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Research Article

Mapping the Research Landscape and Predicting Future Growth: A Bibliometric and Time Series Study of Artificial Intelligence/Machine Learning Applications in Mechatronics Engineering Using Web of Science Data

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Abstract

This study examines the impact of Artificial Intelligence and Machine Learning technologies on the fields of Mechatronics Engineering, Robotics, and Automation. Through a comprehensive bibliometric analysis of publications indexed in the Web of Science database, the historical development, key research trends, and prominent themes of this interdisciplinary domain are revealed. Additionally, six different time series forecasting methods Auto Regressive Integrated Moving Average, Error, Trend, Seasonality, Theta, Holt-Winters, Polynomial Regression, and Naive Model are employed to predict the number of scientific publications for the year 2025. The analysis results indicate a growing influence of Artificial Intelligence/ Machine Learning in the field of mechatronics and a clear upward trend in publication volume. This study quantitatively illustrates the interaction between Artificial Intelligence, Machine Learning, and mechatronics engineering.

Keywords: Mechatronics, Artificial Intelligence Applications, Bibliometric Analysis, Time Series Analysis, Publication Trends

Mekatronik Mühendisliğinde Yapay Zekâ ve Makine Öğrenmesi Uygulamalarında Web of Science Tabanlı Bibliyometrik ve Zaman Serisi Analizi: Araştırma Eğilimlerinin Belirlenmesi ve Gelecek Yayın Sayısının Tahmini

Öz

Bu çalışma, Yapay Zekâ ve Makine Öğrenmesi teknolojilerinin Mekatronik Mühendisliği, Robotik ve Otomasyon alanlarındaki etkisini incelemektedir. Web of Science veri tabanındaki yayınlar üzerinden yapılan kapsamlı bir bibliyometrik analiz ile bu interdisipliner alanın tarihsel gelişimi, temel araştırma eğilimleri ve öne çıkan temaları ortaya konmuştur. Ayrıca, Otoregresif Entegre Hareketli Ortalama Modeli, Hata, Trend, Mevsimsellik Modeli, Theta, Holt-Winters, Polynomial Regression ve Naive Model gibi altı farklı zaman serisi tahmin yöntemi kullanılarak 2025 yılına ait bilimsel yayın sayıları öngörülmüştür. Analiz sonuçları, Yapay Zeka/ Makine Öğrenmesi'nin mekatronik alanındaki yükselen etkisini ve bu alanlarda belirgin bir yayın artış trendini göstermektedir. Bu çalışma, Yapay Zekâ ve Makine Öğrenmesinin mekatronik mühendisliğiyle etkileşimini nicel olarak ortaya koymaktadır.

Anahtar Kelimeler: Mekatronik, Yapay Zekâ Uygulamaları, Bibliyometrik Analiz, Zaman Serisi Analizi, Yayın Eğilimleri

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1. Introduction

Bibliographic analysis is a method used to examine academic literature on a specific topic by analyzing the distribution, trends, authorship, sources, and citations of publications. This analysis serves to identify key studies, the developmental trajectory of a research area, and potential opportunities for future research. The objective of such analysis is to obtain quantitative data about the subject under investigation and to ensure the healthy interpretation of this data through visualization techniques. Bibliographic analysis is primarily employed to gain insights into the current state of knowledge in a particular field before initiating new research. It facilitates the identification of subtopics, related disciplines, areas of impact, and active researchers working on the subject.

Artificial Intelligence (AI) is a scientific discipline focused on developing systems that simulate human intelligence and perform cognitive functions such as problem-solving, learning, and decision-making. In 1943, Warren McCulloch and Walter Pitts developed the first model of an artificial neuron [1]. The term “artificial intelligence” was first introduced by John McCarthy during the Dartmouth Conference in 1956 [2]. Initial AI models began to emerge during the 1950s and 1960s, with the Logic Theorist, developed by Newell and Simon, being one of the most notable examples of the period [3]. Despite high expectations in the 1970s, AI research slowed due to hardware limitations and lack of data, leading to a stagnant phase known as the “AI Winter”. In contrast, the present era is often referred to as the golden age of AI, with remarkable progress seen across various domains, from autonomous vehicles to diagnostic systems in healthcare.

Mechatronics is an engineering discipline formed by the integration of mechanical engineering, electronics, computer science, and control engineering. Mechatronic systems aim to create more intelligent, flexible, and high-impact machines by ensuring the integrated operation of mechanical and electronic components. The term “mechatronics”" was first introduced in Japan in the early 1970s by Tetsuro Mori [4]. The first paper that included the term “mechatronics” was published in 1984. This paper, titled “Mechatronics – Developments in Japan and Europe”, appeared under the “Business & Economics – Development Studies” category [5]. During the 1970s, companies such as Toyota in Japan began developing automated production systems and adopting robotic technologies. With the acceleration of technological advancements after the 2000s, the development pace of mechatronic systems significantly increased. The integration of new technologies such as smart sensors, AI, the Internet of Things (IoT), and cloud computing has led to the emergence of more autonomous and independent mechatronic systems. Today, these systems are widely used in fields such as automotive, medical devices, aerospace, agriculture, and consumer technologies. In the future, mechatronic systems are expected to become even more prevalent in areas such as intelligent robotics, automated transportation systems, and wearable technologies, increasingly incorporating AI-driven solutions.

The referenced bibliometric study explores the dynamic impact of automation on mechanical engineering research. Covering publications from 1972 to 2022, the study utilizes the Scopus database and applies keyword search strategies targeting titles, abstracts, and keywords. It

highlights the continued prominence of “mechanical engineering” as a core topic, while thematic interests such as "control systems" and "robotics" exhibit fluctuating trends over time. In addition, collaboration network analysis identifies key researchers like Wang X, Li D, and Zhang X as influential figures within their respective academic communities. The study suggests future directions focusing on the convergence of information technologies with automation, strengthening global collaborations, and investigating links between academic output and real-world technological progress.[6]

The referenced study examines the scientific structure of mechatronics and its association with innovative products. Mechatronics is defined as an integration of mechanical engineering, electronic control, and software design in product development. Using a systematic review and bibliometric analysis, the study identifies five global research themes: product development applications, education and curriculum, mechatronic system components, use of AI, and system design methodologies. It also emphasizes that the term “innovation” is often linked not only to technical aspects but also to commercial value and return on investment. [7] However, this study primarily focuses on the general impact of automation and does not directly address the role of AI. It also does not include any future projections or publication forecasting. Furthermore, it does not employ bibliometric visualization tools such as VOSviewer, which are useful for identifying and illustrating conceptual relationships. In contrast, the present study differs both in scope and methodology, as it specifically examines the intersection of mechatronics engineering and AI/machine learning (ML), incorporates forecasting techniques, and utilizes VOSviewer to visualize thematic clusters and research trends.

