A Bibliometric Analysis of Machine Learning in Image Processing

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Abstract

Machine Learning in Image Processing represents a burgeoning field at the intersection of computer science, artificial intelligence, and image analysis. The exponential growth of research (Compute trends Across Three Eras of Machine Learning, 2022) in this multidisciplinary domain has generated a vast body of knowledge that is both complex and dynamic. This paper presents a comprehensive bibliometric analysis that endeavors to unravel the intricate web of scholarly contributions, identify influential works and authors, map evolving research themes, and elucidate collaboration patterns.Our bibliometric approach offers insights into the most influential publications, prolific authors, and prominent institutions, providing a lens through which to comprehend the trajectory of research.

By examining citation patterns, we assess the impact and reach of research within this domain, offering a valuable perspective on how knowledge is propagated and integrated into subsequent scholarship. In conclusion, this paper not only aids in navigating the multifaceted landscape of Machine Learning in Image Processing but also contributes to the broader discourse on the dynamics of interdisciplinary research in an era of rapid technological advancement.

1. Introduction

In the realm of computer science and artificial intelligence, the intersection of Machine Learning (ML) and Image Processing (IP) has emerged as a captivating and transformative field. This fusion, often referred to as "Machine Learning in Image Processing," transcends traditional boundaries, revolutionizing the way we extract knowledge from visual data. As digital imagery becomes increasingly prevalent in our society, the role of ML in analyzing and interpreting images has profound implications across various domains, including healthcare, autonomous vehicles, surveillance, and entertainment.

1.1 The Digital Visual Revolution

The 21st century has witnessed a digital visual revolution, fueled by the proliferation of cameras in everyday devices, the advent of powerful GPUs, and the availability of vast image datasets. This has accelerated the development of machine learning algorithms capable of not only understanding the content of images but also enhancing their quality, recognizing patterns, and making autonomous decisions based on visual information. Applications range from facial recognition systems that unlock smartphones to complex medical image analysis tools diagnosing diseases and assisting in surgical procedures.

1.2 An Expanding Research Landscape

The past two decades have witnessed an unprecedented surge in research publications related to ML in IP, a testament to its central role in contemporary technological advancements. This body of work spans a wide spectrum, from pioneering algorithms in computer vision to sophisticated deep learning architectures. Researchers worldwide have contributed to this expanding knowledge repository, with a multitude of journals, conferences, and repositories serving as the conduits for disseminating their findings.

2. Background and Context

The exponential growth in research publications related to ML in IP signifies its importance in our technological landscape. This burgeoning field is characterized by its interdisciplinary nature, drawing insights from computer science, machine learning, computer vision, and image processing. Such collaboration across disciplinary boundaries has been instrumental in pushing the boundaries of what is achievable with visual data.

The evolution of research in this domain is both fascinating and complex. The synthesis of ML techniques with image processing has paved the way for groundbreaking achievements, such as image recognition, object detection, and medical image analysis. However, the sheer volume of research output can make it challenging to grasp the key themes, influential contributors, and emerging trends within this expansive field.

3. Research Gap

While numerous studies have explored the applications and methodologies of Machine Learning (ML) in Image Processing (IP), a comprehensive bibliometric analysis of this rapidly evolving field is conspicuously absent from the existing literature. This research gap necessitates a closer examination of the intricate web of scholarly publications, citations, and collaborations that underpin the landscape of ML in IP.

3.1 Understanding the Research Landscape

Machine Learning in Image Processing represents a multidisciplinary domain where computer science, artificial intelligence, image processing, and data analysis converge. Within this amalgamation of knowledge, a multitude of research threads have emerged, each contributing to our understanding of how ML can be harnessed to analyze, enhance, and interpret images. These threads range from fundamental algorithmic developments to practical applications that impact diverse sectors, including healthcare, automotive technology, and entertainment.

