A Bibliometric Analysis of CCTV Surveillance with AI, ML, and DL

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Abstract-

CCTV cameras have been widely used for surveillance and are considered strong evidence in criminal investigations. This paper examines how integrating artificial intelligence, machine learning, and deep learning with CCTV has shifted its role from intrusion detection to intrusion prevention. With technological advancement using AI, ML, and DL it is easier to recognize and detect faces, objects, and to track & do real-time analysis. In this paper, the authors have tried to use a bibliometric analysis to research closed-circuit television (CCTV) surveillance. The paper is based on PRISMA screening and caters for the data from 2015 to 2025. This paper uses the Dimension database to identify patterns, such as the most cited papers and countries actively researching in this domain. The UGC CARE List Type II has been considered for the same, and 266 papers were found through this process. Other software, including Microsoft Excel and VOS viewer, supported analyses such as analyzing the most cited papers, observing and mapping the trends, co-authorship networks, and viewing the maximum work done in this domain is from which country, etc.

Findings show a significant rise in AI-driven CCTV research since 2018, with South Korea and India at the forefront. This document highlights opportunities, research deficiencies, and likely areas of interest for smart surveillance systems.

The paper is organized into six sections: an overview of CCTV and its development, the objective and problem statement, followed by a literature review that focuses on security, intrusion detection, CCTV, and its integration with AI, ML, and DL. The data collection process is covered in a later section, Section 3, and the results and discussion are presented in Section 4, along with important insights and bibliometric analyses based on statistics, geographical demography, networks, and citations. The limitations of the study are described in Section 5, and some directions for further research are covered in Section 6.

Keywords:
Closed-circuit television (CCTV), PTZ (Pan-Tilt-Zoom), Artificial Intelligence (AI), Machine Learning (ML), Intrusion Detection System (IDS), Deep Learning (DL), Bibliometric Analysis, Total Publications (TP), Total Citations (TC), and Citations Per Paper (CPP)

1. Introduction:

English inventor and lawyer Wordsworth Donisthorpe created the first motion camera. In 1870, he received a patent for the moving picture camera which he named as Kinesigraph [11].

Initially the closed-circuit television, or CCTV, was working as a video camera system that sent a signal to a specific monitor or set of monitors for real-time monitoring. Since its introduction for military surveillance in the 1940s, closed-circuit television (CCTV) technology has grown to be a vital component of the world's security system. The first CCTV system to monitor V-2 rocket was developed in 1942 by German engineer Walter Bruch [16].

With the introduction of Video Cassette Recorders (VCRs) [7, 8] in the 1970s and 1980s, cameras eventually assisted in storing the evidence on magnetic tapes. The ability to view recorded footage

for future reference, as opposed to monitoring real-time or live cases, has revolutionized surveillance capabilities and aided in the resolution of many cases [11].

The next development was the switch from analog to digital cameras in the 1990s and 2000s. These cameras could be directly connected to the system and had improved video quality and a more manageable data storage method [19]. When the first IP camera, the Neteye 200, was introduced in 1996, footage could now be sent over computer networks instead of special coaxial connections [1, 11, 19, 21]. Followed by the development of PTZ (Pan-Tilt-Zoom) cameras, which allowed operators to remotely move the camera to follow the subject [10,11]. Later in the 2010s, the fixed-position cameras were replaced by 360-degree rotational cameras, zoom in/out and change direction [17, 18]. They solved earlier problems of fixed positioning and blind spots.

Many of today's CCTV systems also include Motion detection [19], Human presence sensing, and automatic tracking of moving objects (identifying human, animal, object, etc.) The bi-directional communication (both audio-video) [14, 15, 24, 25] from both sender/receivers has made it safer, more interactive. These days, the camera is integrated with Cloud, allowing data to be saved remotely and can be accessed from anywhere in the world, ensuring that evidence cannot be destroyed by damaging the local recorder.

The role of AI has enhanced the CCTV camera into predictive based model which is often used to analyze and predict real time data.

1.1. Where are CCTV cameras used?

CCTV cameras are installed near marketplaces, parking lots, hospitals, banks, malls, jewellery stores, etc., to keep a close vigilance on the passerby. The CCTV cameras are also installed inside the homes or even at the main gates of the home to monitor and keep a check on the guests (or intruders). Companies use the cameras to secure their commercial spaces, and employees in a control room to monitor the cameras at shopping malls or some jewelry exhibitions. To offer monitoring and to reduce the crime rate, CCTV cameras are commonly installed. CCTV cameras have proven useful for gathering evidence and identifying those who have violated privacy. In the past, CCTV cameras have assisted in the resolution of numerous cases [23].

The advancement in technology and the introduction of AI, ML, and DL have transformed CCTV systems from passive recording tools to intelligent systems capable of real-time decision-making. The audio-video has given more power to security and to stay connected with their family members, observe patients, or check on employees [13].

This paper gives a thorough bibliometric review of global research conducted between 2015 and 2025 on the integration of intelligent technologies into CCTV surveillance. Through the literature found in books, journals, conference papers, articles, and peer-reviewed works, bibliometric study aids in understanding the quantitative analysis of the advancement of the research project [20].

To monitor the advancements in this field, this paper used the Dimension AI tool along with statistical tools such as Microsoft Excel, Google Sheets, and Vos Viewer. In the context of security and intrusion detection through CCTV, this paper compares the applications of artificial intelligence (AI), machine

learning (ML), and deep learning (DL) in surveillance. The analysis emphasizes the citation metrics (total published, total cited, etc.), quantity of publications, and scholarly significance in each topic. Additionally, it highlights important research trends, cooperative networks, and new problem hotspots in the developing field of smart surveillance. The research demonstrates the growing importance of developing AI, ML, and DL for responsiveness, predictability, and flexibility in both industry and academia.

1.2. Conceptual Framework

The conventional CCTV, which was initially designed for passive observation, was replaced by Smart CCTV systems with cloud storage (which means data tampering will be little difficult), network connectivity and digital improvements like 360-degree rotation, following the subject, audio-video interaction, and many more features. When Smart CCTV is integrated with Artificial Intelligence, Machine Learning, and Deep Learning, these systems become advanced predictive surveillance tools with real-time detection, anomaly analysis, and autonomous decision-making capabilities. The conceptual framework depicted in Figure 1 below, which highlights how new capabilities and moral challenges are introduced with each level of technological complexity, exemplifies this pattern.