This study comprehensively explores the multifaceted interaction between mechatronics engineering and AI/ML technologies. A review of the literature revealed a lack of systematic and bibliometric analyses based on quantitative data focusing on the intersection of these two fields. Addressing this gap, the present study analyzes past publication trends using objective data to uncover the historical development, main research trends, and prominent thematic areas of AI applications in the field of mechatronics. Moreover, it goes a step further by employing time series analysis methods to forecast the number of scientific publications for the year 2025, thereby offering insights into the future potential of the field. In this respect, the study not only sheds light on the past but also provides a strategic perspective for researchers and decision-makers alike.

In literature review, mechatronics engineering is currently in significant interaction with AI. AI serves as a tool to make mechatronic systems smarter, more autonomous, and more impactful. AI applications have become increasingly widespread, particularly in robotic technologies, automation systems, and smart production lines. AI focuses on enhancing the decision-making processes of mechatronic systems by processing sensor data and adapting to environmental factors. For instance, AI-based robots can autonomously perform tasks in industrial production lines, operating with greater flexibility and impact thanks to their learning and adaptation capabilities. Additionally, intelligent maintenance systems utilizing AI can predict machine failures and enable preventive interventions, thereby reducing operational costs. In this way, mechatronic engineering offers more sustainable and impactful solutions while optimizing

production processes. AI not only improves the performance of mechatronic systems but also enhances safety and efficiency by minimizing human intervention.

In daily life, the efficient operation of electronic information systems in mechatronics engineering depends on precise data transmission and analysis. However, data errors and security vulnerabilities can obstruct this process. In large-scale engineering projects in particular, data accuracy can determine the success of the entire project, and incorrect data may lead to significant losses. When integrated with mechatronics engineering, AI can detect data errors and identify information gaps in a timely manner. AI enables efficient data screening, reports errors in real-time, and allows technicians to make rapid corrections. This strengthens data control in engineering projects and enhances competitiveness in the industry [8].

AI studies also enable the digital management and virtualization of mechatronic products and processes. The trend toward smart mechatronic systems began in the late 20th century in Western developed countries and has generated substantial economic value. Today, with the strengthening of digital management systems through electronic information technology, the process of making mechatronic systems intelligent continues to advance rapidly [9].

Various methodologies have emerged for integrating AI into mechatronics systems. These include core approaches such as ML, computer vision, soft computing, natural language processing, and intelligent system design. At their intersection, the focus is often on real-world applications such as manufacturing automation, robotics, and human-machine interaction. The central goal in the fusion of these two domains appears to be the creation of self-optimizing intelligent systems. Overall, the convergence of AI and mechatronics holds the promise of driving major transformations in both industrial and societal systems [10].

A bibliometric analysis examining the impact of Industry 4.0 on the healthcare sector focuses on how technologies such as IoT, AI, Big Data Analytics, and Robotics- brought forth by Industry 4.0 are transforming patient care, resource utilization, and research processes. This study analyzed data collected from the Web of Science database covering the years 2014 to 2025. According to the results, a significant increase in the number of publications related to Industry 4.0 and healthcare has been observed, especially since 2018 [11]. The analysis highlights the importance of conducting bibliographic reviews over specific time periods to map the sector and explore overlapping areas with Industry 4.0.

2. Material and Methods

A literature review is a systematic examination and evaluation of existing knowledge and papers relevant to specific research or study. This section presents the literature review focused on the role of AI in the field of mechatronics engineering. It elaborates on the impact of AI within mechatronics engineering and explores its subdomains in detail.

This section outlines the purpose of the research, the analyses conducted, the data sources used, and the methods of analysis.

2.1. Research Objective

This study aims to systematically investigate the intersection of AI and mechatronics engineering by conducting a comprehensive bibliographic analysis based on quantitative data extracted from literature. The primary objective is to identify the core research domains, thematic clusters, and developmental trends associated with the concept of "Artificial Intelligence in Mechatronics Engineering." In doing so, the study seeks to offer a holistic understanding of the field's current landscape, reveal existing gaps, and provide insights that may guide future research directions. Additionally, by incorporating forecasting techniques, the research extends beyond retrospective analysis to explore potential future developments in this interdisciplinary area.

2.2. Data and Analysis

Various tools and software are used in bibliometric analysis. In this study, the VOSviewer software was employed, along with the analytical interface of the Web of Science database. VOSviewer is recognized as a powerful tool for analyzing scientific publication trends, identifying collaboration networks within research domains, and revealing prominent topics in literature. It provides capabilities for mapping, multidimensional analysis, and visualization, enabling in-depth analytical approaches on the dataset.

This study focused on recent publications in the Web of Science database. A comprehensive search was conducted using the terms "Artificial Intelligence" and "Mechatronic." To ensure broader coverage, terms closely related to AI and mechatronics were also included in the search. The literature review was guided by the following query algorithm:

(((“Artificial Intelligence”) OR (“Machine Learning”)) AND ((“Automation”) OR (“Robotics”) OR (“Mechatronics”)))

This structure was selected because the terms "robotics" and "automation" are often used interchangeably with "mechatronics," and "machine learning" is commonly considered a core methodology within AI. The results of the research indicate that innovative applications emerging at the intersection of these two fields are increasingly represented in the scientific literatüre. The search revealed a total of 57,163 papers published between 1970 and 2015. In line with the aim of this paper, 44,673 studies published between 2014 and 2025 were selected as the primary dataset. The annual distribution of these studies is visualized in Figure 1. Upon examination, a significant upward trend in publications within the relevant research area can be observed. Although the year 2025 is not yet complete, the projected number of publications has been estimated using AI-based forecasting. Furthermore, the increase in literature reflects not only academic interest but also growth in industrial R&D investments. The proliferation of high-quality data plays a critical role in enhancing existing technologies and enabling new technological breakthroughs. In this context, the findings of this study serve as a robust reference point for strategic decision-making that could shape future academic directions.

