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A Bibliometric Mapping of Airport Security: Research Trends, Thematic Structure, and Practical Implications

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Abstract

This study presents a bibliometric mapping of the academic literature on airport security, aiming to chart the intellectual structure, thematic evolution, and collaboration patterns of the field and to translate these patterns into implications for security practitioners and policymakers. A total of 1,207 documents indexed in the Scopus database between 2010 and March 2025 were retrieved and analyzed using bibliometric mapping techniques implemented in VOSviewer. Co-authorship, keyword co-occurrence, publication-trend, and subject-area analyses were conducted to identify the most influential authors, the dominant research themes, and the disciplinary distribution of the field. The co-authorship network revealed ten major clusters comprising 44 authors and 102 connections, with Adrian Schwaninger emerging as the most central author, reflecting a distinct human-factors research tradition alongside a fast-growing computer-vision tradition. The keyword co-occurrence analysis identified 49 keywords occurring at least six times among 3,062 unique keywords, with “airport security,” “security,” “deep learning,” and “aviation security” as the most frequent terms. Publication output rose markedly after 2019, driven mainly by research on deep learning, X-ray imaging, object detection, and threat-recognition systems. Engineering and computer science were the leading subject areas. Beyond mapping the field, the study translates these findings into concrete implications for airport security operators and regulators, and identifies underexplored themes—including passenger experience, policy design, and the integration of human-factors and automated-detection research—that merit further investigation.

1. Introduction

Security constitutes a cornerstone not only of societal well-being but also of the infrastructure that underpins transportation systems, playing a decisive role in mitigating terrorism, smuggling, and other threats through the support of advanced technologies. Ensuring passenger safety and preventing potential threats within modern airport security screening processes is a domain that directly and indirectly influences a country’s international prestige, policy orientation, and economic performance.

Airports constitute critical nodes of the global transportation network, hosting civil aviation activities of major importance to national security. The expansion of terminal infrastructure, the growth of commercial areas and flight frequencies, and the emergence of crises such as regional conflicts have generated a continuous need for new regulations, policies, and technological solutions in airport security. Following the September 11, 2001 attacks in particular, airport security acquired heightened international significance, prompting the introduction of numerous new security measures (Price and Forrest 2016) and a shift toward risk-based, intelligence-driven screening strategies such as the United States’ Transportation Security Administration (TSA) PreCheck program (Albert et al. 2021). In recent years, academic interest in airport security has grown substantially. Alongside this growth, the continuously evolving regulatory framework of the expanding air transport sector, together with the widespread adoption of advanced technological devices, makes it increasingly challenging to produce genuinely original contributions to the literature. Various methodological approaches are therefore

employed to diversify contributions, track emerging trends, and revisit existing studies from new perspectives. Bibliometric analysis is one such method.

Bibliometric analyses constitute a powerful set of quantitative techniques for identifying publication trends within a specific research domain, determining the most influential studies and authors, examining research collaboration patterns, and detecting existing gaps in the literature (Van Eck and Waltman 2010). This methodological approach has been increasingly applied within transportation security research more broadly, including a recent bibliometric mapping of risks in maritime transportation (Yazar Okur and Gökbulut 2026) as well as studies on airport service quality (Bakır et al. 2022), the Internet of Things in aviation (Burak and Küsbeci 2024), and airport competitiveness (Şahin 2024). These studies collectively underscore the value of bibliometric mapping for consolidating fragmented and rapidly growing bodies of transportation-security knowledge into forms that are usable by researchers and practitioners alike. In the present study, a bibliometric approach is applied to systematically analyze the academic literature on airport security, based on articles indexed in the Scopus database, with explicit attention to what the resulting map implies for security practice and policy.

2. Purpose and Method

This study employs literature review and bibliometric analysis methods to reveal the current state of academic knowledge on airport security. Within this scope, 1,207 academic documents related to airport security, published in the Scopus database over the 2010–2025 period, were first retrieved. The structure, trends, and development of this literature were then analyzed through bibliometric mapping techniques performed in VOSviewer (Van Eck and Waltman 2010), with the aim of providing a holistic perspective on the field and constructing a systematic synthesis of existing knowledge. The resulting analysis is intended to identify topics that remain underexplored in the literature and to propose directions for future research and practice.

Bibliometric analysis is a quantitative method that maps the evolution of scientific fields by examining publication volume, citation counts, keyword usage, and the development of research topics over time. It reveals the academic accumulation and developmental trajectory of a specific field by systematically processing large, unstructured bibliographic data sets (Donthu et al. 2021).

2.1 Data Source and Search Strategy

Bibliographic records were retrieved from the Scopus database using the search query TITLE-ABS-KEY(“airport security”) AND PUBYEAR > 2009 AND PUBYEAR < 2026 AND LANGUAGE(english), covering the period between 2010 and the end of March 2025. Following the search, the retrieved records were exported in a format compatible with VOSviewer (version 1.6.x) for network construction and visualization (Van Eck and Waltman 2010). No further eligibility screening beyond the database query is

reported in the original data set; readers should note this as a methodological limitation, discussed further in Section 6.