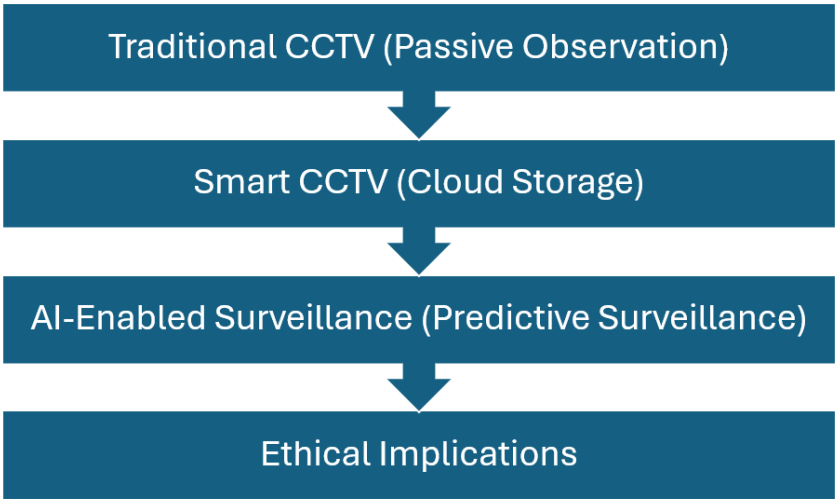

Figure 1: Conceptual Framework

1.3. Problem Statement:

The purpose of the study was to determine the development of academic communication on the topic of "CCTV" published in the last ten years, as well as the publication sources, prominent authors, significant journals, most productive affiliations and nations, and production by year. The study uses bibliometric analysis to conduct such an analysis and uncover important cybersecurity insights.

1.4. Aims and Objectives:

The objectives of the research are as follows:

- To see which authors have contributed the most in terms of citations and papers published.
- To determine which countries, make the biggest contributions to the CCTV domain.

- To compile a list of organisations involved in the study and growth of CCTV-related material.
- To investigate the open-access literature on CCTV, smart CCTV, and the function of CCTV in surveillance.
- To study the relevance and impact of AI in the field of surveillance.

2. Literature Review

CCTV cameras have changed a lot from the original kind, which initially could only be captured at a particular time and based on real time monitoring could inform the police about the crime, which can be considered as eyewitness. CCTV system was used extensively for banks, business establishments and traffic surveillance, where live views were shown on multiple screens, and mostly required human supervision. The surveillants were monitoring the feed. However, this system was not foolproof. A distraction for a moment and you could miss a criminal activity. They had to monitor the screens continuously in real-time. This was a difficult task to execute and very tiring. With advancements in VCR technology the recordings help in resolving the cases, backing the case with relevant evidence to prove innocent in the court.

The smart CCTV systems work quite differently from the older ones. Using cutting-edge technologies such as Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL), these systems can now also influence our behavior. By incorporating sophisticated algorithms, they can now adapt and self-learn, analyze patterns, and raise real-time alerts whenever it identifies an unknown person, suspicious behavior, or unattended objects [1,3,6], facial recognition, and motion tracking [2,5, 12, 14, 25] they can raise an alarm or send a signal. This new development has turned standard monitoring into proactive, automated threat detection, significantly improving situational awareness and response abilities.

The field of **smart surveillance** has seen a remarkable transformation with the integration of **Artificial Intelligence (AI)**, **Machine Learning (ML)**, and **Deep Learning (DL)**. Earlier surveillance systems relied heavily on manual monitoring and analog recording systems, making real-time threat detection impractical [5, 8, 14]. As technology evolved, IP- based digital systems with basic motion sensors emerged, but these were still limited in intelligence.

Recent developments have enabled automated facial recognition, abnormal behavior detection, and intrusion alerts powered by deep learning models [14]. These capabilities have greatly enhanced public safety, especially in urban and high-risk environments. According to George [9, 24], DL-based surveillance systems demonstrate increased accuracy and reduced false positives compared to traditional detection methods [5].

Furthermore, the integration of cloud computing and IoT allows for scalable surveillance architecture, remote monitoring, and real-time data sharing. The bibliometric growth identified in this study confirms the trend: publications and citations related to AI-integrated CCTV research have shown a substantial increase from 2018 onward.

Early CCTV systems were dependent on human operators, resulting in limited accuracy and delayed threat detection. The transition to digital and IP-based systems introduced automated motion detection but lacked intelligence. Recent advancements in AI and DL have enabled automated facial recognition, anomaly detection, behavior analysis, and intrusion alerts with significantly improved reliability. Cloud computing, IoT, and edge-based architecture have further enhanced scalability, real-time processing, and remote monitoring. However, literature also highlights pressing ethical concerns- including data privacy, algorithmic bias, and surveillance overreach- indicating a need for balanced frameworks that ensure both security and civil liberties.

3. Data Collection and Methodology

RQ1: What is the publication trend in CCTV + AI research from 2015–2025?

RQ2: Which countries, authors, and institutions contribute the most?

RQ3: What are the dominant themes, clusters, and keyword trends?

To identify and study the above-mentioned questions. This research utilizes a Systematic Literature Review (SLR) and bibliometric analysis, following the PRISMA 2020 guidelines (Page et al., 2021). The research framework adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, a standardized reporting protocol designed to enhance transparency and reproducibility in evidence synthesis [22].

Bibliometrics is a quantitative method to analyze scholarly communication (Pritchard, 1969). It uses indicators such as Total Publications (TP), Total Citations (TC), Citation Per Paper (CPP), and Total Link Strength (TLS) to evaluate research productivity and influence.

Publications were filtered across four phases: identification, screening, eligibility, and inclusion. The primary database used was Dimensions, and results were limited to journals indexed under UGC CARE List-II from 2015 to 2025. Microsoft Excel and VOS viewer were used for data analysis and visualization.

Data for this study were collected from the Dimensions database (https://app.dimensions.ai/), with filters applied to include only journals indexed in the UGC CARE List-II. The search period covered January 2015 to March 2025. Two Boolean search queries were developed:

- **Query 1:** (“CCTV” OR “video surveillance”) AND (“security” OR “intrusion detection”)
- **Query 2:** (“CCTV” OR “video surveillance”) AND (“security” OR “intrusion detection”) AND (“artificial intelligence” OR “machine learning” OR “deep learning”)

The results were merged, deduplicated, and screened for relevance, excluding records unrelated to surveillance or security contexts.

3.1. PRISMA- The selection process followed PRISMA guidelines. Records identified in Dimensions were systematically screened by title, abstract, and full text, with exclusion reasons documented. The PRISMA flow diagram summarises the data filtering pipeline (Figure 2).

