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Systematic Literature Review on Multivariate Analysis: Research Trends, Methods and Frameworks

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ABSTRACT
The focus of this research is to look at the development of analytical multivariate statistical research from 2000-2025. This study tries to identify fundamentally and thoroughly which journal-related multivariate analysis developments are the most significant, the most influential researchers, what research topics are developing, the types of datasets and methods used in multivariate analysis. Bibliometric analysis is used to look systematically based on relevant information from scientific publications, multivariate analysis articles accessed through IEEE Explore and Scopus. In the bibliometric analysis stage using Vosviewer, as many as 483 journals were analyzed for the number of citations, analysis of interconnected keywords and others. Therefore, it was found that the most significant journals were IEEE Transactions on Biomedical Engineering, IEEE Transactions on Geoscience and Remote Sensing. The most influential authors are B. Aiazzi; S. Baronti; M. Selva; with a total of 643 citations writing about the regression multivariate adopted to improve spectral quality. Emerging Research Topics Multivariate Time Series Forecasting. Methods that often appear are Regression, Correlations, Clustering, Principle Component Analysis...

INTRODUCTION

There is a lot of research that has been done on multivariate analysis applied in various fields of science (Adegoke et al., 2019; Georga et al., 2013; Lv et al., 2020; Mujahid et al., 2017; Raj et al., 2020; Riaz et al., 2019; Sahu et al., 2016; Tandeo et al., 2009). There is still very little research done on the literature review on statistics as a whole (Lim, Yong B. et al., 2016; Marchy & Juandi, 2023) Although there have been some studies on the multivariate analysis review literature (James & McCulloch, 1990; Krzanowski, 2014). But very few have conducted a literature review on multivariate analysis as a whole.

Many research phenomena or problems involve many variables that should be analyzed simultaneously. Research involving more than one or two variables is called multivariate analysis (Deepa et al., 2020; Ding et al., 2020; Karadayi et al., 2020; Khan et al., 2018). In simple terms, variables are said to be multivariate if the variables are observed simultaneously or simultaneously (Santoso, 2010). If the observation of the research variables is not carried out simultaneously, then the right analysis is univariate analysis. The second characteristic of multivariate analysis is the data obtained from observations in which the data analysis is carried out simultaneously, where the variables are interconnected, both theoretically and empirically (Raj et al., 2020; Rezaeieh et al., 2020; Riaz et al., 2019).

In multivariate analysis, the interpretation of the results of the analysis is carried out comprehensively or comprehensively (Georga et al., 2013; Shen et al., 2020; Succetti et al., 2020; Sun et al., 2020). Multivariate analysis can be said to be the use of statistical methods related to several variables whose measurements are carried out

simultaneously from each research object, with a simultaneous analysis process and comprehensive interpretation implementation. So that the important key to multivariate analysis is research in which there are relationships, so the analysis process must be carried out simultaneously (Solimun et al., 2017).

The development of multivariate statistics is very rapid, this is because it is supported by the advancement of statistical software in its calculation and the increasing complexity of data problems that must be calculated multivariate , such as (Toubeau et al., 2019; D. Wang et al., 2018; Zeng et al., 2016; Zhao et al., 2021) which tells a lot about deep learning, Neural network and others. In this study, we will look at the development of multivariate statistical analysis research for the last 25 years from 2000 to 2025 in Indonesia and other countries using the bibliometric analysis method. More specifically, this study has the following objectives: RQ1 Multivariate journal Which analysis is the most significant? RQ2 Who is the most influential researcher in the field of Multivariate Analysis? RQ3 What kind of research topics did researchers choose in the field of Multivariate Analysis? RQ4 What types of datasets are most used for Multivariate Analysis? RQ5 What methods are often used for Multivariate Analysis?

This means that this research tries to identify fundamentally and comprehensively the development of Multivariate Analysis research applied in various fields of science such as in the fields of computer science, health, medicine, and so on. So that the development of methods, datasets, and multivariate analysis topics can be seen clearly.

This research has four parts. The first contains an introduction that tells in an outline and in depth the reasons why this topic was raised. Next is the literature review, this is about reviewing the relevant literature related to Multivariate Analysis. Then the research methodology was also presented and how the analysis techniques of the bibliometrics were discussed. Furthermore, the findings of the research continued with the discussion and the last part is the Conclusion.