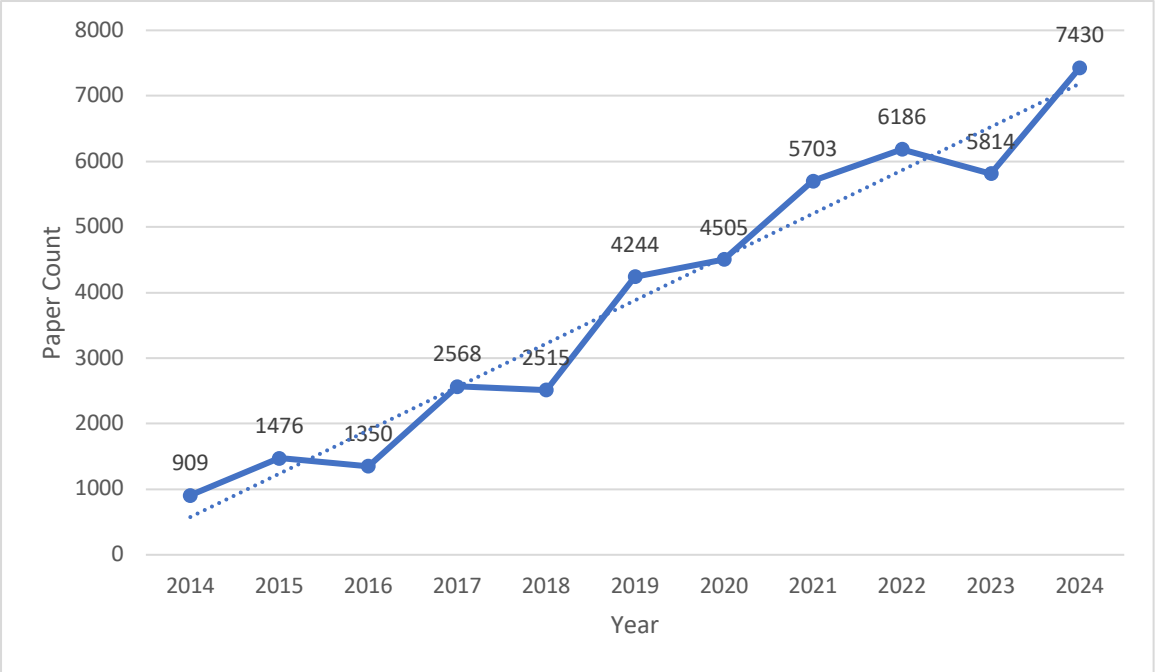

Figure 1. Yearly Paper Count

3. Results and Discussion

This section presents the findings obtained from the study along with their visual representations.

Categories of Documents Analysis refers to the classification of scientific publications within the Web of Science database into academic subject areas. These categories indicate the scientific field or area of specialization of the journal in which each article is published. In today's research landscape, where interdisciplinary structures are gaining increasing importance, such classifications provide a clearer framework for analyzing research trends. They not only facilitate field-based literature reviews but also enable the interpretation of interdisciplinary connections. In this context, category distribution reflects not only the diversity of data but also highlights the priority areas of scientific interest.

A visual representation of the research domains covered by the published documents is provided in Figure 2. These visual analyses help researchers position their own work within the broader scientific landscape and identify future focal points. The area with the highest concentration of publications was "Computer Science Artificial Intelligence" with a share of 34.10%, followed by "Robotics" with 13,545 publications, accounting for 30.46% of the total. This high proportion in the robotics category indicates a rising trend in research linked to Industry 4.0, smart systems, and automation applications.

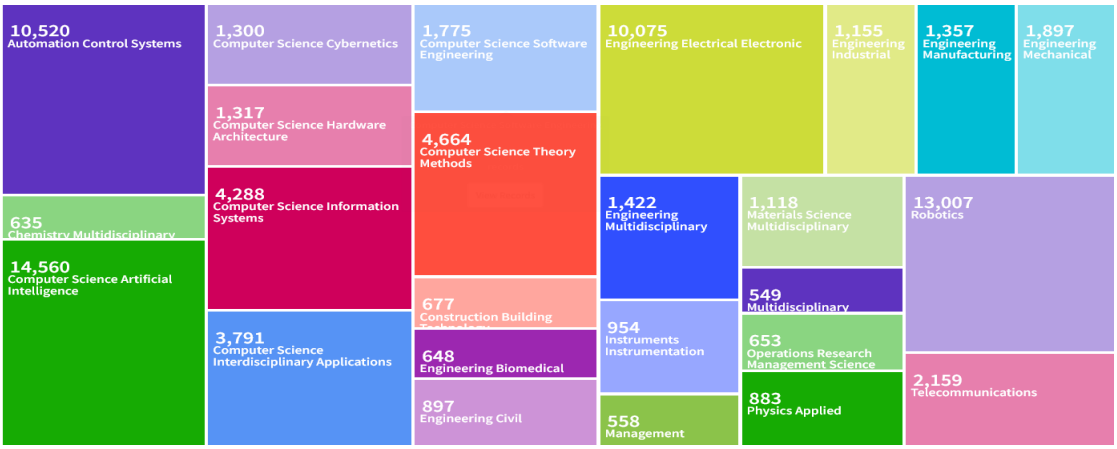

Figure 2. Categories of Documents

Types of Document Analysis refer to the classification of publications based on their format and purpose in the scientific literature. Each document type varies in terms of its publication objective and content. This diversity plays a key role in understanding the multidimensional structure of scientific output. The data obtained from the analysis are listed in Table 1. Upon examination, it is noteworthy that only one bibliographic analysis was identified. This was the study titled "The use of automated information systems in the investigation of criminal offences" published in 2023 in the journal Revista Amazonia Investiga [13]. This finding indicates that certain types of analysis remain limited within this domain and highlights a gap that can be explored in future research. According to the findings of our 2014–2024 literature review, the existence of only one prior bibliographic analysis in this field enhances the scientific significance of the present study and underscores this topic as a promising area for future research.

Table 1. Types of Documents Included in the Analysis

Document Type	Document Count
Proceeding Paper	21,729
Article	17,961
Review Article	2,416
Editorial Material	484
Review Article	2,416
Editorial Material	484
Early Access	427
Book Chapters	426
Meeting Abstract	211
Retracted Publication	51
Correction	28
Letter	24
Book Review	11
Book	9
News item	6
Retraction	3
Publication with Expression of Concern	2
Bibliography	1
Meeting	1
Software Review	1

Co-authorship of Authors Analysis addresses the question of "who collaborates with whom" in scientific production. Central authors appear at the core of visualizations as key researchers who influence the flow of knowledge and the direction of the field. In this analysis, a filter was applied to include only authors with a minimum of five publications and at least one citation, resulting in 3,948 authors being selected from a total of 124,781. According to the results, "Daniela Rus" ranked first with 167 documents and 13,485 citations, followed by "Wu Xinyu" with 74 documents and 1,840 citations. The visualization of the obtained data is provided in Figure 3. In the visualization, the prominent size of Daniela Rus's name indicates that she is the central author connecting other researchers-i.e., the one with the highest number of citations. These results clearly demonstrate the influential role that certain authors play in shaping the direction of the field.

Figure 3. Co-authorship of Authors Analysis

In the co-authorship analysis, the top-ranked author Daniela Rus has the most highly cited publication titled "Design, fabrication and control of soft robots", published in 2015, with 4,208 citations [10]. The most influential publication by the second-ranked author, Wu Xinyu, is titled "Reconfiguration, Camouflage, and Color-Shifting for Bioinspired Adaptive Hydrogel-Based Millirobots*", published in 2020, with 208 citations [14].