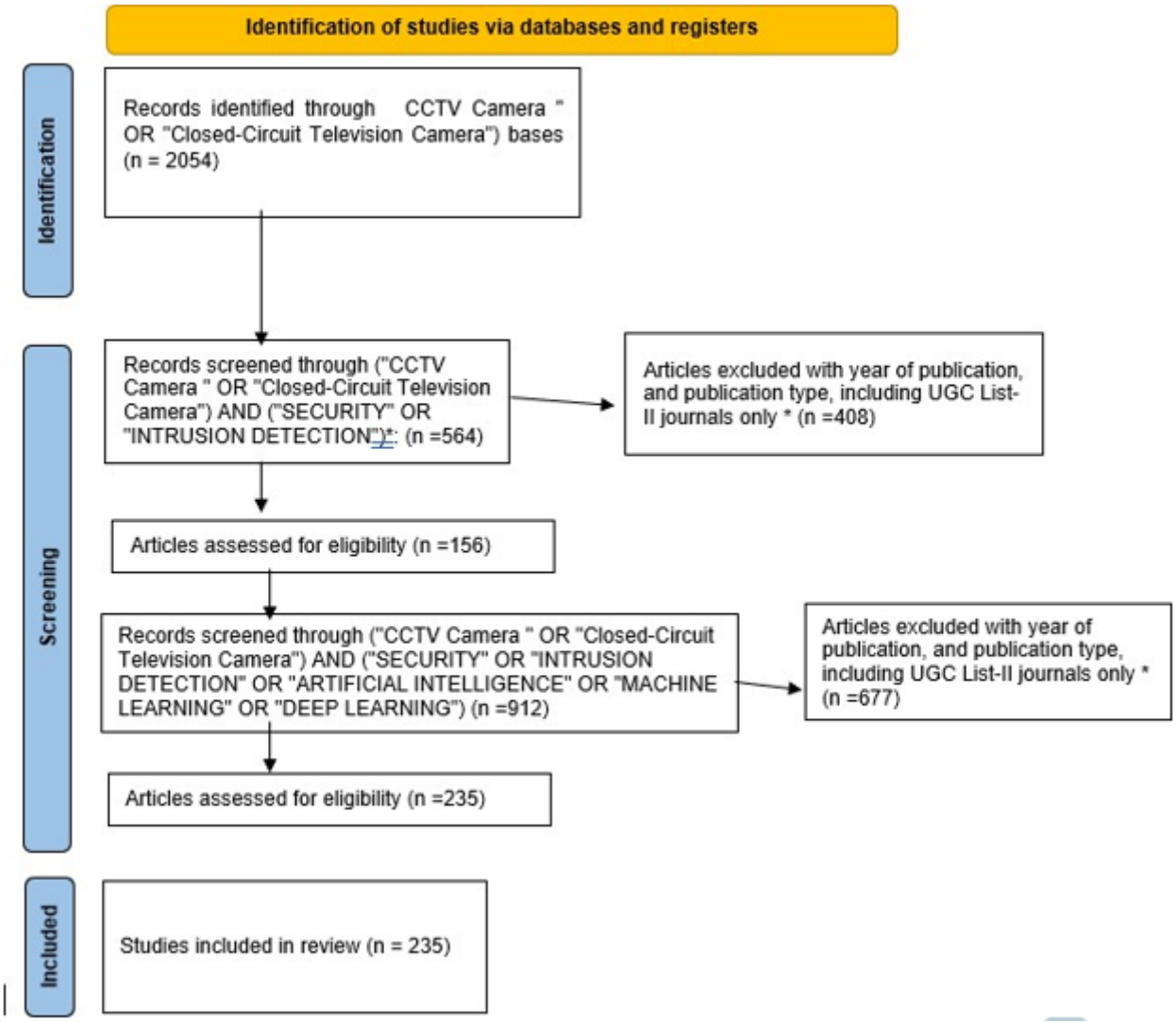

Figure 2: PRISMA flow diagram showing identification, screening, and inclusion of studies in bibliometric analysis.

Initial Search Result

("CCTV Camera " OR "Closed-Circuit Television Camera")	2054
With publication type (CHAPTERS- 298, Edited books-1, ARTICLES-1028)	1327
UGC List	680
2015-2025	503
("CCTV Camera " OR "Closed-Circuit Television Camera") AND ("SECURITY" OR "INTRUSION DETECTION")	564
2015-2025	358

With publication type= 266 (CHAPTERS- 90, EDITED BOOKS-1, ARTICLES-175)	358
UGC List	156

("CCTV Camera " OR "Closed-Circuit Television Camera") AND ("SECURITY" OR "INTRUSION DETECTION" OR "ARTIFICIAL INTELLIGENCE" OR "MACHINE LEARNING" OR "DEEP LEARNING")	912
With publication type= 266 (CHAPTERS- 90, EDITED BOOKS-1, ARTICLES-175)	266
UGC List	266
2015-2025	235

Table 1: Keyword Search

3.2. Different Keyword Search

("CCTV Camera " OR "Closed-Circuit Television Camera") AND ("SECURITY" OR "INTRUSION DETECTION" OR "ARTIFICIAL INTELLIGENCE" OR "MACHINE LEARNING" OR "DEEP LEARNING")		
Year	TP	TC
2025	17	4
2024	37	45
2023	35	241
2022	44	502
2021	31	604
2020	31	465
2019	10	558
2018	14	239
2017	6	47
2016	8	56
2015	2	17
	235	2778

("CCTV Camera " OR "Closed-Circuit Television Camera") AND ("SECURITY" OR "INTRUSION DETECTION")		
Year	TP	TC
2025	7	0
2024	14	13
2023	16	139
2022	22	258
2021	16	390
2020	17	251
2019	7	411
2018	10	42
2017	6	47
2016	8	56
2015	2	17
	125	1624

Table 2: Two Different Keyword Searches

As per the analysis given in Table 2, the following table shows the difference between the two keywords' results:

Difference in publications with AI, ML, DL added				
Year	TP	TC	How many papers have been added every year because of AI,ML or DL?	How it has impacted the citation?
2025	10	4	58.82	100.00
2024	23	32	62.16	71.11
2023	19	102	54.29	42.32
2022	22	244	50.00	48.61
2021	15	214	48.39	35.43
2020	14	214	45.16	46.02
2019	3	147	30.00	26.34
2018	4	197	28.57	82.43
2017	0	0	0.00	0.00
2016	0	0	0.00	0.00
2015	0	0	0.00	0.00
	110	1154	46.81	41.54

Table 3: Difference in Total Publications and Total Citations

Integration of Artificial Intelligence, Machine Learning, and Deep Learning into CCTV surveillance research has significantly enhanced both the volume and academic impact of publications. This reflects a major shift in global research priorities towards intelligent and predictive surveillance systems.

It is evident, as per Table 3, that **110 additional papers** were published due to the inclusion of **AI/ML/DL**. Also, the **number of citations** has increased by **41.54%,** i.e., **1154** increased **citations**. From **2018**, onwards, there's a clear **upward trend** in both ***publication count*** and ***citations*** for AI-integrated CCTV research.