LITERATURE REVIEW

Multivariate Statistics

Statistics is one of the fields of science required in various scientific fields that involve data processing or data analysis. Statistics itself is a science and method used to collect, organize, present, analyze, and interpret data into information to support effective decision-making (Suharyadi, 2015). Statistics is practical knowledge and as an applied science that plays an important role in the application of methods and concepts to data analysis, experimentation activities, as well as observation and inference.

However, many research phenomena or problems involve many variables that should be analyzed simultaneously. Research involving more than one or two variables is called multivariate analysis (Santoso, 2010). In simple terms, there are four characteristics of multivariate digging variables

1. Variables can be said to be multivariate if the variables are observed simultaneously or simultaneously. If the observation of the research variables is not carried out simultaneously, then the right analysis is univariate analysis.
2. The second characteristic of multivariate analysis is that data obtained from observations is thus analyzed simultaneously, where the variables are interconnected, both theoretically and empirically.
3. The third characteristic of multivariate analysis is the interpretation of the results of the analysis carried out comprehensively or comprehensively.

4. Multivariate analysis can be said to be the use of statistical methods related to several variables whose measurements are carried out simultaneously from each research object, with a simultaneous analysis process and comprehensive interpretation.

So that the important key to multivariate analysis is research in which there are relationships, so the analysis process must be carried out simultaneously (Solimun et al., 2017). The development of multivariate analysis is currently very rapid, both in theory, method and application. This is because his research generally involves many variables that are measured or observed simultaneously, and very rarely that depend on only one variable. In addition, in line with the development of computing technology with the development of computers and Artificial Intelligence are easily accessible throughout the world and at relatively affordable prices. Thus, the complexity constraint in the multivariate analysis calculation process can be overcome.

Bibliometric Analysis

Bibliometric analysis is not only used to evaluate performance, but also for mapping. Mapping is a process that allows one to recognize the elements of knowledge and their configuration, dynamics, mutual dependencies, and interactions (Madjido, 2021). Knowledge mapping in bibliometrics is used for technology management purposes, including the definition of research programs, decisions regarding activities related to technology, the design of knowledge base structures, and the creation of education and training programs. In relation to bibliometrics, science mapping is a method of visualizing a field of science. This visualization is done by creating a landscape map. In the map, science topics will appear by entering bibliographic data, keywords, citations and others (Skute, 2019).

The bibliometric method uses bibliographic data from publication databases to build a picture of the structure of the scientific field (Zupic & Čater, 2015). Bibliometric analysis is a study based on the assumption that researchers must communicate the results of their research to other researchers. Because this will provide scientific development if researchers carry out joint activities to study certain research topics (Tupan et al., 2018).

Systematic review analysis is a method of understanding large amounts of information, and is a means of contributing to answers to questions about what works and what doesn't, and many other types of questions (Petticrew & Roberts, 2006). In addition, this method can also be used to map areas of uncertainty and identify where little or no relevant research has been conducted, but where new studies are needed (Petticrew & Roberts, 2006).

Bibliometric analysis is based on relevant information about scientific publications that can be retrieved from specific data sources. The information is usually organized in the appropriate search field. Relevant information from bibliometric databases on scientific publications, such as Source Identification (such as Journal Title, Volume, Page), Author Name, Company Address, Reference, Document Type, Title, Keyword, Abstract, Subject Title, Controlled term, Acknowledgement. (Glanzel, 2003).

While in (Arksey & O'Malley, 2005) The relevant information used is as follows: Author, year of publication, location of study, Type of intervention and comparison (if any) duration of intervention, Study population, Research objectives, Methodology, Outcome of the results.