Co-authorship of Organisations Analysis examines collaborative scientific output between organizations (e.g., universities, research institutes, companies) instead of individual authors. This type of analysis reveals patterns of institutional collaboration in scientific research and identifies which institutions are more engaged in collaborative knowledge production.

In this analysis, institutions with a minimum of 10 publications and at least 5 citations were included, reducing the total from 22,027 institutions to 1,521. The results provide a clearer view of the building blocks of global research networks. According to the analysis, "Chinese

Academy of Sciences" ranks first with 1,349 documents and 25,161 citations, followed by the "University of Chinese Academy of Sciences" with 815 documents and 11,827 citations.

Interestingly, although the "Massachusetts Institute of Technology (MIT)" ranks lower in terms of the number of documents (722), it leads in terms of impact, with 35,080 citations. This highlights that in academic productivity, impact (citations) can be more significant than sheer output. This is further validated by the visualization in Figure 4, where MIT appears in a central position indicating its pivotal role in the research network.

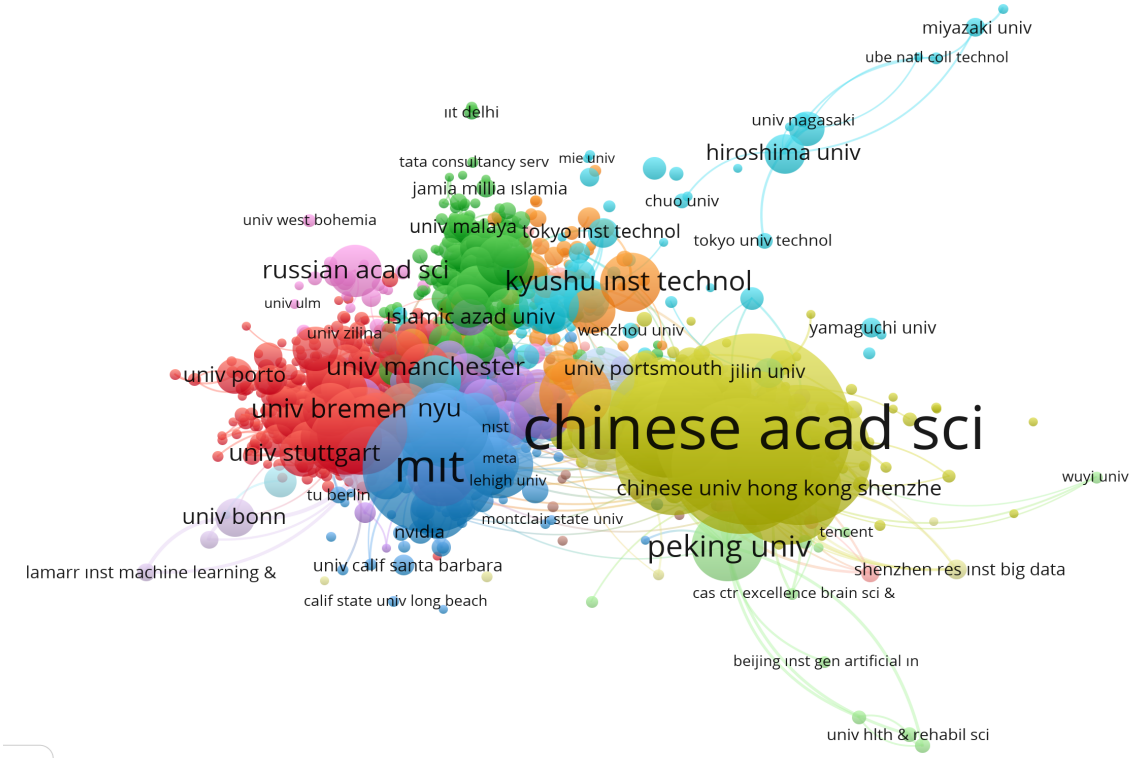

Figure 4. Co-authorship of Organisations Analysis

Co-authorship of Countries Analysis is a type of bibliometric analysis that examines scientific collaboration between countries. This analysis allows for evaluating how many joint publications exist between countries, which nations are more open to international collaboration, and which countries play a central role in scientific production.

In this analysis, data from 155 countries were examined. After applying a filter requiring a minimum of 10 documents per country, the number of countries included was reduced to 99. This filtering enhances the focus on more scientifically active nations and provides a more accurate assessment of country-level participation in global research networks.

The United States ranks first with 8,250 documents and 192,102 citations. "People's Republic of China" follows in second place with 12,802 documents and 136,654 citations. Despite having a higher number of publications, China lags behind the "USA" in citation count, indicating a difference in the impact level of the published works.

This result emphasizes that citation count -rather than publication quantity- is a more meaningful indicator of scientific influence and contribution. The strategic importance of a country's output in the context of international collaboration is thus underlined. The visualization of the data is presented in Figure 5.

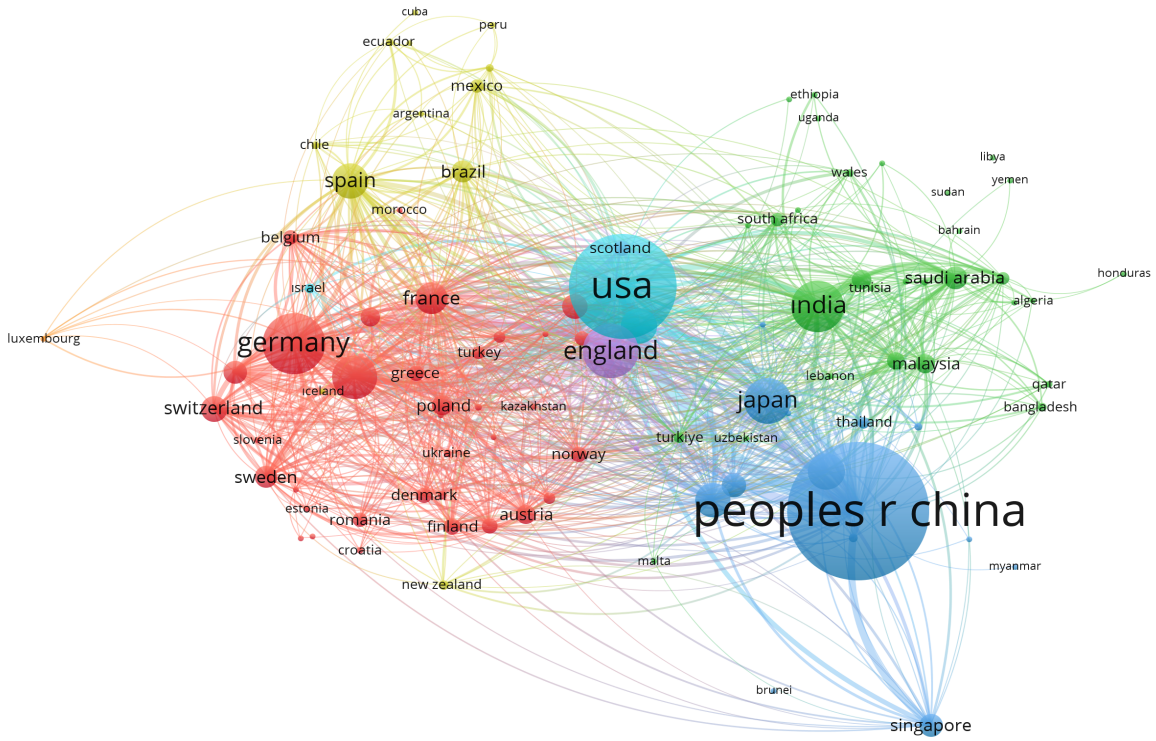

Figure 5. Co-authorship of Countries Analysis

Co-occurance of Author Keywords Analysis is a type of bibliometric analysis that examines the frequency with which keywords assigned by authors are used together in publications. This analysis helps to reveal other relevant keywords that should be considered when conducting research on a given topic.

