action detection stand out remarkably in terms of prevention and security, achieving the highest score. This suggests that this technique is effective in identifying potentially dangerous situations before they become critical incidents. On the other hand, anomaly detection shows a solid performance in accuracy and speed, allowing incidents to be resolved efficiently and reducing the number of false positives. This improves confidence in the automation of surveillance systems. In contrast, object and threat detection shows lower

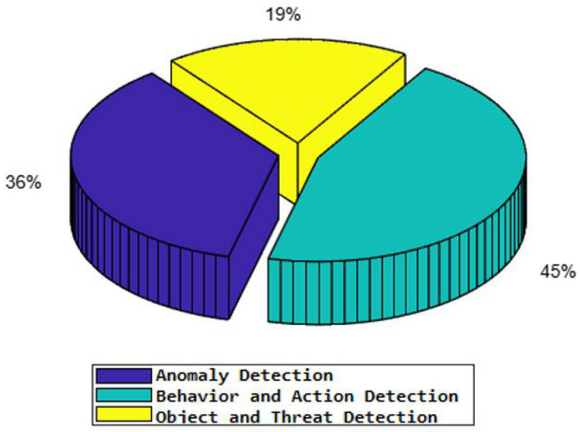

Figure 17. Distribution of detection techniques integrated with AI

results, especially in terms of efficiency and speed, indicating that, although it is essential for identifying dangerous elements, it may be less effective in detecting suspicious behavior in real-time.

Table 7 summarizes artificial intelligence video surveillance detection techniques and their improvements in security. It details improvements in areas such as identification of suspicious activity, incident prevention, and speed of response. In addition, the number of articles that support each technique is shown, allowing to identify which are the most studied ones.

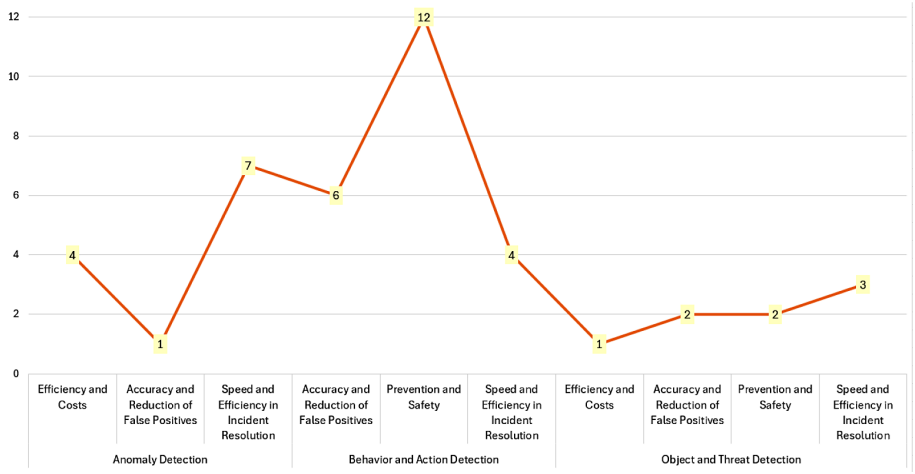

Figure 18. Articles reviewed the three detection techniques and their safety improvements

Table 7. Systematization based on detection techniques and their security improvements

Category		Quantity	Articles
Anomaly detection	Efficiency and costs	4	(24) (36) (58) (48)
	Accuracy and reduction of false positives	1	(28)
	Speed and efficiency in incident resolution	7	(26) (31) (35) (40) (42) (43) (57)
Behavior and action detection	Accuracy and reduction of false positives	6	(23) (59) (49) (50) (54) (60)
	Prevention and safety	12	(19) (22) (27) (56) (33) (34) (38) (39) (41) (44) (45) (46)
	Speed and efficiency in incident resolution	4	(21) (52) (37) (51)
Object and threat detection	Efficiency and costs	1	(32)
	Accuracy and reduction of false positives	2	(20) (29)
	Prevention and safety	2	(30) (47)
	Speed and efficiency in incident resolution	3	(25) (55) (53)

RELATED WORK

In a recent study (61), an exhaustive systematic review of the literature was carried out to analyze the use of artificial intelligence techniques in the identification and prediction of areas with high crime incidence. The study covered five scientific databases, such as Scopus and Web of Science, from a total of 3015 documents. After applying rigorous selection criteria, 132 studies were chosen, which were finally reduced to 18 that specifically addressed the application of neural networks to identify crime patterns in different regions of Latin America. The results indicated that these technologies not only enhance the capacity of security forces to anticipate and respond to criminal incidents but also optimize the allocation of resources, promoting greater public safety in urban areas.

On the other hand, in a different investigation (62), a systematic review was conducted focusing on the application of artificial intelligence for face recognition in video surveillance systems. This study examined papers retrieved from databases such as ProQuest, ScienceDirect, and Google Scholar, starting with 12,293 papers. After applying inclusion and exclusion filters, 13 relevant studies were selected. The results showed that the most common tools in face recognition were OpenCV and the Viola-Jones algorithm. The positive impact of these systems in improving public safety, facilitating the identification of suspects, and contributing to the creation of safer environments in communities was highlighted.

CONCLUSIONS

After performing a systematic review of 42 articles related to artificial intelligence in video surveillance systems, it is concluded that artificial intelligence contributes decisively to improving the identification of suspicious activities and optimizing incident response. The implementation of these technologies has proven to be particularly relevant in Asia, leading research and development in this field. This continent stands out for its advanced adoption of AI technologies in video surveillance, in contrast to other regions where development is still in earlier stages.

South Korea and India as leaders in the implementation of AI technologies, followed by China and Pakistan. These countries have positioned themselves at the forefront in the practical adoption and development of AI technologies applied to video surveillance, reflecting a significant commitment to innovation and security enhancement through AI.

Regarding technologies integrated with AI to improve the efficiency and accuracy of video surveillance systems, it is observed that the internet of things, computer vision, and edge computing are the most frequently mentioned technologies, highlighting their crucial role in collecting and processing large volumes of data in real-time. Furthermore, in all the articles reviewed, deep learning is identified as the main technology that makes artificial intelligence possible in this field. On the other hand, AI integration approaches with incident management systems, such as real-time detection, predictive analytics, and response automation,

have optimized the ability of these systems to reduce response times to critical events and increase accuracy in identifying dangerous situations.

Also noteworthy are recent trends in the development of architectures for real-time detection of suspicious activity, highlights the use of 2D and 3D convolutional neural networks together with algorithms such as YOLO, which have proven to be effective in identifying suspicious objects and behavior in real-time. This has resulted in significantly improved security in monitored environments, plus growing interest in more advanced architectures such as ConvLSTM and vision transformer suggests that the field continues to evolve. On the other hand, detection techniques such as behavior detection, anomaly detection, and object detection have significantly influenced the accuracy and reduction of false positives. The most notable improvement achieved with these techniques is the prevention of incidents and increased security, as they allow the identification of potentially dangerous situations before they occur, thus optimizing the overall performance of video surveillance systems and improving their real-time responsiveness.

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