3.2 The Challenge of Scale and Complexity

The sheer volume of research output in this field, coupled with its ever-expanding scope, presents a formidable challenge for scholars, practitioners, and policymakers alike. Keeping pace with the latest trends, identifying seminal works, and recognizing the thought leaders who drive innovation have become increasingly complex endeavors. This complexity arises not only from the quantity of publications but also from the diversity of research methodologies, datasets, and application domains.

3.3 Bibliometrics as a Lens

To address this challenge, this study employs bibliometric analysis as a powerful lens through which to scrutinize the ML in the IP research landscape. Bibliometrics is the systematic analysis of bibliographic information, such as citations,

co-authorships, and publication trends, to uncover hidden patterns, relationships, and insights within the scholarly communication ecosystem.

3.4 Closing the Knowledge Gap

In essence, this bibliometric analysis seeks to bridge the knowledge gap that currently exists in understanding the intricate landscape of Machine Learning in Image Processing. By providing a comprehensive overview of the research outputs, influential players, collaborative networks, and knowledge dissemination channels within this field, this study offers a valuable resource for researchers, policymakers, and practitioners.

Furthermore, it contributes to the broader discourse on the dynamics of interdisciplinary research in the digital age. It illuminates the pathways through which knowledge is created, shared, and built upon, offering valuable insights into the evolution of a field that continues to redefine our relationship with visual data.

In the subsequent sections of this paper, we will delve into the methodology employed for our bibliometric analysis, followed by the presentation and discussion of our findings. By the conclusion of this paper, readers will gain a comprehensive perspective on the landscape of Machine Learning in Image Processing, fostering a deeper appreciation for its impact and potential.

4. Purpose and Objectives

The primary objective of this study is to employ bibliometric techniques to:

1. Identify and analyze the most influential publications, authors, and institutions in the field: Through citation analysis and co-authorship networks, we intend to shed light on the key players shaping the discourse.

2. Map the evolution of research themes and trends over time: By categorizing and visualizing research topics, we can trace the evolution of key themes, identifying seminal works that have driven innovation.

3. Uncover collaboration patterns among researchers and institutions: Collaborative networks are a cornerstone of scientific progress. Understanding the dynamics of collaboration in this field can offer insights into knowledge dissemination.

4. Investigate the dissemination and impact of research through citation analysis: Citation patterns provide a lens through which we can evaluate the influence and relevance of specific works, authors, and institutions.

5. Offer a comprehensive overview that can guide researchers, policymakers, and practitioners in navigating the multidimensional landscape of ML in IP: By synthesizing the findings, we aim to provide a valuable resource for those seeking to understand the state of research and its implications.

5. Methodology

5.1 Data Collection

Data for this bibliometric analysis was obtained from the Scopus database. A search query was formulated using relevant keywords to capture scholarly publications related to Machine Learning in Image Processing.

5.2 Data Analysis and Visualization

The collected data was cleaned and formatted in Microsoft Excel. Basic descriptive statistics were generated to understand publication trends. Power BI and Tableau were used to create interactive visualizations, representing publication trends, collaboration networks, and keyword co-occurrence patterns.

Co-authorship networks were constructed and visualized using VOSviewer to identify prolific authors and research collaborations. Keyword co-occurrence analysis was also conducted using VOSviewer to uncover key research themes and their evolution over time.

5.3 Interpretation and Insight Generation

Results from the data analysis were interpreted to derive insights. These insights were used to answer research questions and meet study objectives, including identifying influential publications, authors, institutions, and mapping research trends. We will examine the results in the following section.

5.4 Ethical Considerations

The study adhered to ethical guidelines, focusing on publicly available, de-identified scholarly publications to protect privacy and consent. Proper citation and acknowledgment of data sources and analysis tools were observed.