In particular, keyword combination analysis is crucial in interdisciplinary studies, as it helps identify relationships between different research domains. It enables researchers to see which topics are interconnected and which terms are used interchangeably.

The resulting keyword co-occurrences serve as a guide for researchers to explore new and emerging areas of study. In this analysis, a threshold of 10 occurrences was set, and out of 78,379 unique keywords, 2,178 exceeded the threshold.

The most frequently used keywords were, respectively “Machine Learning”, “Artificial Intelligence”, “Deep Learning”, and “Automation”. The prominence of these terms reflects the growing influence of AI-based systems in the field of mechatronics.

Table 2. List of Co-occurance of Author Keywords

Keyword	Occurences	Total Link Strength
Machine Learning	*6,613*	17,092
Artificial Intelligence	*4,630*	13,200
Deep Learning	*2,384*	6,886
Automation	*1,956*	6,535
Robotics	*1,756*	5,301
Robots	*731*	4,609
Task Analysis	*478*	3,391
Training	*422*	3,118
Feature Extraction	*527*	2,883
Reinforcement Learning	*912*	2,565
Optimization	*515*	2,378
Computer Vision	*713*	2,234
Neural Networks	*616*	2,088
Internet of Things	*463*	1,879
Sensors	*325*	1,783

A visualization has been carried out on this list, and the visual is represented by Figure 6.

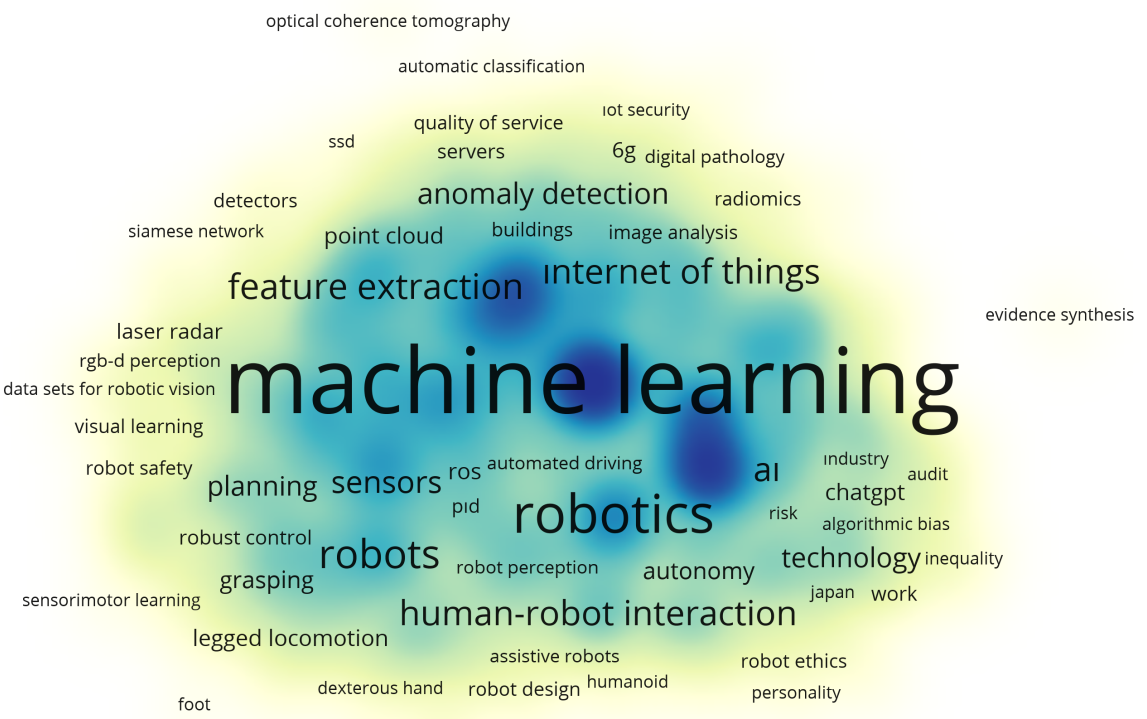

Figure 6. Co-occurance of Author Keywords Analysis

Citation of Documents Analysis is a bibliometric analysis that reveals how many citations scientific publications (articles, conference papers, book chapters, etc.) have received and which publications have had the most impact. This analysis identifies the most influential and reference-worthy works in a particular field. It is used to identify the most impactful publications on the research topic, find documents with the highest citation density, and identify

the most frequently cited works in a given field. A minimum citation threshold of 10 citations was applied, resulting in 10,872 publications being analyzed. As a result, the most cited work was "Rus (2015)" with 4,208 citations, followed by "Huang (2018b)" with 1,398 citations. The naming convention used here follows the format of the first author's surname and the publication year of the most cited paper. Based on this analysis, the majority of the most-cited paper was published in 2015, with the highest cited work being "Design, fabrication and control of soft robots" [10]. The visualization of this analysis is presented in Figure 7.