4. Results and Discussion

4.1. Analysis by year

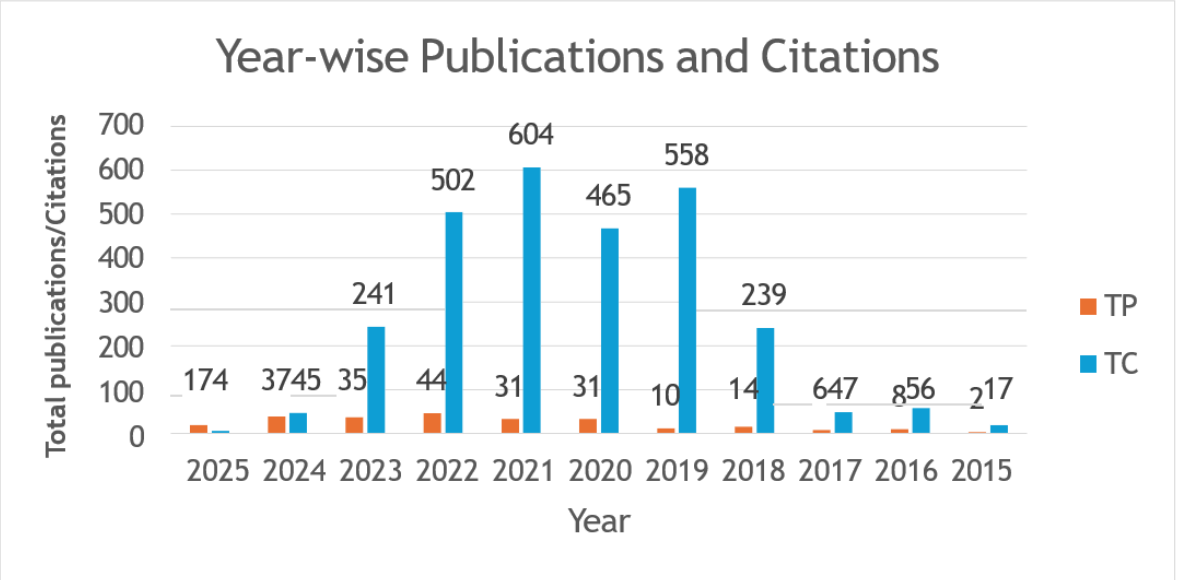

Figure 3: Annual trends of CCTV surveillance publications and citations (2015–2025).

Bibliometric analysis provides insights into the contributions of various countries, institutes, authors, and journals in the research field. In this analysis, data was collected from the Dimensions database using the keywords.

This analysis aims to help determine where the studies have been conducted and the future direction. This analysis will help analyse the development and growth in this domain. The Year-wise trends show a marked rise in AI-enabled CCTV research from 2018 onward, aligning with global adoption of intelligent surveillance systems. Citations also peaked between 2020 and 2023.

4.2. Analysis of Geographic Location

For the **geographic location analysis**, the VOS viewer tool was employed to generate citation**- based country** mapping. The analysis utilised bibliographic data extracted from the ***Dimensions*** database, which served as input for ***VOSviewer*** to **visualise** the **spatial distribution** of research activity. This mapping provides insights into the countries where research on CCTV, Security, AI, ML, and DL is most frequently cited, thereby indicating regions with the highest research output and influence.

In this analysis, a threshold was set within the **VOS viewer**, requiring a minimum of **5 documents** from each **country** and at least **10 citations** per **country**. Out of a total of **56 countries**, only **9 met** the threshold criteria, highlighting the ***global leaders*** in this research domain.

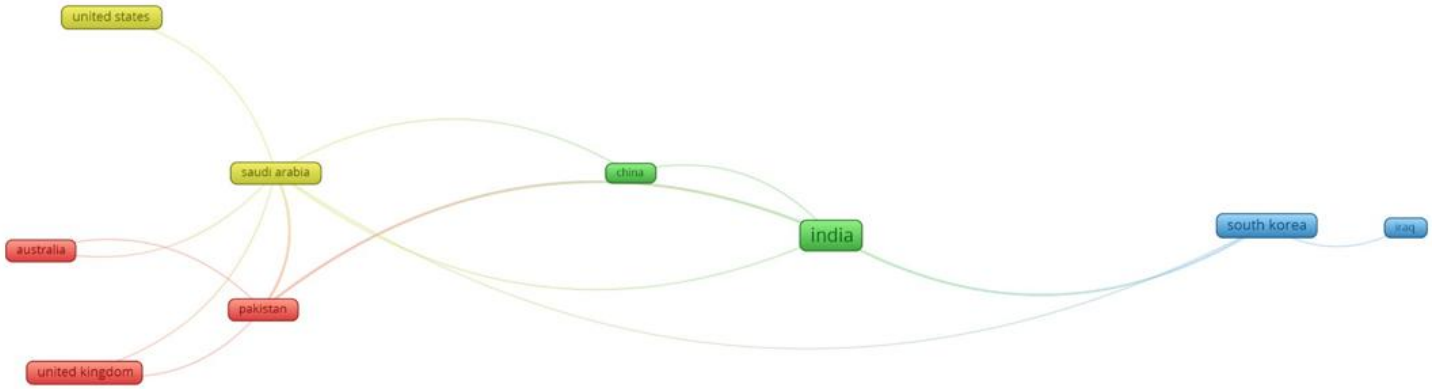

Figure 4: Global co-authorship network of countries contributing to CCTV surveillance research. Node size represents publication volume; link strength represents collaboration frequency.

Notably, **India** emerged as the most active contributor, with **93 publications** and **895 citations**. This was followed by **South Korea** with **29 publications and 514 citations**, among other prominent nations. These findings suggest that ***India*** and ***South Korea*** are at the forefront of scholarly contributions in the field of **intelligent CCTV surveillance systems**. Pakistan (8 documents, 285 citations) and Saudi Arabia (9 documents, 131 citations) have the highest Total Link Strength (TLS) of 10. The top 5 countries where the most work is cited are Pakistan, Saudi Arabia, India, South Korea, and Australia.

4.3. Network Analysis

The following Figure 5 represents a cluster of the number of occurrences of co-authors appearing among the papers. The relationship of the work is shown between the authors. The link represents

the authors' work on the documents they have published. Here, ***the minimum number of documents*** was set to 2, and a **minimum number of citations** for an author is set as **10**; out of 852 authors, **14 authors** meet the threshold value.