2.2 Co-Authorship Analysis of Authors

According to the co-authorship analysis, a network map was created by setting a criterion of at least one publication and at least one citation per author, in order to identify the most connected and collaborating authors. The analysis, conducted among the most highly connected names, yielded ten clusters comprising 44 authors and 102 connections:

- The Red (First) cluster includes seven authors: Adrian Schwaninger (29 connections), Michel Stefan (9), Mendes Marcia (6), Koomen Ger and De Ruiter Jaap (4 each), Hättenschwiler Nicole (3), and Von Bastian Claudia (2).
- The Green (Second) cluster includes six authors: Dolder Zoé (3), Fumagalli Carla Sophie (3), Ghelfi-Waechter (5), Grote Gudela (2), Schmutz Jan (2), and Walter Stephanie (5 connections).
- The Blue (Third) cluster includes Ehlert Ulrike, Hedinger Patrik, Heimgartner Nadja, Thomas Livia, and Wirtz Petra, each with 6 connections.
- The Khaki (Fourth) cluster includes Buser Daniela (2), Latscha Marius (3), Riz Porta Robin (4), Sauer Jürgen (3), and Sterchi Yanik (9 connections).
- The Purple (Fifth) cluster includes Fuhrer Mirjam (1), Hofer Franziska (15), Jonas Klaus (2), Wetter Olive (1), and Wetter Olive Emil (3 connections).
- The Turquoise (Sixth) cluster includes Chavaillaz Alain (4), Huegli David (4), Merks Sarah (2), and Sauer Juergen (6 connections).
- The Orange (Seventh) cluster includes Bearth Angela (6), Ghelfi Signe Maria (3), Siegrist Michael (3), and Stotz Tamara (4 connections).
- The Brown (Eighth) cluster includes Budgell Glen, Halbherr Tobias, and Wales Alan, each with 3 connections.
- The Pink (Ninth) cluster includes Hardmeier Diana, Martin Mike, and Riegelnig Judith, each with 3 connections.
- The Light Red (Tenth) cluster includes Baeriswyl Sophie and Krause Andreas, each with 3 connections.

Notably, the Turquoise and Brown clusters include several authors (Chavaillaz, Halbherr, Budgell, Wales) whose work directly investigates screener training, competency, and trust in automation (Halbherr et al. 2013; Chavaillaz et al. 2019), confirming that the Schwaninger-centered network as a whole represents a coherent human-factors research tradition rather than a loose grouping of co-authors. Beyond the co-authorship network clusters, Shuiwang Ji, Wei Xu, Ming Yang, and Kai Yu ranked among the most highly cited authors identified in the field, collectively accumulating 5,243 citations; their prominence reflects the weight of highly cited computer-science contributions in the broader field rather than membership in the collaboration network itself. The resulting co-authorship network is shown in Fig. 1.

2.3 Keyword Analysis of Authors

According to the keyword analysis, 49 keywords repeating at least six times among 3,062 keywords were identified, resulting in six clusters, 193 connections, and a total link strength of 338. The most frequent keywords include “airport security” (137 repetitions), “security” (42), “airport” (36), “deep learning” (33), “aviation security” (29), “visual search” (29), and “terrorism” (22). These terms are also among the strongest in terms of total link strength, indicating their centrality to the intellectual structure of the field. The corresponding keyword network is presented in Fig. 2.

3. Findings

3.1 Publication Trends

Among the 1,207 academic studies identified in the Scopus database on airport security between 2010 and 2025, publication output remained moderate but steady over 2010–2018, before rising markedly from 2019 onward and peaking in 2023–2024. This upward trajectory coincides with the broader diffusion of deep-learning-based computer-vision techniques into security applications, as well as the growing global emphasis on aviation security following heightened geopolitical tensions in the period. Schwaninger A. (20 publications), Mitroff S. R. (13), Skorupski J. and Uchronski P. (12 each), Tambe M. (9), Sharpanskykh A. (8), and Cain M. S., Janssen S., Kierkowski A., Sauer J., and Sterchi Y. (7 each) are among the most prolific authors in the field (Figs. 3, 4).

3.2 Subject Area Distribution

In terms of subject area, the 1,207 studies were distributed as follows: 494 in Engineering, 365 in Computer Science, 268 in Social Sciences, 106 in Physics and Astronomy, 84 in Mathematics, 64 in Decision Sciences, 80 in Medicine, 74 in Materials Science, 39 in Chemical Engineering, 96 in Business, Management and Accounting, 25 in Economics, Econometrics and Finance, and 48 in Psychology (Fig. 5). Because Scopus assigns each document to one or more subject-area categories simultaneously, these figures sum to more than the total number of documents and should be read as counts of subject-area assignments rather than mutually exclusive document counts. The dominance of Engineering and Computer Science is consistent with the strong technical orientation of the field toward detection systems and computer-vision applications, while the sizeable Social Sciences and Psychology contribution reflects the parallel, human-factors-oriented research tradition identified in Section 2.2, concerned with screener performance and behavioral aspects of security screening (Halbherr et al. 2013; Chavaillaz et al. 2019).

The temporal overlay of keyword co-occurrences (Fig. 6) further shows that terms such as “deep learning,” “object detection,” and “YOLO” cluster toward the more recent end of the publication window, corroborating the post-2019 shift toward computer-vision-based detection research identified in Section 3.1.