6. Results

6.1 Total number of research citations for various publishers

This study in Image Processing investigated the most cited publishers in this field of Machine Learning in Image Processing. The results showed that the Institute of Electrical and Electronics Engineers Inc. (IEEE) is the most cited publisher (As shown in Table 1.) with 19 citations. This is followed by Springer Science and Business Media Deutschland GmbH (9 citations), Elsevier B.V. (5 citations), MDPI (5 citations) and IOP Publishing Ltd (3 citations).However, there is a wide variation in the number of citations received by different publishers, suggesting that the quality of the research published by each publisher varies. Here, the total number of citations Counts to 58, which is a relatively less number of citations as compared to other Machine Learning fields like Computer Vision, Reinforcement Learning, etc.

Table 1. Count of Number of citations from different Publishers.

Publisher name	Number of citations
Institute of Electrical and Electronics Engineers Inc.	19
Springer Science and Business Media Deutschland GmbH	9
Elsevier B.V.	5
MDPI	5
IOP Publishing Ltd	3
Taylor and Francis Ltd.	3
Association for Computing Machinery	2
BioMed Central Ltd.	2
Elsevier	2
Elsevier Ltd	2
European Association of Geoscientists and Engineers, EAGE	2
IEEE Computer Society	2
John Wiley and Sons Inc	2
Total	**58**

Source: Own work

In the current research, The average number of Citations Published in Machine Learning in Image Processing is around 4.5. Some of the publishers with the fewest citations are Elsevier, EAGE, BioMed Central Ltd, etc. all with 2 citations each.

6.2 Distribution of research citations for prominent research papers

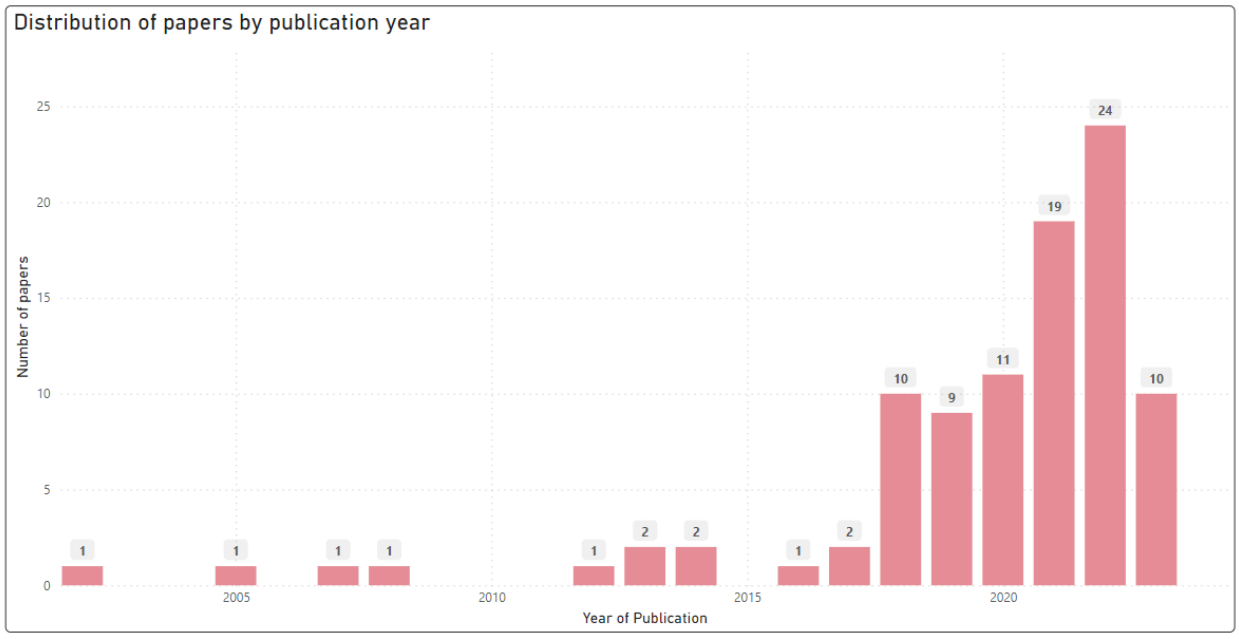
Publishers' citations eventually connect to good publishing authors and quality of the articles. This study investigated the most cited articles in the field of image processing and machine learning. The results showed that the article titled "Machine learning-based image processing for on-line defect recognition in additive manufacturing" has the highest number of citations (214). This suggests that this article is of high quality and has been widely read and cited by other researchers. The article titled "The State-of-the-art Review on Applications of Intrusive Sensing, Image processing techniques and Machine learning methods in Pavement monitoring and analysis" has the second highest number of citations (100) followed by "Successful leveraging of image processing and machine learning in seismic structural interpretation: A review" has the third highest number of citations (81).