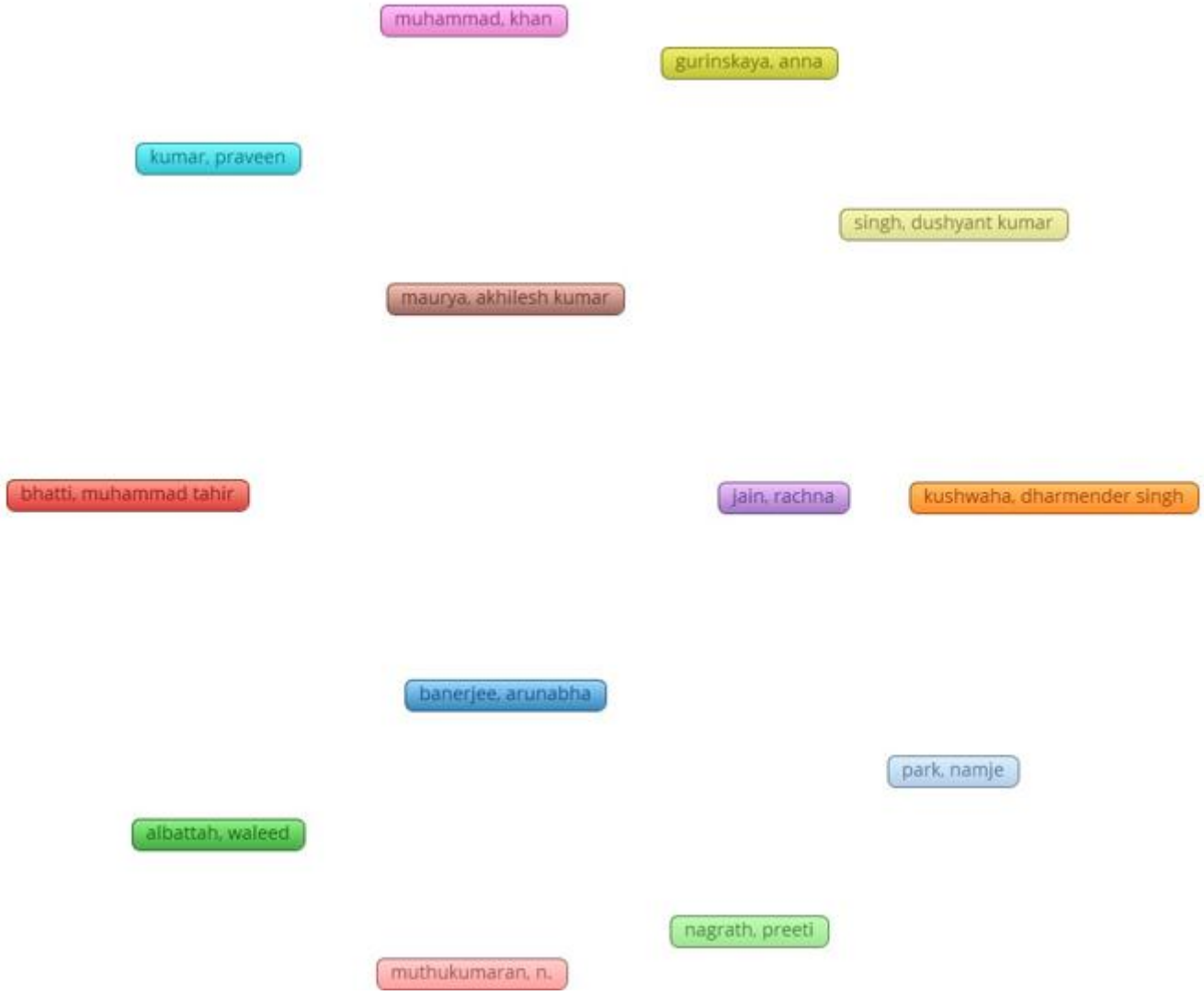

Figure 5: Co-occurrence map illustrating thematic evolution in surveillance research.

4.4. Co-author based on organization and country

The following figure depicts the co-authorship of various organizations, for which the ***minimum number of documents*** of an organization is given as **3**, and the ***minimum number of citations*** of the organization is given as **10**. Out of **343** organizations, only **9 organizations** meet the threshold: **Amity**, **Anna University, and VIT**.

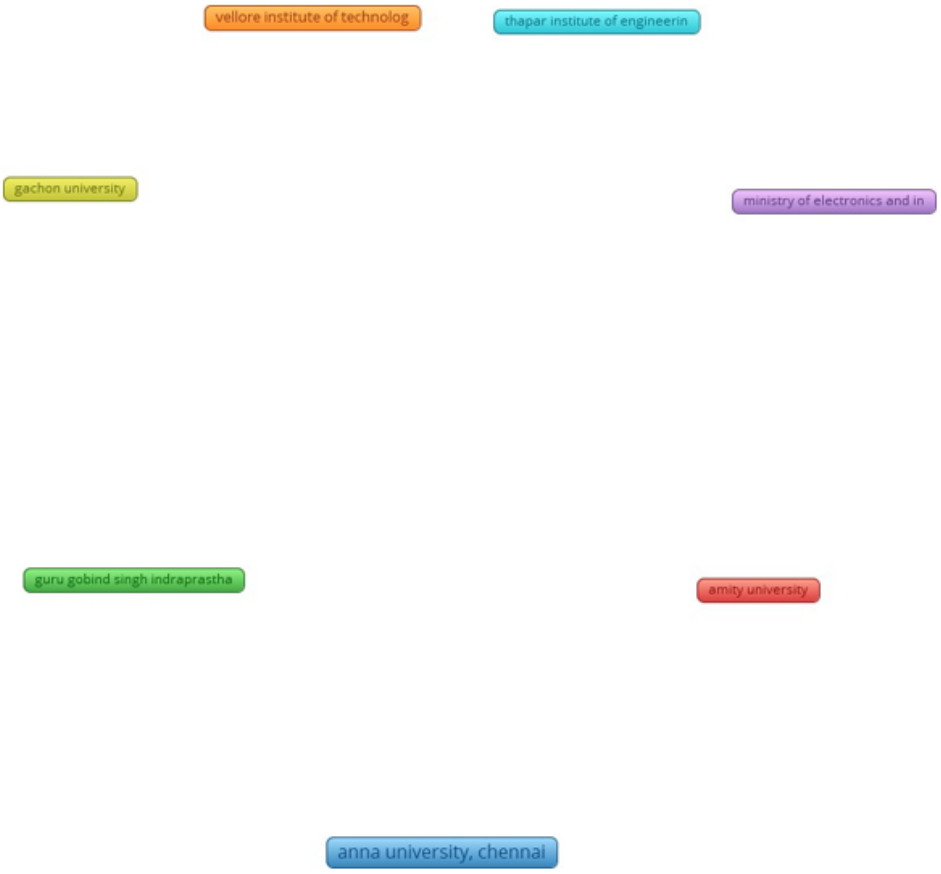

Figure 6: Leading journals and conference proceedings in CCTV and AI-driven surveillance research.

The following figure depicts the **co-authorship** of various **countries**, for which the minimum number of documents of a **country** is given as 3, and the **minimum number** of **citations** of the **country** is given as **10**. Out of **56** countries, only **17 countries** meet the **threshold**: India, Suadi arabia, South Korea, United States, Pakistan, China, Iraq, UK, Australia, etc.