4. Discussion

The bibliometric mapping performed in this study reveals two largely parallel research traditions within the airport security literature. The first, anchored by the Red, Turquoise, and Brown clusters centered on Adrian Schwaninger and collaborators, is predominantly human-factors- and applied-psychology-oriented, concerned with screener performance, visual search, and cognitive aspects of X-ray image interpretation (Halbherr et al. 2013; Chavaillaz et al. 2019). The second, reflected in the high citation counts of Shuiwang Ji, Wei Xu, Ming Yang, and Kai Yu, and in the strong representation of Engineering and Computer Science subject areas, is technology-driven and centered on deep-learning-based object detection. This divergence suggests that, despite sharing a common application domain, the human-factors and computer-vision literatures on airport security have developed with limited cross-citation, a pattern also observed in the recently published bibliometric mapping of maritime transportation risks (Yazar Okur and Gökbulut 2026), suggesting that this bifurcation between human-factors and technology-centered research may be a general feature of transportation-security scholarship rather than a peculiarity of aviation alone.

Within the technology-driven cluster, the findings are consistent with a substantial and rapidly growing body of applied computer-vision research on X-ray baggage screening. Several studies have evaluated deep-learning object-detection architectures for threat-object recognition in baggage imagery (Dhiraj and Jain 2019; Saavedra et al. 2021), while broader surveys have mapped the evolution of object-detection methods specifically for X-ray security imaging (Wu et al. 2023). The prominence of the YOLO (You Only Look Once) algorithm identified in the keyword and citation analysis is corroborated by multiple applied studies that adopt YOLO-based architectures for threat detection in X-ray images (Galvez et al. 2019; Krišto et al. 2020) and, more recently, for airport security-check screening using improved YOLO variants (Philip et al. 2024). Taken together, these studies indicate that YOLO and its successive versions have become a de facto standard architecture for real-time threat detection in the aviation-security domain, consistent with the centrality of “deep learning” and “visual search” in the keyword co-occurrence network reported in Section 2.3.

For security operators and regulators, three practical implications follow from this mapping. First, the persistence of a distinct human-factors cluster—built on decades of controlled research on screener training and competency (Halbherr et al. 2013)—indicates that automated detection should be treated as a complement to, rather than a substitute for, screener training programs; agencies deploying deep-learning detection aids should budget for parallel investment in recurrent human training, consistent with evidence that trust in automation among screeners must be actively managed rather than assumed (Chavaillaz et al. 2019). Second, the rapid rise of YOLO-based detection research after 2019 suggests that procurement and certification frameworks for AI-assisted screening equipment should be updated at a comparable pace, so that regulatory approval processes do not lag several years behind the technology being evaluated in the literature. Third, the field-wide emphasis on risk differentiation illustrated by programs such as TSA PreCheck (Albert et al. 2021) offers a template that could be more systematically connected to the deep-learning detection literature mapped here, since risk-based

prescreening and automated threat detection currently appear as largely separate research streams rather than an integrated risk-based technology strategy.

By contrast, the passenger-experience and service-quality dimension of airport operations—illustrated by Bakır et al.'s (2022) bibliometric analysis of airport service quality—appears only marginally connected to the security-focused literature mapped here. This suggests a research gap at the intersection of security screening and passenger experience, an area of growing practical relevance as airports seek to balance stringent security requirements with passenger throughput and satisfaction. Similarly, while studies such as Burak and Küsbeci (2024) and Şahin (2024) demonstrate the productive application of bibliometric methods to other aviation sub-domains, comparable bibliometric attention to the policy, regulatory, and economic dimensions of airport security remains limited relative to its technical dimension.

5. Conclusion

This study has carried out a bibliometric mapping of the academic literature on airport security, systematically examining trends, influential authors, keywords, and research areas, and translating these patterns into implications for security practice and policy. By analyzing 1,207 academic studies indexed in the Scopus database, it has been determined that research output on airport security has increased markedly in recent years, particularly after 2019, and that this growth has been dominated by deep learning, object recognition, X-ray imaging, and threat-detection research, existing alongside a smaller but well-established human-factors research tradition.

The findings point to concrete opportunities for the field. AI-supported security systems, deep learning, machine learning, and related algorithms such as YOLO, convolutional neural networks (CNN), and unmanned aerial vehicle (UAV)-based detection, as well as biometric recognition technologies, are areas of study that have attracted increasing interest and research in recent years. The YOLO algorithm in particular, capable of detecting objects quickly and in a single pass (Krišto et al. 2020), is expected to contribute to important areas of aviation security beyond baggage screening, including foreign-object detection, video and radar surveillance, and traffic management (Philip et al. 2024). At the same time, the analysis indicates that closer integration between this technology-driven literature and the human-factors and risk-based-policy traditions (Halbherr et al. 2013; Albert et al. 2021) would strengthen the field's relevance to practitioners.

This study contributes to monitoring scientific developments in the field of airport security, supports the identification of new research opportunities in the literature, and provides a consolidated, practice-oriented resource for future studies.