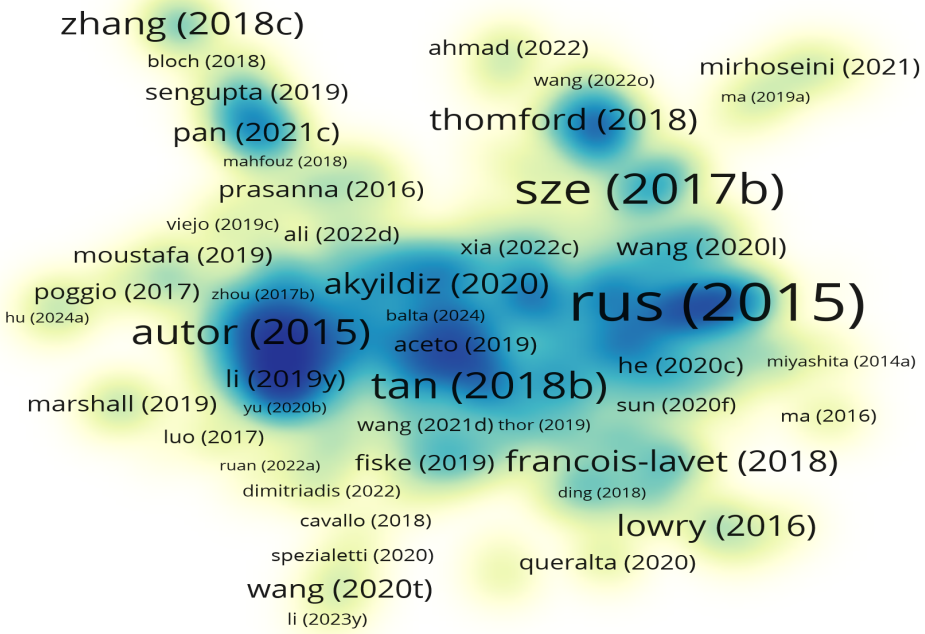

Figure 7. Citation of Documents Analysis

Citation of Sources Analysis refers to an analysis of the total number of citations received by the sources of scientific publications (journals, conferences, etc.). The key insight gained from this analysis is identifying the most prominent and widely cited publications in the researched area. A minimum of 10 documents and 5 citations per source were applied as a filter, reducing the number of sources from 10,072 to 638. The top source was "IEEE Robotics and Automation Letters" with 871 documents and 12,380 citations, followed by "IEEE Access" with 611 documents and 11,862 citations. Another significant finding was that the "Nature" source, with only 13 documents, received 8,382 citations, indicating that despite fewer documents, these publications have significant scientific influence. The impact of these publications is reflected in their prestige and scientific value. The resulting density chart is shown in Figure 8. This analysis also serves as a strategic guide for researchers when selecting journals for publication.

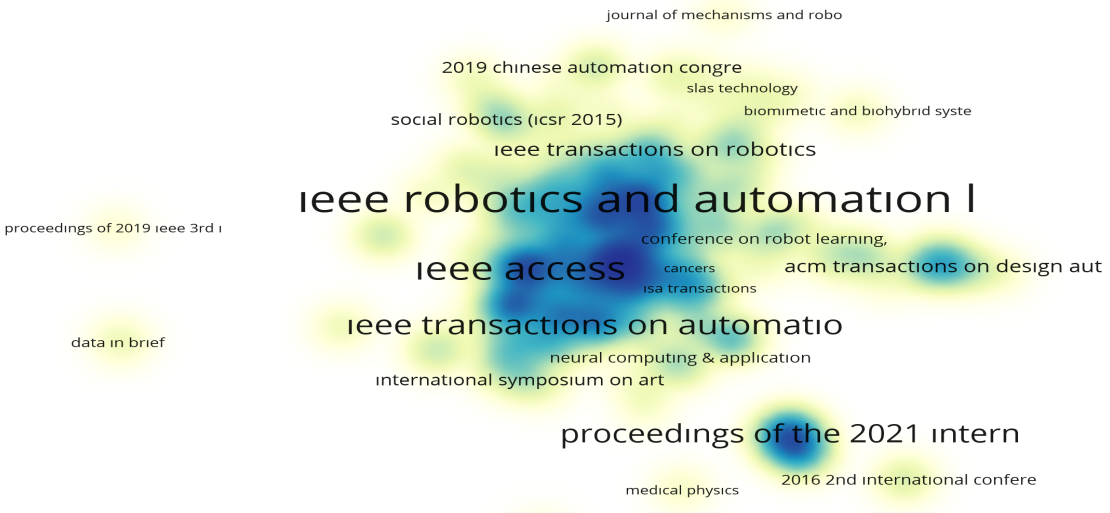

Figure 8. Citation of Sources Analysis

Citation of Authors Analysis shows the total number of citations received by an author's publications and the collaboration intensity with other authors. It serves as a reference for identifying the most cited and influential authors in the field. After applying the filter of at least 10 documents per author, 1,118 authors were identified. The leading author was "Daniela Rus", with 167 publications and 13,485 citations, and 904 connection strength, indicating that she is a central figure in the field with extensive collaborations. The second-most impactful author was "Xinyu Wu", with 74 publications, 1,840 citations, and 724 connection strength, demonstrating the high impact and collaborative power of his publications. Wu's most cited paper is "Reconfiguration, Camouflage, and Color-Shifting for Bioinspired Adaptive Hydrogel-Based Millirobots" published in 2020 [15]. The visualization of this analysis is presented in Figure 9.

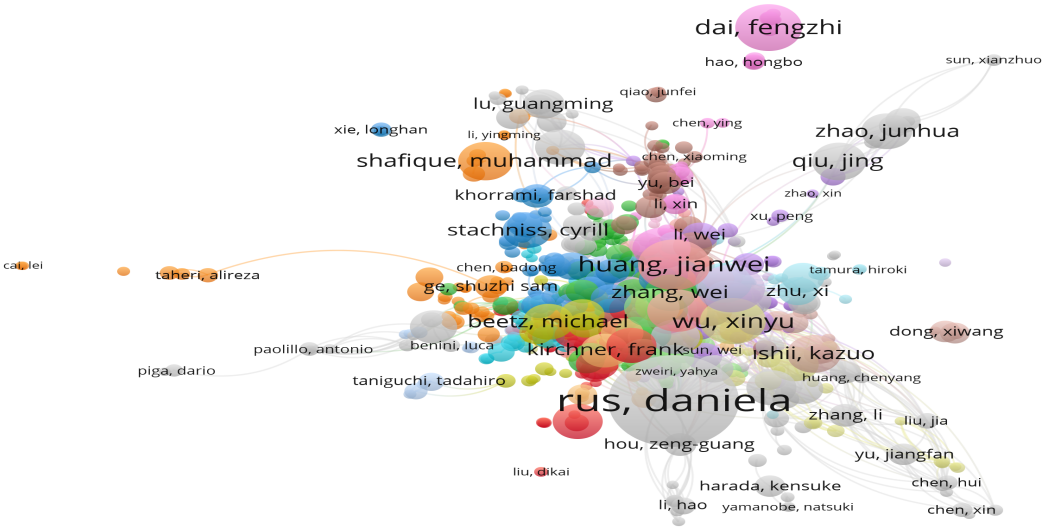

Figure 9. Citation of Authors Analysis

Bibliographic Coupling of Authors Analysis examines whether authors share common references. If two authors' papers cite the same sources, there is a bibliographic link between

these authors. To make the connections more apparent, a filter was applied requiring at least 10 authors per document and 1 citation. This resulted in 1,114 authors. The leading author in this analysis is again "Daniela Rus", with 167 documents, 13,485 citations, and 83,995 connection strength, followed by "David Zhang" with 53 documents, 1,223 citations, and 65,736 connection strength. The visualization of this analysis is presented in Figure 10.