Title	Authors	ISSN	No. of citations
Machine learning-based image processing for on-line defect recognition in additive manufacturing	Caggiano A.; Zhang J.; Alfieri V.; Caiazzo F.; Gao R.; Teti R.	00078506	214
The State-of-the-Art Review on Applications of Intrusive Sensing, Image Processing Techniques, and Machine Learning Methods in Pavement Monitoring and Analysis	Hou Y.; Li Q.; Zhang C.; Lu G.; Ye Z.; Chen Y.; Wang L.; Cao D.	20958099	100
Successful leveraging of image processing and machine learning in seismic structural interpretation: A review	Wang Z.; Di H.; Shafiq M.A.; Alaudah Y.; Alregib G.	1070485X	81
Image processing and machine learning in the morphological analysis of blood cells	Rodellar J.; Alférez S.; Acevedo A.; Molina A.; Merino A.	17515521	67
Early weed detection using image processing and machine learning techniques in an australian chilli farm	Islam N.; Rashid M.M.; Wibowo S.; Xu C.-Y.; Morshed A.; Wasimi S.A.; Moore S.; Rahman S.M.	20770472	56
Machine learning approaches for predicting high cost high need patient expenditures in health care 08 Information and Computing Sciences 0801 Artificial Intelligence and Image Processing	Yang C.; Delcher C.; Shenkman E.; Ranka S.	1475925X	47
An in situ probe for on-line monitoring of cell density and viability on the basis of dark field microscopy in conjunction with image processing and supervised machine learning	Wei N.; You J.; Friehs K.; Flaschel E.; Nattkemper T.W.	10970290	37
Machine learning for high-throughput field phenotyping and image processing provides insight into the association of above and below-ground traits in cassava (Manihot esculenta Crantz)	Selvaraj M.G.; Valderrama M.; Guzman D.; Valencia M.; Ruiz H.; Acharjee A.	17464811	36
Non-local morphological PDEs and p-laplacian equation on graphs with applications in image processing and machine learning	Elmoataz A.; Desquesnes X.; Lezoray O.	19324553	35
Combining image processing and machine learning to identify invasive plants in high-resolution images	Baron J.; Hill D.J.; Elmiligi H.	01431161	27
Machine learning ensemble with image processing for pest identification and classification in field crops	Kasinathan T.; Uyyala S.R.	09410643	26
Total			**726**

Overall, the above data table (Table 2.) shows that there is a growing interest in the field of image processing and machine learning. The articles have been cited by a significant number of researchers, which suggests that they are of high quality. The articles cover a wide range of topics, from invasive plant identification to defect recognition in additive manufacturing. This suggests that image processing and machine learning are being used in a variety of applications.