6. Limitations and Future Research

This study is subject to several limitations that should be considered when interpreting its findings. First, the analysis relies exclusively on the Scopus database; while Scopus offers broad coverage, complementary databases such as Web of Science or IEEE Xplore may capture additional engineering-

oriented publications not indexed in Scopus, and a multi-database triangulation would strengthen future replications. Second, the study is restricted to bibliometric mapping (co-authorship, keyword co-occurrence, publication trends, and subject-area distribution) and does not incorporate citation-based techniques such as co-citation or bibliographic-coupling analysis. Third, the search was not accompanied by a documented systematic screening protocol (e.g., inclusion and exclusion criteria based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses, PRISMA); future studies could adopt such a protocol to improve transparency and reproducibility. Future research is encouraged to (i) conduct a qualitative content analysis of the most highly cited papers identified here, (ii) examine the currently underexplored intersection between security screening and passenger experience, and (iii) extend the bibliometric mapping to policy- and regulation-oriented literature on airport security, which appears comparatively underrepresented relative to the technical literature.

Declarations

Competing interests:

The author has no relevant financial or non-financial interests to disclose.

Ethics approval:

Not applicable. This study is based exclusively on secondary, publicly indexed bibliographic metadata retrieved from the Scopus database and does not involve human participants, animals, or primary data collection.

Consent to participate:

Not applicable, as this study did not involve human participants.

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Author Contribution

T. Mildan is the sole author and is responsible for all aspects of this work, including conception, data collection, analysis, and writing.

Data availability:

The bibliographic dataset analyzed in this study was retrieved from Scopus (Elsevier) and is available from the corresponding author upon reasonable request.

References

1. Albert LA, Nikolaev A, Lee AJ, Jacobson SH (2021) A review of risk-based security and its impact on TSA PreCheck. IISE Trans 53(6):657–670. https://doi.org/10.1080/24725854.2020.1825881
2. Bakır M, Özdemir E, Akan Ş, Atalık Ö (2022) A bibliometric analysis of airport service quality. J Air Transp Manag 104:102273. https://doi.org/10.1016/j.jairtraman.2022.102273
3. Burak MF, Küsbeci P (2024) Internet of things and aviation: a bibliometric and visualization analysis. Kybernetes 53(11):4502–4521. https://doi.org/10.1108/K-04-2023-0664
4. Chavaillaz A, Schwaninger A, Michel S, Sauer J (2019) Expertise, automation and trust in X-ray screening of cabin baggage. Front Psychol 10:256. https://doi.org/10.3389/fpsyg.2019.00256
5. Dhiraj, Jain DK (2019) An evaluation of deep learning–based object detection strategies for threat object detection in baggage security imagery. Pattern Recognit Lett 120:112–119. https://doi.org/10.1016/j.patrec.2019.01.014
6. Donthu N, Kumar S, Mukherjee D, Pandey N, Lim WM (2021) How to conduct a bibliometric analysis: an overview and guidelines. J Bus Res 133:285–296. https://doi.org/10.1016/j.jbusres.2021.04.070
7. Galvez RL, Dadios EP, Bandala AA, Vicerra RP (2019) YOLO-based threat object detection in X-ray images. In: 2019 IEEE 11th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM). IEEE, pp 1–5. https://doi.org/10.1109/HNICEM48295.2019.9073599
8. Halbherr T, Schwaninger A, Budgell GR, Wales A (2013) Airport security screener competency: a cross-sectional and longitudinal analysis. Int J Aviat Psychol 23(2):113–129. https://doi.org/10.1080/10508414.2011.582455
9. Krišto M, Ivasic-Kos M, Pobar M (2020) Thermal object detection in difficult weather conditions using YOLO. IEEE Access 8:125459–125476. https://doi.org/10.1109/ACCESS.2020.3007481
10. Philip JJ, Panda S, Meesala KR, Garad J, Bandhari O, Rani R, Kumar S (2024) Object detection in airport security checks. In: 2024 International Conference on Advances in Computing Research on Science Engineering and Technology (ACROSET). IEEE, pp 1–6. https://ieeexplore.ieee.org/document/10743507
11. Price J, Forrest J (2016) Practical aviation security: predicting and preventing future threats, 3rd edn. Elsevier, Amsterdam
12. Saavedra D, Banerjee S, Mery D (2021) Detection of threat objects in baggage inspection with X-ray images using deep learning. Neural Comput Appl 33(13):7803–7819. https://doi.org/10.1007/s00521-020-05521-2
13. Şahin Y (2024) Havaalanı rekabetinin bibliyometrik analizi [A bibliometric analysis of airport competitiveness]. Premium E-J Social Sci (PEJOSS) 8(44):927–936.

https://doi.org/10.5281/zenodo.13151091

14. Van Eck NJ, Waltman L (2010) Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics 84(2):523–538. https://doi.org/10.1007/s11192-009-0146-3
15. Wu J, Xu X, Yang J (2023) Object detection and X-ray security imaging: a survey. IEEE Access 11:45416–45441. https://doi.org/10.1109/ACCESS.2023.3273736
16. Yazar Okur İG, Gökbulut Rİ (2026) A bibliometric mapping of risks in maritime transportation: milestones, current research trends, and future research opportunities. J Transp Secur. https://doi.org/10.1007/s12198-026-00333-2