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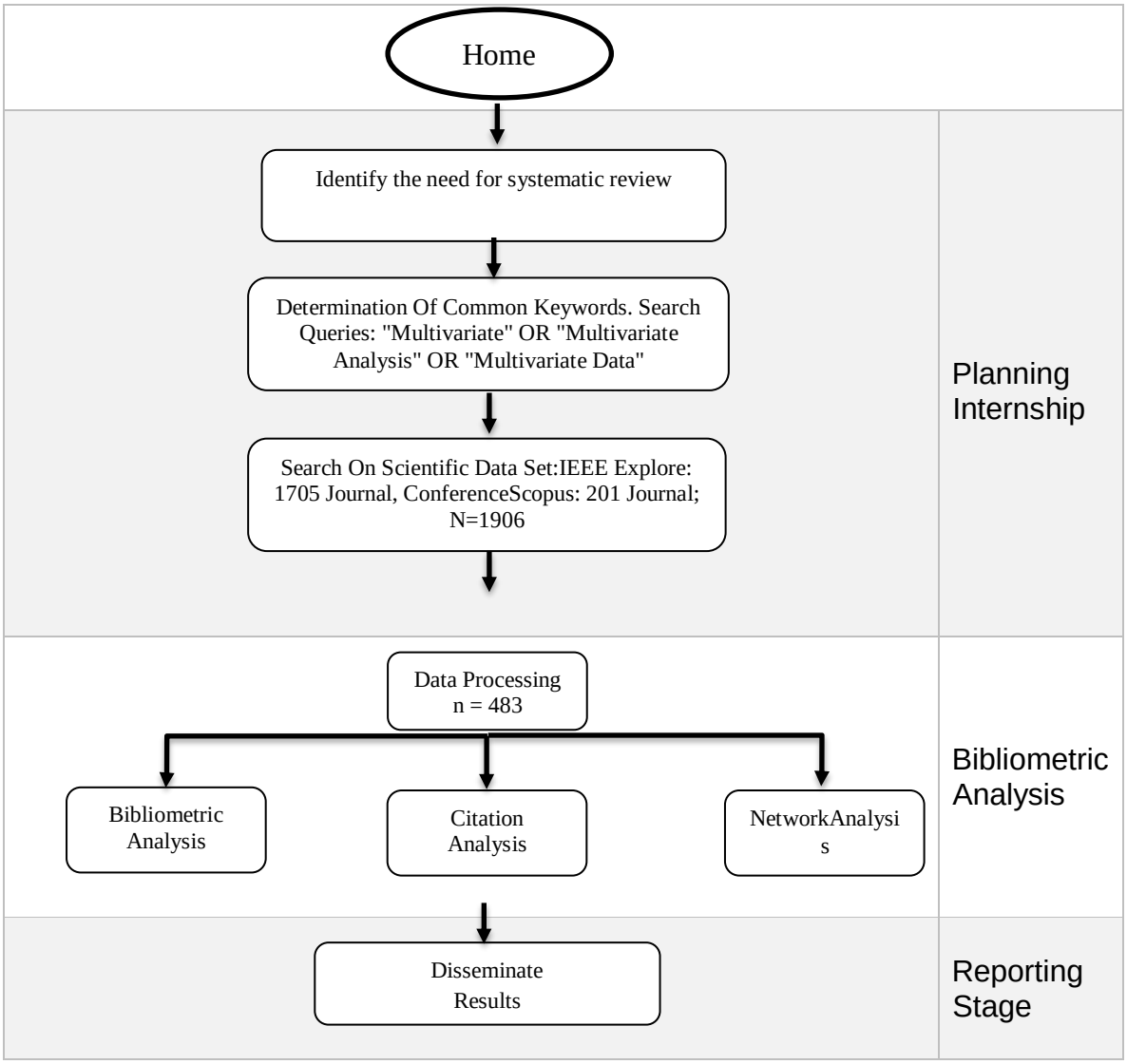
RESEARCH METHODOLOGY

This type of research is descriptive research using bibliometric analysis. This study uses data from scientific publications in the field of multivariate statistics indexed on the IEEE Explore and Scopus websites from 2000-2022. Steps to be taken in mapping science with bibliometric or systematic review methods according to (Zupic & Čater, 2015) Broadly speaking, *Research Design, Compilation Of Bibliometric Data, Analysis, Visualization, Interpretation.* However, in this study, the research stage was inspired by several previous studies (Karatuğ et al., 2023; Watts, 2015) which is seen in the image below:



Source: Processed Research Data, *2024*

Figure 1. Systematic Stages of Literature Review

The research began by reviewing that a systematic approach of literature review would be used to look at the development of multivariate statistical analysis. This is because the systematic approach of literature review is a series of processes of identifying, assessing and interpreting all research evidence with the aim of answering certain research questions (Wahono, 2015).

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As in Figure 1, the research stage consists of 3 stages, namely the Planning Stage, Bibliometric Analysis, and Reporting Stage. At the Planning Stage or research planning, it begins by identifying the need for this research, namely bibliometric analysis in the development of multivariate statistical analysis. The next stage is the determination of common keywords to be used on search engines. The keywords used with the following syntax are "Multivariate" OR "Multivariate Analysis" OR "Multivariate Data". Next is to search on the IEEE Explore webside and with the keywords that have been determined, there are 1705 Journals and Conferences that appear related to multivariate analysis. The next search was on Scopus and found 201 multivariate journals with a total of 1906 journals and conferences.