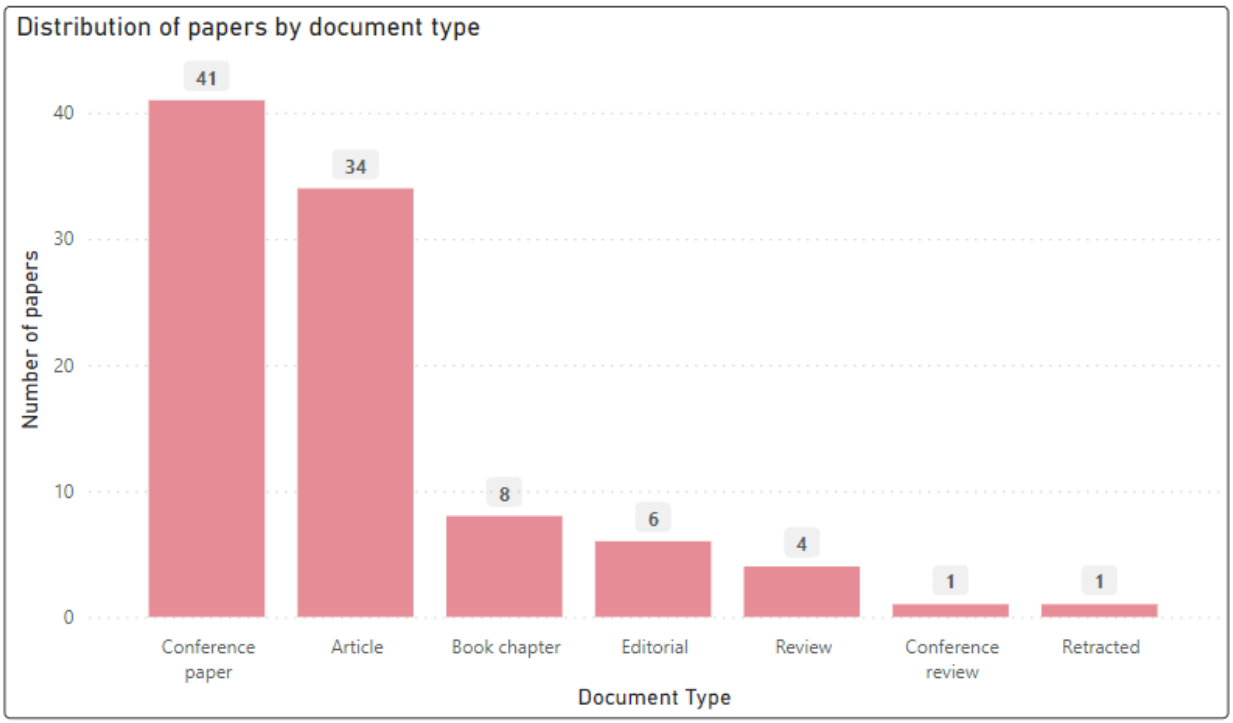
However, there are some limitations to this study. First, the study only considers a small sample of articles. A larger sample would be needed to make more reliable conclusions. Second, the study only considers citations from a single database. Citations from other databases may not be included. Third, the study does not consider the quality of the journals in which the articles are published.
Despite these limitations, the study provides some insights into the research in the field of image processing and machine learning. These insights can be used by researchers to identify promising areas of research and to stay up-to-date on the latest developments in the field.

6.3 Number of publications throughout the years



The above bar chart shows the number of research papers by the year of publication. The number of papers in this field has been steadily increasing over the past few years. From 2002 up until the year 2015, there were only 9 studies done but in the following 8 years, the number rose to 86 papers. This suggests that there is a growing interest in publishing titles in the field of Image processing which is a positive development for the publishing industry. This is likely to lead to encourage researchers to pursue this topic of interest