Figures

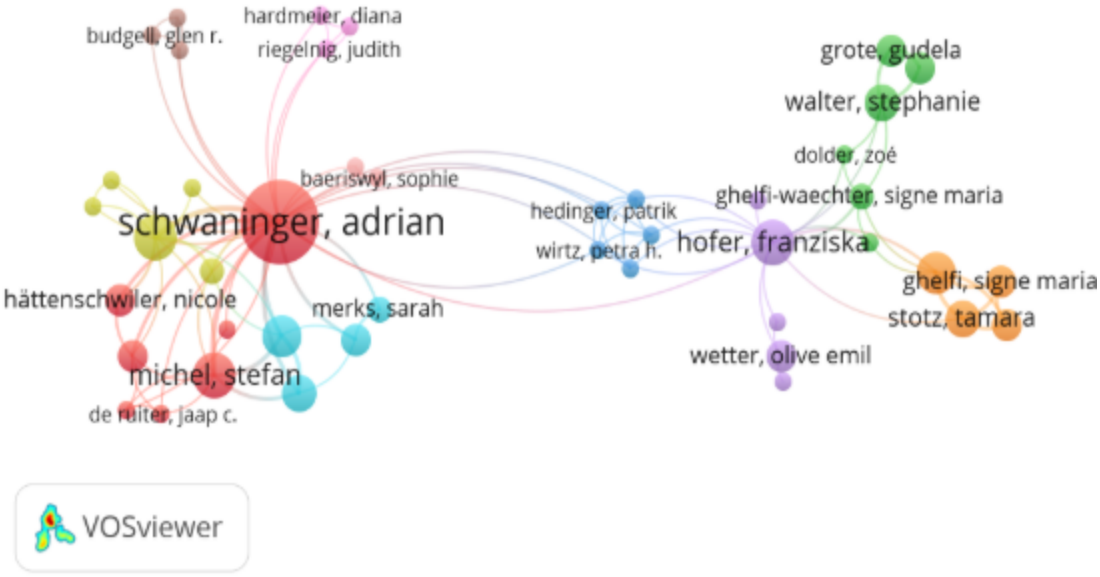


Figure 1

Co-author networks illustrating collaboration among authors

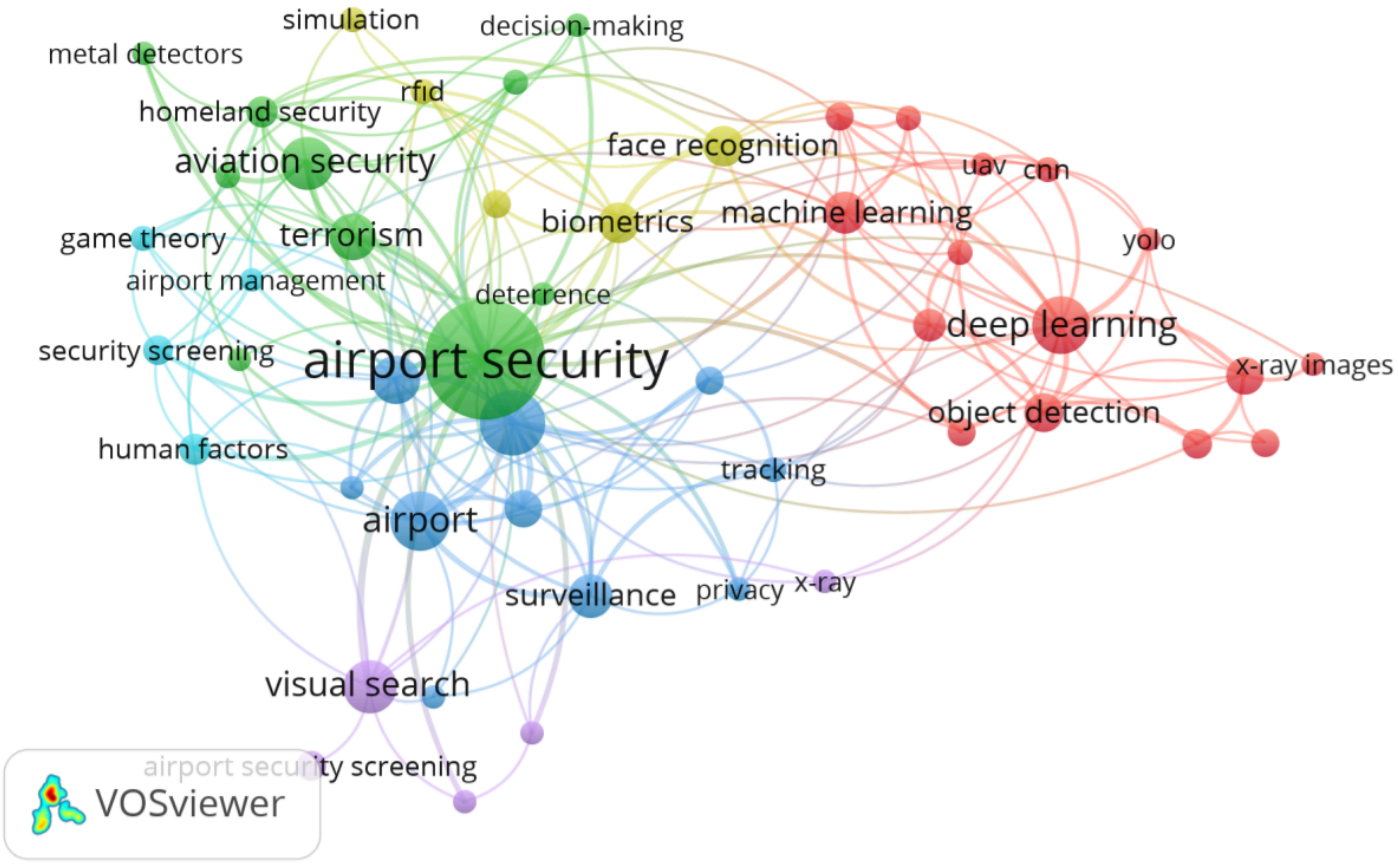