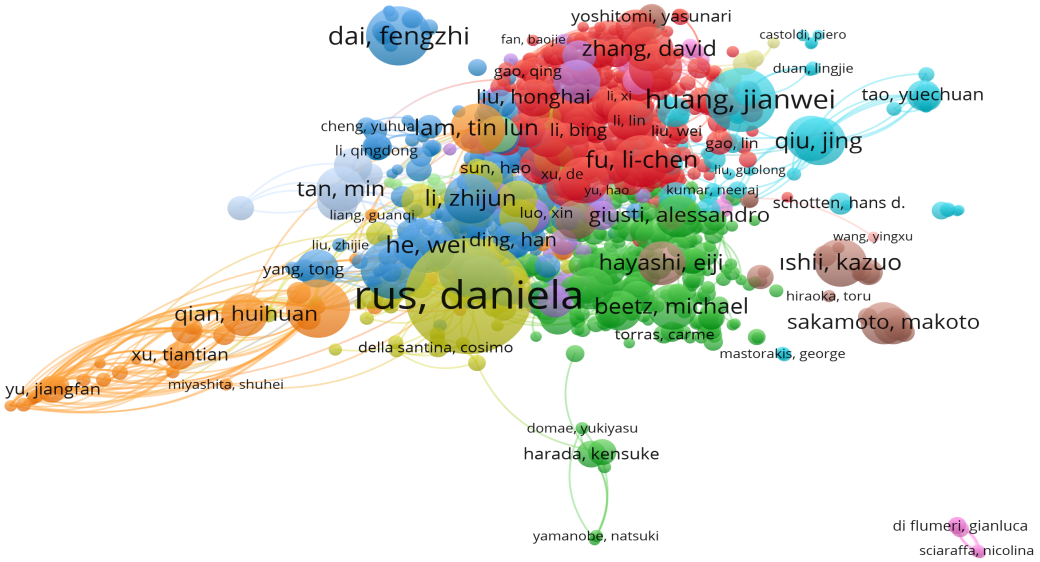

Figure 10. Bibliographic Coupling of Authors Analysis

Another key aspect that gives the article its title is the prediction of data for the year 2025 based on existing trends. To achieve this, a comprehensive forecasting study was conducted using six different time series analysis methods. The models applied are as follows: ARIMA, ETS, Holt-Winters, Polynomial Regression, Naive, and Theta forecast models predictions were generated for each model individually and visualized through graphs in Figure 11.

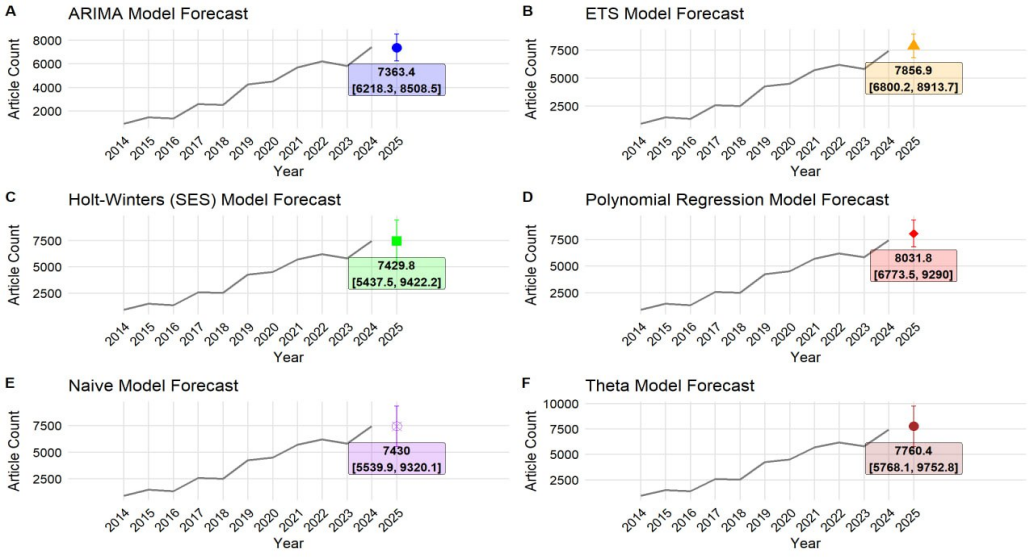

Figure 11. Prediction using various time series models

Figure 11 shows the past yearly article frequencies for the years 2014-2024, together with the predicted article frequency for year 2025 according to six various time series models. Each panel (A-F) corresponds to one model. The gray line shows the trend as observed, and the colored marker shows the point prediction by the model for 2025. Most importantly, a vertical error bar around the 2025 prediction point shows the 95% confidence interval (CI). The interval gives a range within which the true number of publications in 2025 will lie with 95% probability, according to the model and past data. The exact point predictions generated by each time series model for the 2025 publication number, along with their respective 95% confidence intervals, varied between the methods.

The ARIMA model forecasted 7363.4 publications with a 95% CI of [6218.3, 8508.5]. The ETS model resulted in a prediction of 7856.9 with a 95% CI of [6800.2, 8913.7]. For Holt-Winters (SES) model, the forecast was 7429.8 with 95% CI [5437.5, 9422.2]. The Polynomial Regression model had the highest point estimate of the group at 8031.8, its 95% CI [6773.5, 9290]. The naive model's prediction was 7430 with a 95% CI of [5539.9, 9320.1]. Finally, the Theta model projected 7760.4 publications with a 95% CI of [5768.1, 9752.8]. Together, these numbers convey the variation of estimated publication volume in 2025 based on various modeling strategies and measure the uncertainty of each forecast.

Models like ARIMA, ETS, and Polynomial Regression appear to provide relatively narrower confidence intervals, suggesting perhaps less uncertainty in their respective point forecasts than models like Holt-Winters, Naive, and Theta, whose intervals are wider. Overall, all the models predict a continuing upward trend in the number of publications in the year 2025, corroborating the notion of sustained growth in the area of research in AI/ML applications in Mechatronics and related areas.

Figure 12 provides a detailed visualization of the flowchart and operational steps of the models.

Figure 12. Flow chart of time series models

The time spent by the time series used in the analysis is visualized in Figure 13. As shown in the figure, the ARIMA model took the longest time.