6.4 Distribution of the type of publication for the research papers

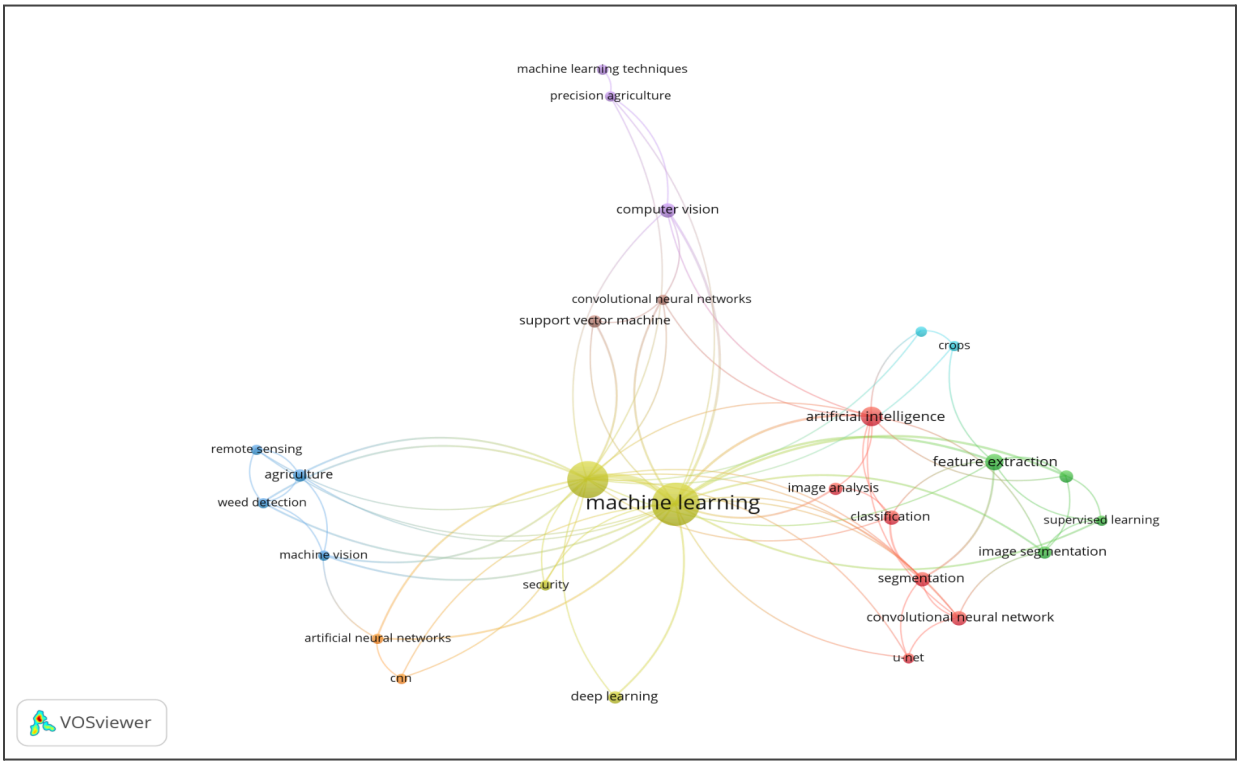


The bar graph displays the number of research papers by the document type they were presented in. The most common document type is conference papers, with 41 titles followed by articles with 20 titles. The other document types, though less common, are essential contributors to the bunch. The other types include book chapters, editorials, reviews, conference reviews, and retracted papers.