Figure 2

Authors' keyword networks

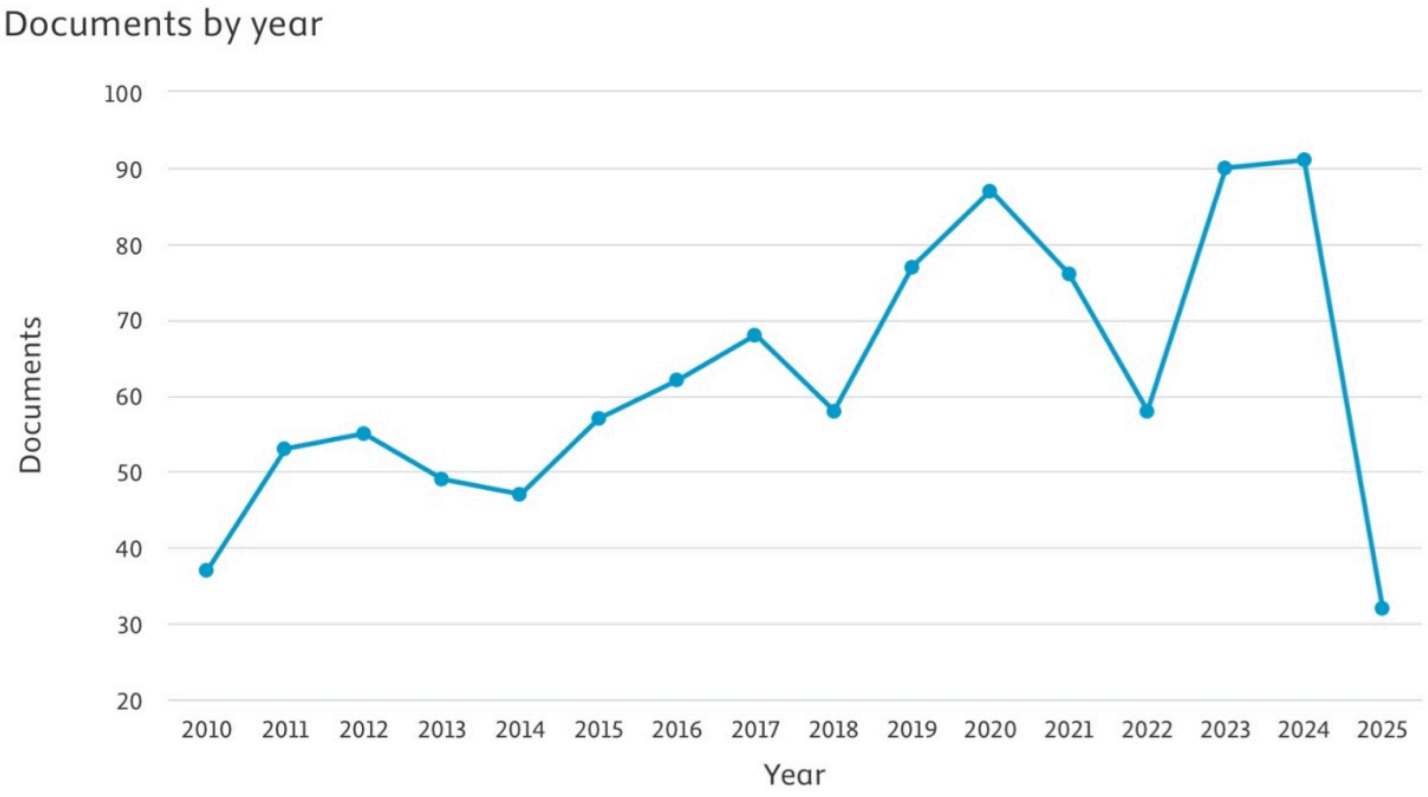


Figure 3

Number of articles published between 2010 and 2025