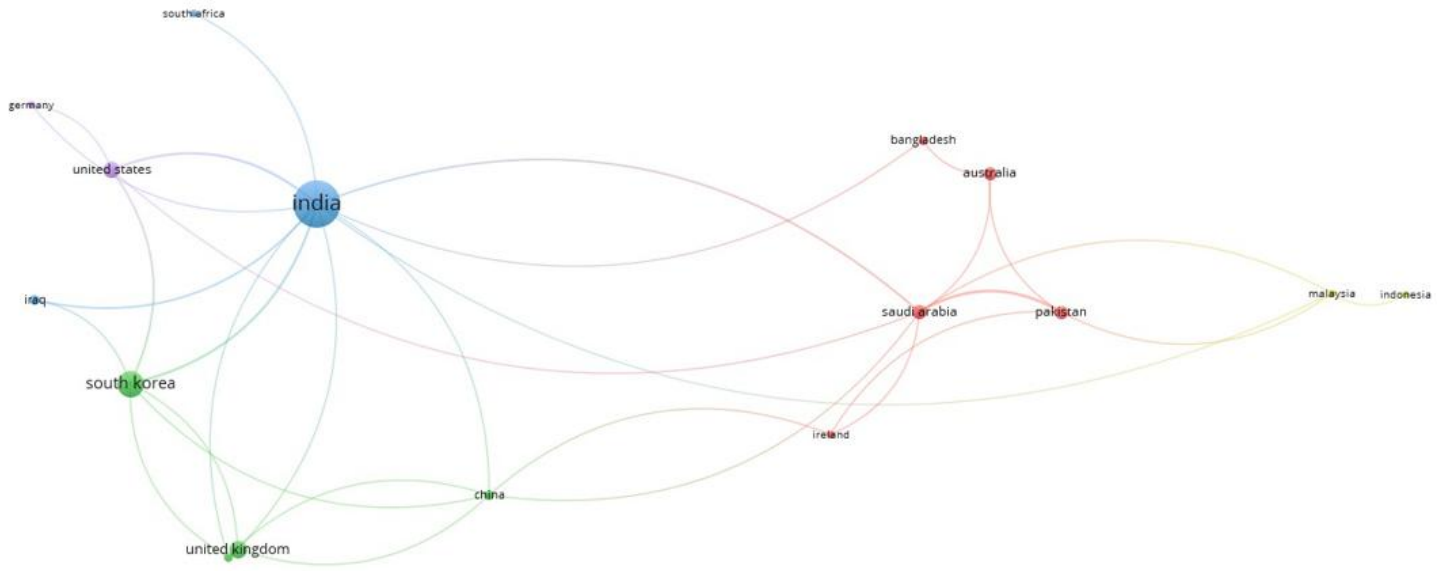

Figure 7: Co-authorship & Countries

4.5. Most Cited Authors

Table 4 depicts the most cited authors. Here, the minimum number of documents was set to 1, and a minimum number of citations of an author is set as 10; out of 852 authors, 278 authors meet the threshold value.

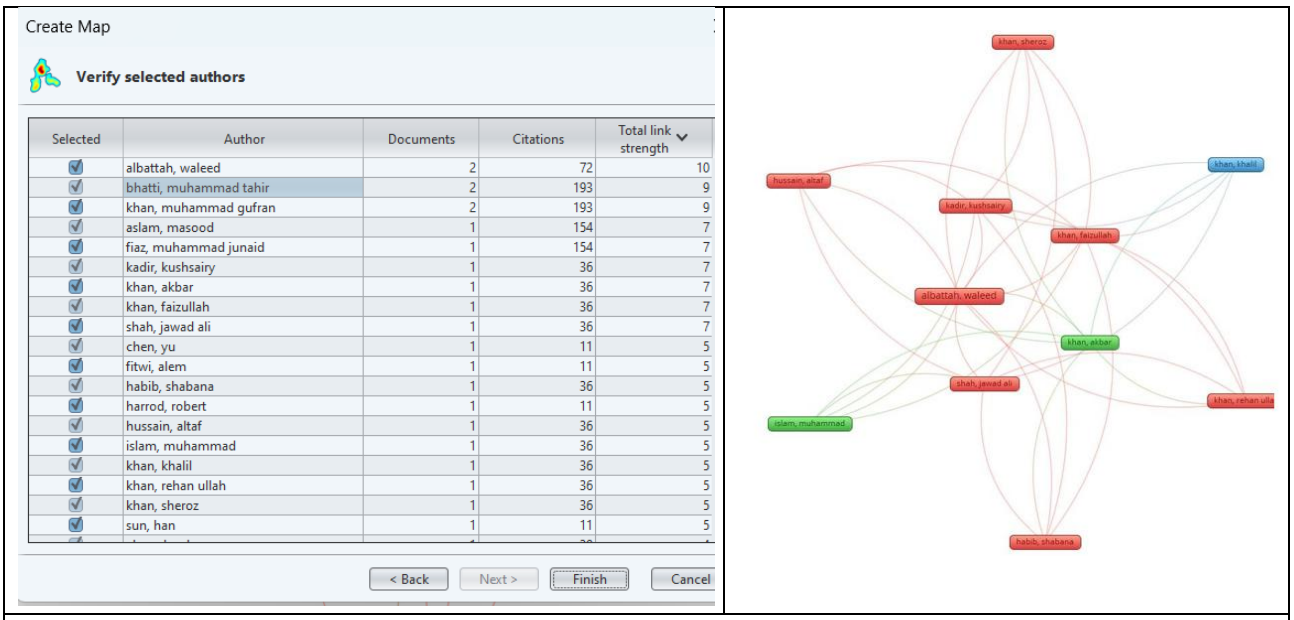

Table 4: Most cited authors

4.6. Bibliographic coupling & Authors

The following figure depicts the bibliographic coupling of authors, for which the minimum number of documents of an author is given as 2, and the minimum number of citations of the author is given as 10. Out of 852 authors, only 15 meet the threshold. There are 3 clusters, cluster 1 has 5 items, cluster 2 and cluster 3 have 2 authors each.