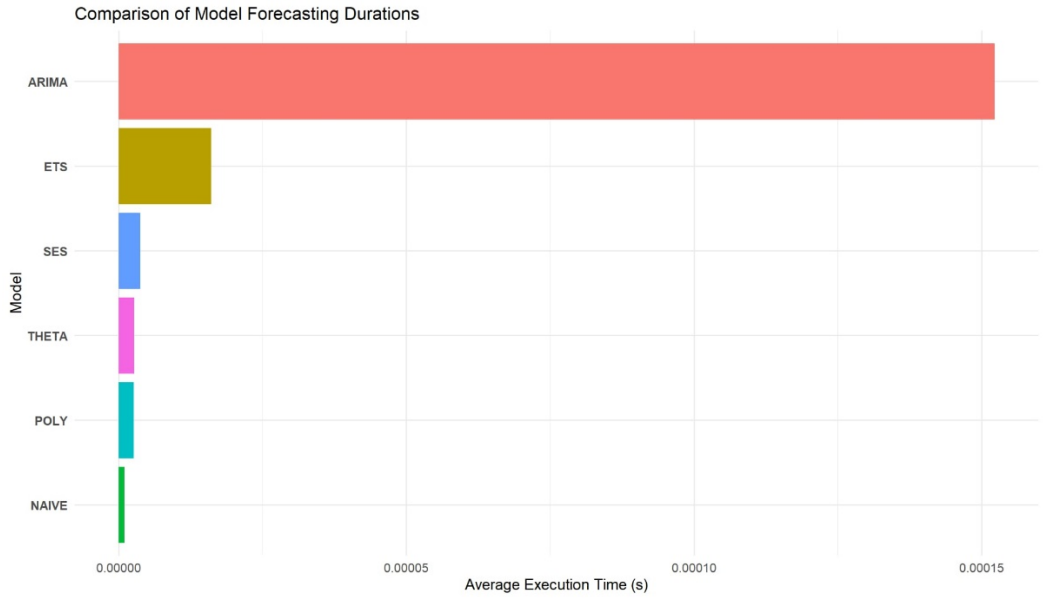

Figure 13. Analysis time of models

The ARIMA model produced a conservative forecast with a moderately wide confidence interval; however, its execution time was significantly longer than the other models [15]. The ETS model yielded the most reliable results, offering a balanced prediction with the narrowest confidence interval and consistent performance [16]. Although the SES model provided a reasonable forecast, its wide confidence interval introduced considerable uncertainty [17]. The polynomial regression model produced relatively high predictions, but its wider confidence interval suggests a risk of overfitting [18]. While the naive model is computationally efficient, its broad prediction interval reflects a high degree of uncertainty [19]. The Theta model offered a reasonable forecast, but its confidence interval was not as narrow as that of the ETS model, placing it behind in terms of precision [20].

Mechatronics engineering-related bibliographic studies in literature often rely on general keyword-based searches. For instance, one such analysis was conducted using the Compendex database, where a broad search was carried out to identify documents related to mechatronics. Additionally, subject guides from the libraries of universities offering mechatronics programs were examined to identify relevant resources [21]. However, the present study differs from such prior work in two key aspects: it utilizes a different database with a more focused search strategy, and it uniquely incorporates the role of AI research within the scope of mechatronics, which was not addressed in previous studies. Moreover, the absence of any predictive analysis in previous studies further highlights the originality of this research and its contribution to the field.

The referenced study analyzed 8,520 records obtained from the WoS Core Collection database covering the period from 1975 to 2023, using text mining methods. The study encompasses related fields such as mechatronics, robotics, integronics, and adaptronics, and examines the conceptual co-occurrence of these fields with Industry 4.0 and 5.0 concepts (including Big Data, AI, IoT, Blockchain, among others). The relationships between terms were analyzed in detail

using the VOSviewer tool [22]. In contrast, this study also utilizes the WoS database but focuses more specifically on the interaction between mechatronics engineering and AI/ML. Moreover, unlike the previous study, it incorporates forward-looking projections, such as forecasting the number of publications for the year 2025, thereby providing a strategic perspective for the field. In these respects, the study fills existing gaps in literature and sheds light on the future development dynamics of the domain.

The research findings indicate that academic works are primarily application-oriented and focus on solving specific problems. Additionally, AI techniques have been found to enhance the efficiency, flexibility, and autonomy of mechatronic systems. This suggests that the integration of these two fields will deepen in the future.

In the review of AI applications in mechatronics engineering, Daniela Rus emerged as the most prominent researcher. It was observed that works by Daniela Rus contributed significantly to research on the mechatronics concept. When evaluating countries, USA and People's Republic of China are recognized as key contributors to producing scientific knowledge in this sector. These dynamic structures, which drive evolving technologies, are shaping the future of AI integration in mechatronics engineering.

Although the year 2025 is not yet complete, the estimation of the number of works planned for completion in AI-related research by the end of the year adds originality to the study by providing a fresh perspective. When forecasting the number of papers for the year 2025, several important criteria should be considered. First, the predicted value should be reasonable - neither too low nor too high - and aligned with the overall trend. Second, the prediction interval should be narrow, as lower uncertainty increases confidence in the forecast. Another key factor is avoiding overfitting, which ensures the model generalizes well to future data. Additionally, while execution time can provide insight into the efficiency of the forecasting method, it is not critically important in this case due to the relatively small size of the training dataset. In this context, the most suitable results are provided by the ETS Model, as it offers a narrower confidence interval and a reasonable forecast.

This bibliographic analysis not only summarizes the scope of existing research but also aims to offer researchers insights into new areas and emerging trends in the field.

4. Conclusion

This study aims to highlight the increasing importance of AI applications in the field of mechatronics engineering and scientific developments at the intersection of these two disciplines. The bibliographic review conducted demonstrates that, particularly in recent years, the role of AI technologies in mechatronic systems has significantly increased. The literature reveals that methods such as ML, artificial neural networks, fuzzy logic, and deep learning are widely used in subfields like robotics, automation, control systems, and predictive maintenance.

In addition to these findings, the study reveals several gaps and opportunities for future research. While the majority of current studies are problem-driven and focused on specific

applications, there is a clear need for more theoretical and methodological investigations in the field. Future research should focus on expanding both quantitative and qualitative studies, particularly in subfields such as autonomous systems, intelligent manufacturing, predictive maintenance, and human–robot interaction. Furthermore, ethical challenges, security concerns, and explainability issues in AI-driven mechatronic systems remain underexplored and deserve more scholarly attention. Interdisciplinary collaboration and industry–academia partnerships are also essential for advancing the field. Finally, although this study includes a 2025 publication forecast, further work could explore scenario-based forecasting and utilize alternative data sources to deepen foresight into the evolution of this interdisciplinary domain.

Ethics in Publishing

There are no ethical issues regarding the publication of this study.

Author Contributions

Tülbiya KARAHAN: Data collection, bibliometric analysis (including co-authorship, keyword co-occurrence, and citation analyses), and visualization.

Mustafa ÇAKIR: Conceptualization, time series analysis, and supervision of the research process; final review and editing of the manuscript.

Mesut YILMAZ: Literature review, interpretation of results, and drafting of the introduction and discussion sections.

Okan ORAL: Preparation of figures and tables, translation and language editing, and support in the preparation of the conclusion and references.

All authors have read and approved the final manuscript.

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