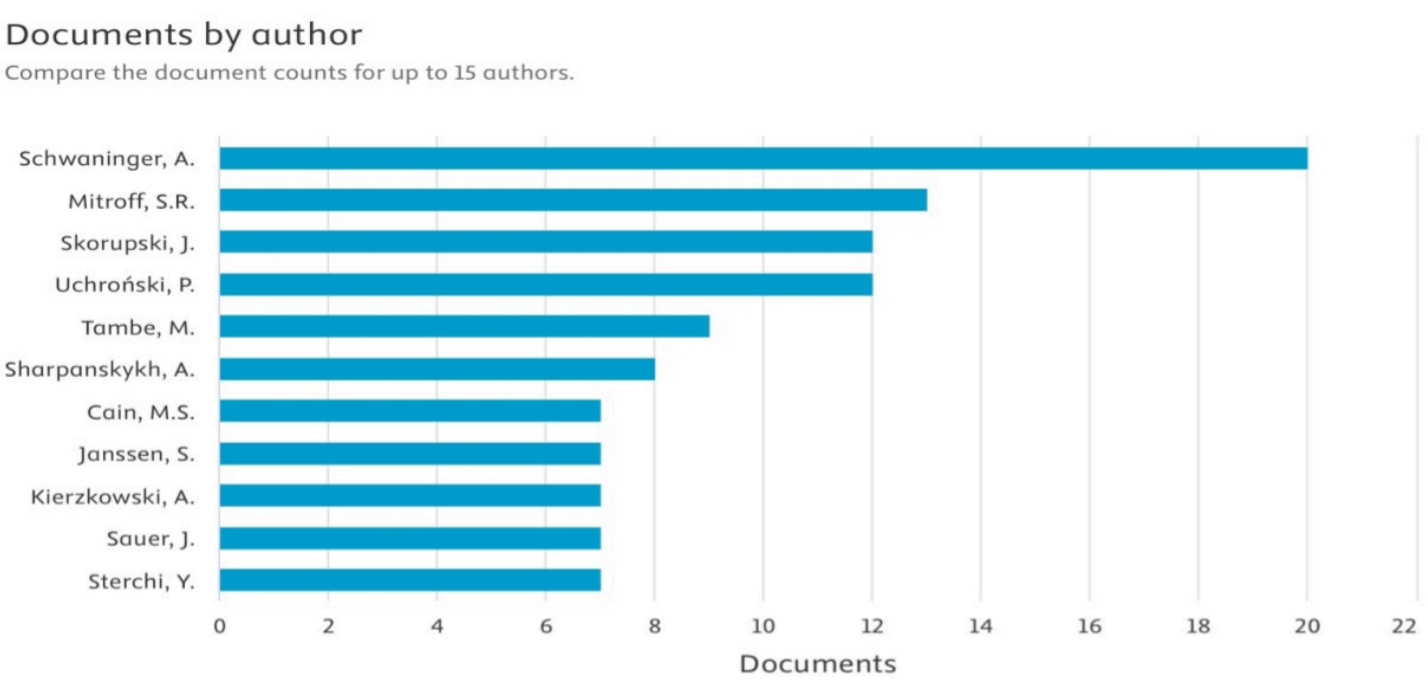


Figure 4

Authors with the highest number of publications

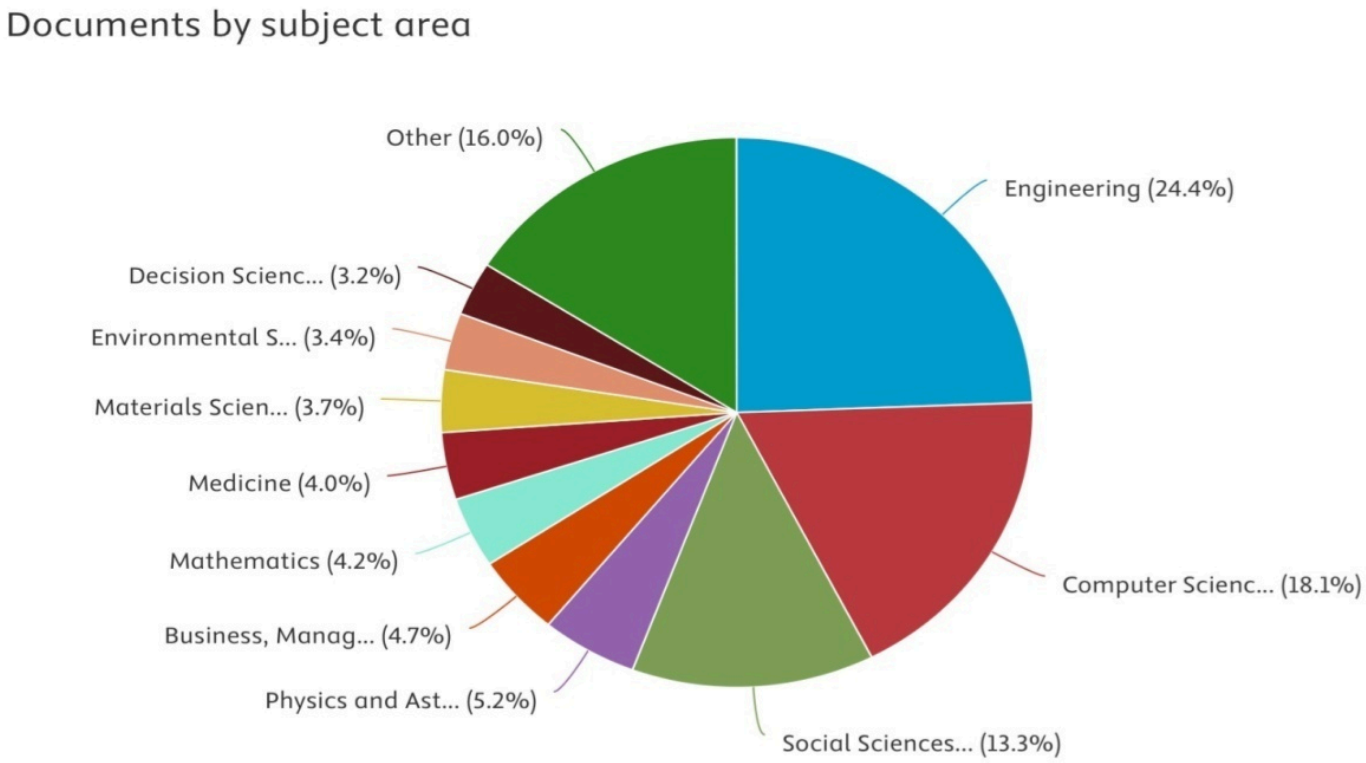


Figure 5