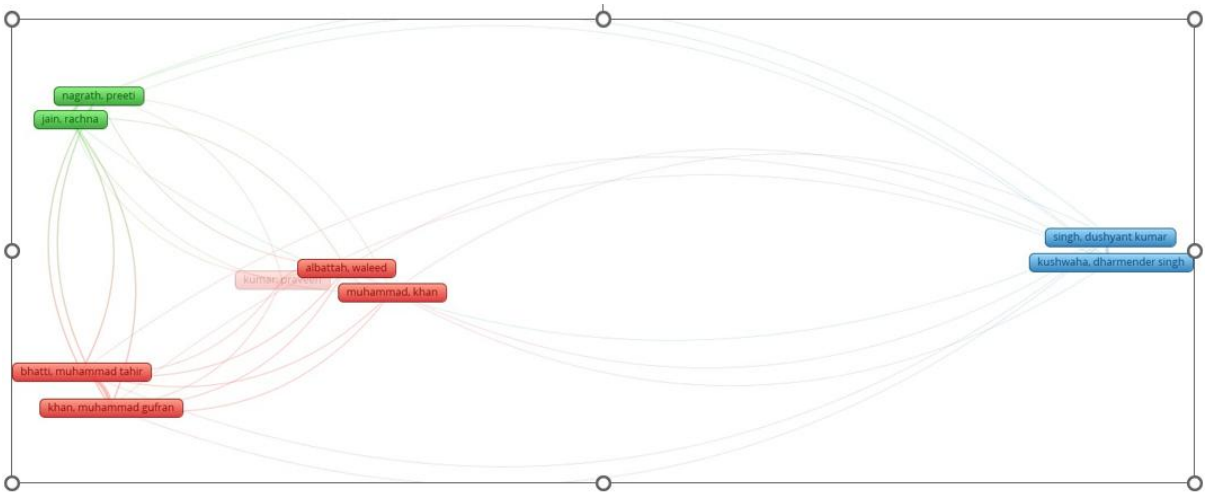

Figure 8: Bibliographic coupling & Authors

4.7. Bibliographic coupling and Countries

The following figure depicts the bibliographic coupling of countries, for which a dataset of a minimum documents of a country is given, 4, and the minimum number of citations of a country is given as 5. Out of 56 countries, only 11 meet the threshold.

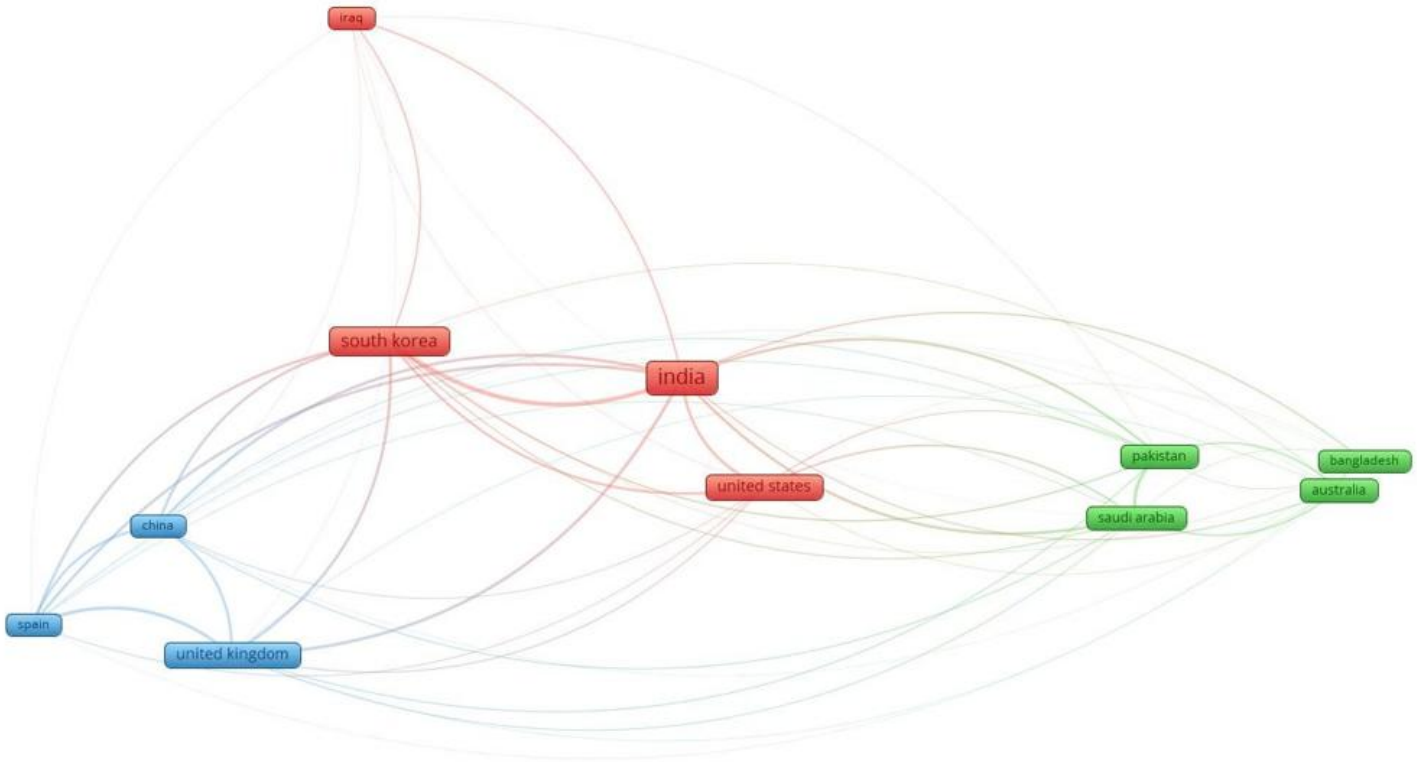

Figure 9: Bibliographic coupling & Countries

India with the highest documents (93), the highest citation (895), and the highest TLS (1808), followed by South Korea

4.8. Top publications

The following figure shows the statistical analysis of the top ten source titles based on the Citation for Anomaly detection. From the chart, it is observed that the Lecture notes in networks and systems Journal has received the maximum TLS, followed by Applied Science. Smart innovation, systems, and technologies journals receive the minimum number of citations, and IEEE Access receives the highest citations.