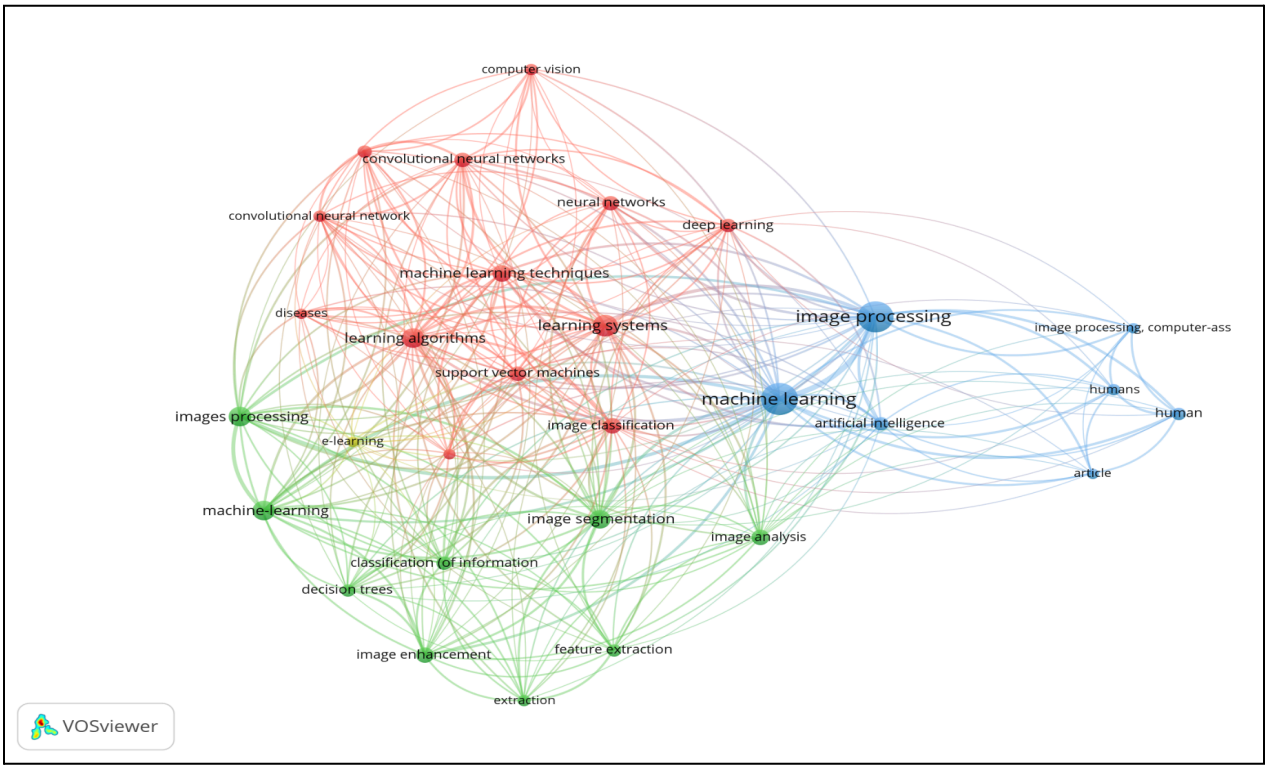
The high number of conference papers suggests that there is a strong emphasis on the leading presentation methodology preferred by researchers followed by articles published in peer-reviewed journals.

6.5 Bibliometric network to analyze author keywords

The analysis of index keywords focuses on identifying the words that frequently appear together in the authors' studies. To construct and visualize the bibliometric network, we employed the WOSviewer software. The subsequent figure illustrates a network of the authors' keywords generated within WOSviewer. Noteworthy attributes, including the size and color of circles, font size, scaling, and colored lines, are used to convey the strength of relationships between these keywords.



6.6 Bibliometric network to analyze index keywords



7. Conclusion:

In conclusion, our bibliometric analysis has shed light upon the dynamic, ever-evolving and expansive landscape of Machine Learning in Image Processing. Through the lens of Scopus data and advanced analytical tools such as PowerBI, WOSviewer and excel, we have unveiled key trends, influential publications, prolific authors, and collaborative networks within this multidisciplinary field.

This study underscores the increasing significance of Machine Learning in Image Processing and the challenges posed by its scale and complexity. It offers valuable insights to researchers, policymakers, and practitioners seeking to navigate this evolving domain. Moreover, it contributes to the broader understanding of how interdisciplinary research shapes the knowledge landscape in the digital age.

As Machine Learning continues to transform the field of Image Processing, this bibliometric analysis serves as a foundational resource, fostering a deeper appreciation for the impact and potential of these technologies in our visual data-driven world.

8. References

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