Distribution of articles by subject area

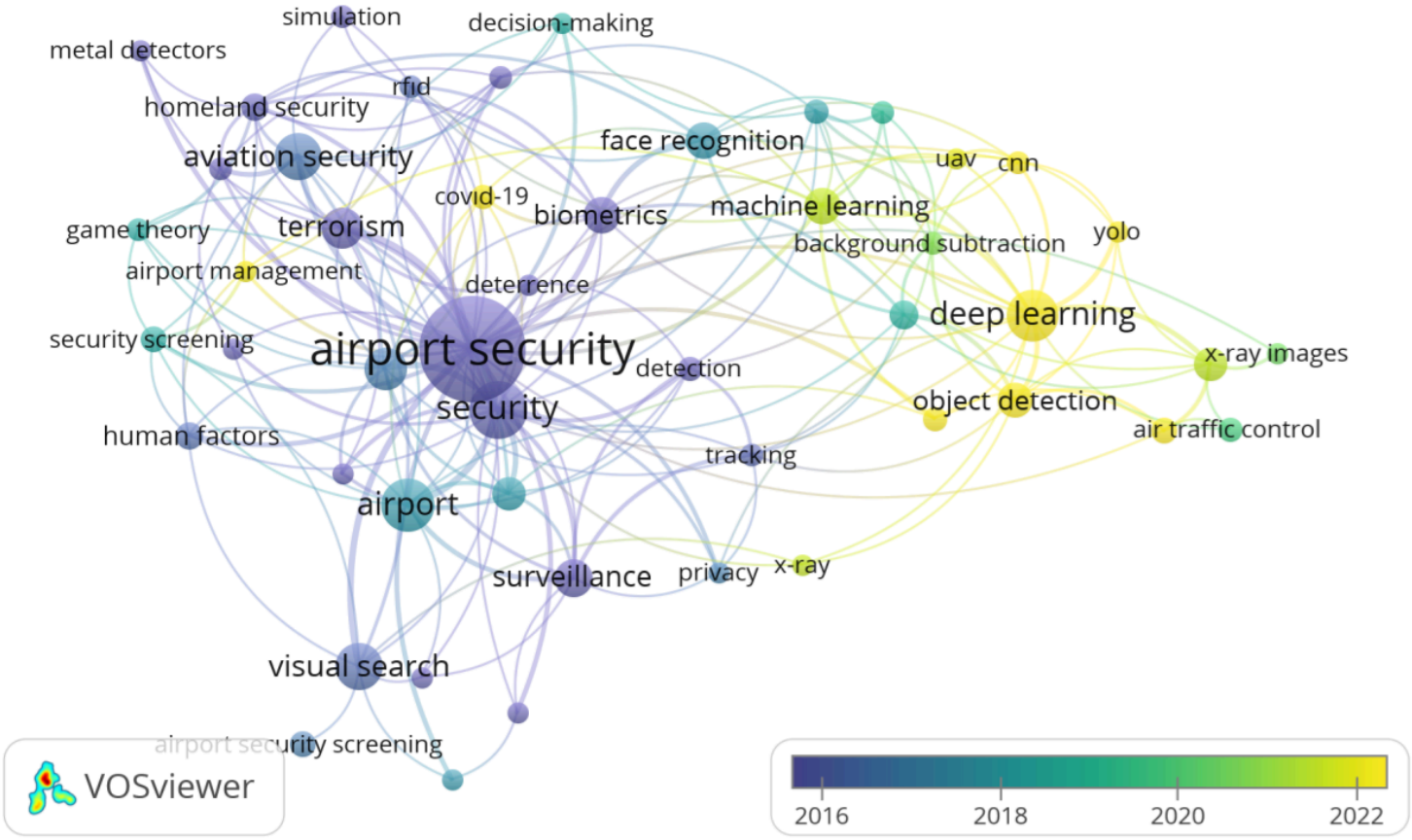


Figure 6

Keyword concentration by year (overlay visualization)