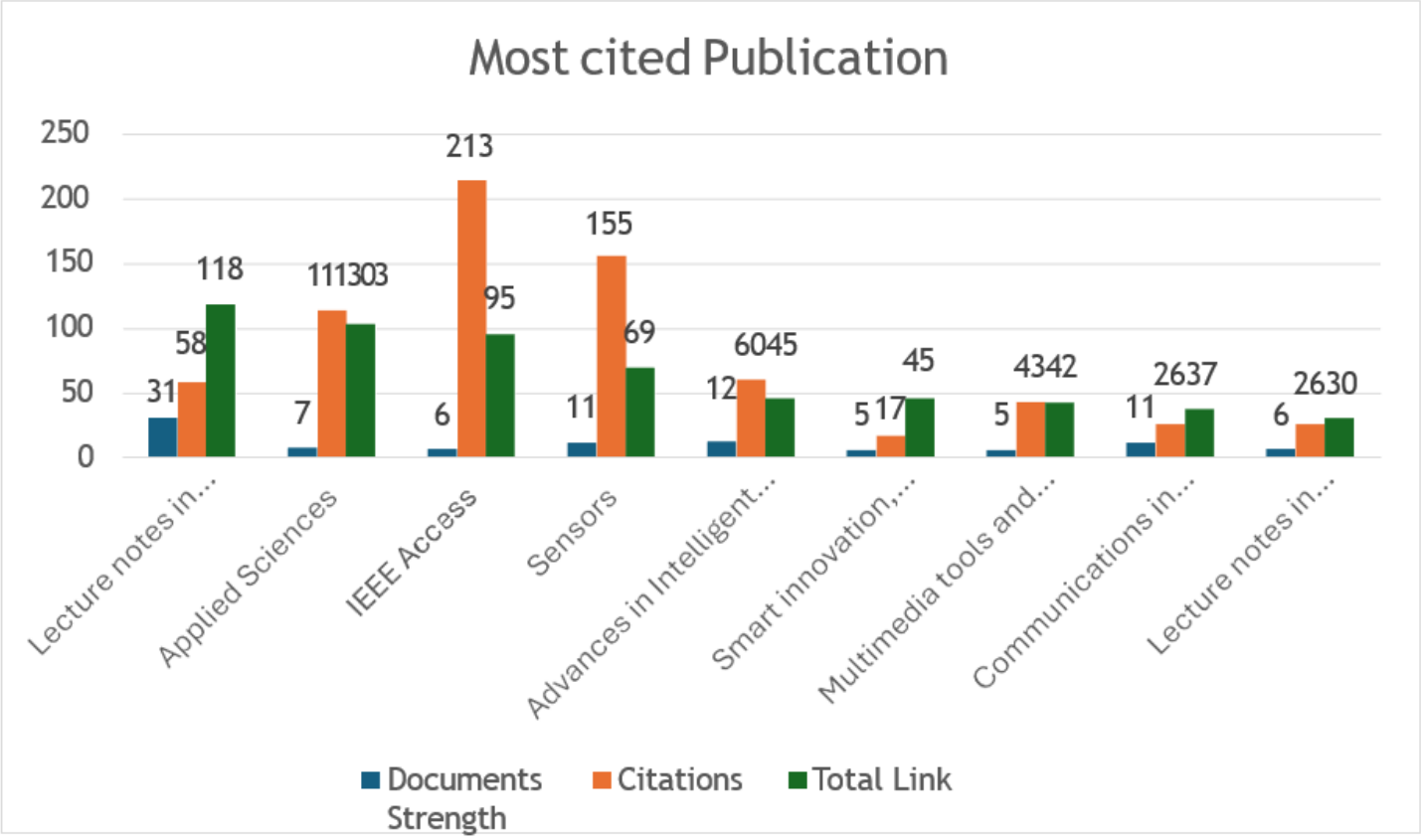

Figure 10: Most cited Publications

5. Limitations of the study:

As the focus of the study was on CCTV, literature taken was from Dimensions AI database using UGC Care List-II which restricts the authors to analyse other relevant papers from other sources for bibliometric analysis. The authors acknowledge the limitation in generalization and interpretation of findings. The limitations of this study include the following.

- Privacy is vulnerable with extensive use of CCTV especially at homes, offices, hospitals, hotels, etc. and is a matter of concern to the public. If the CCTV footage can be hacked or leaked may raise a major concern.
- Data Source Restriction: Only the Dimensions database and UGC CARE List-II indexed journals were used, potentially omitting relevant studies from like Web of Science or Scopus.
- The papers published in English has been only covered and focus on other languages have been excluded.
- Time Frame: The scope is limited to 2015–2025; more longitudinal studies could reveal broader trends.
- Keyword Dependency: Bibliometric output is heavily influenced by the keyword strategy; alternate terms may yield different results.
- Visualization Constraints: VOS viewer's graphical outputs may not fully capture the dynamic complexity of co-authorship and institutional collaboration.

- Bibliometrics provides quantitative data, but such data do not necessarily reflect quality or significance of research endeavors.

6. Findings:

As per the observations it is depicted that there is a strong global shift from conventional CCTV systems to AI-powered smart surveillance. Intelligent models for anomaly detection, facial recognition, and behavioral analysis which has significantly influenced research productivity and impact. However, there is a critical need for more study because ethical concerns including permission, surveillance transparency, and regulatory oversight are underrepresented in the work that is currently being published.

7. Future Scope:

The evolution of CCTV from intrusion detection to intrusion prevention will immensely help society. The advancement in CCTV systems with integration of technologies like AI, ML, DL will help take proactive decisions and help identify and respond to critical situations in real time. For instance, in case of a fatal road accident or somebody walking and they have a brain stroke, heart attack, sugar drop, or any other medical reason due to which the person fainted on the road should automatically be notified to the nearest hospital and police station. Similarly, fire outbreaks in homes, shops, or public spaces should trigger instant alerts to fire brigades and nearby authorities.

Intelligent surveillance can also enhance public safety by detecting crimes such as abduction, theft, or harassment, including sensitive scenarios like assaults in confined spaces (e.g., elevators), and immediately alerting law enforcement and security personnel.

Thus, the future of CCTV lies in creating proactive, responsive, and ethically governed surveillance ecosystems that not only prevent crime but also act as critical infrastructure for emergency response and public safety. The future scope of CCTV surveillance lies in developing intelligent, privacy-aware systems that balance public safety with individual rights. Future research must concentrate on privacy-preserving strategies including anonymization, edge processing, and regulated data access frameworks, even though the increasing usage of AI-enabled CCTV may prompt serious concerns about data privacy, surveillance overreach, and misuse of personal information.

The future of intelligent surveillance lies:

- The Predictive Surveillance Systems: use archival data to predict or forecast crimes or intrusions.
- Real-time Integration with Law Enforcement: Threats are immediately reported to authorities through secure channels.
- Privacy-Preserving AI Models: Developing surveillance that strikes a balance between security and moral issues including data misuse and privacy
- Edge AI Deployment: Processing data on the device itself rather than relying entirely on cloud systems for faster decisions.

- Multi-modal Surveillance: Integrating video, audio, and motion sensors for richer context analysis and situational awareness.

8. Conclusion:

Using tools like PRISMA and VOS viewer to map the academic world, the study finds regional hotspots, citation networks, and collaboration tendencies. The results can serve as a foundation for researchers, security experts, and engineers who want to enhance surveillance systems with intelligent, real-time decision-making abilities.

This comprehensive bibliometric analysis demonstrates how rapidly CCTV surveillance research has progressed, with the developments in AI, ML, and DL. **India** and **South Korea** emerge as **global leaders**. The study identifies key **themes**, **noteworthy authors**, and **collaborative frameworks** while highlighting the urgent need for ethical and regulatory scholarship. The findings set the stage for future advancements in intelligent and accountable surveillance technologies.

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