The second stage of Bibliometric Analysis begins with the selection of the data that has been obtained so that from 1906 data, only 483 data can be obtained. The first criterion for data selection is that articles are used only articles that are published in journals and not in conferences, then the time of publication of articles from 2000 to 2022, articles that are published in English. Data selection is also assisted by using software, namely OpenRifine software. Furthermore, biblimetric analysis was carried out using VosViewer software using Autor Keyword so that citation analysis and Network analysis could be seen. The final stage in this research is to make a report on the results of the research which will later be published in international journals.

Research Question

Research Question (abbreviated as RQ) is a research question that is determined to keep the review focused (Wahono, 2015). The Research Question in this study has been modified from the research (Wahono, 2015) are as follows:

ID	*Research Question*	Motivation
RQ1	Which journal is the most significant Multivariate Analysis journal?	Identification of the most significant journals in the field of Multivariate Analysis
RQ2	Who are the most influential researchers in the field of Multivariate Analysis?	Identify the most active and influential researchers who contributed more to the reset of Multivariate Analysis
RQ3	What kind of research topics are chosen by researchers in the field of Multivariate Analysis	Identify research topics and trends in Multivariate Analysis
RQ4	What types of datasets are most used for Multivariate analysis?	Identification of common datasets used in Multivariate analysis methods
RQ5	What methods are often used for Multivariate analysis	Identify opportunities and trends for methods from Multivariate analysis

Source: Processed Research Data, 2024

RESULT AND DISCUSSION

RQ1 Journal of the Most Significant Multivariate Analysis

The distribution of data from 2000 to 2022 shows that the development of applied research in multivariate analysis has increased significantly and is still in demand by researchers. From Figure 2, it can be seen that more research has been published since 2010 until now. This is due to the increasingly complex development of computerization and the internet that requires thorough and complex data analysis (Chen & Wang, 2022). So that in the future multivariate analysis research in various fields will continue to develop and is very interesting to do.

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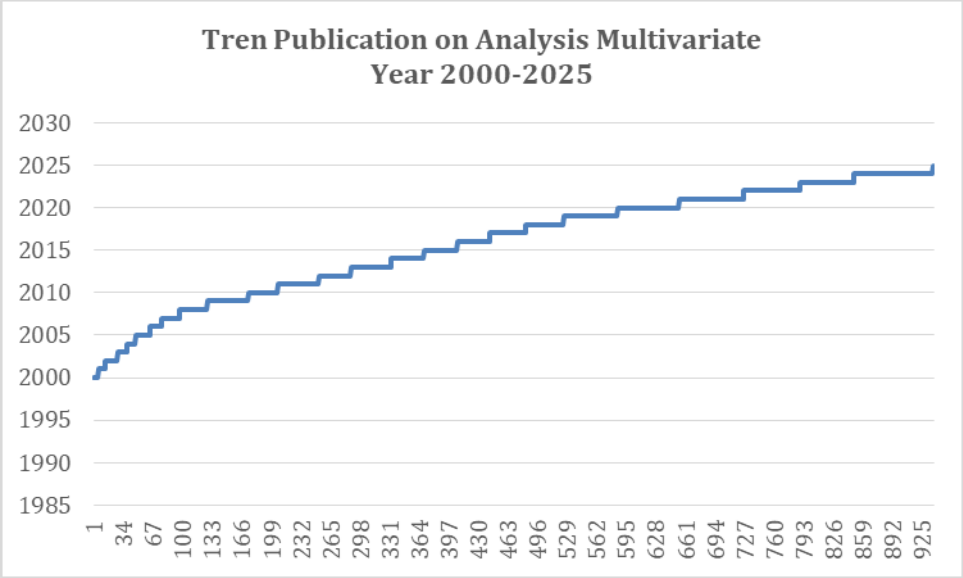

Figure 2. Multivariate Research Trends Analysis from 2000-2025

The first Reseach Question is which Journal is the most significant application of Multivariate Analysis. Multivariate analysis is applied in various fields of science such as computer science, engineering, health, medicine and others. Of the 483 journals with more than 1000 articles, the author took the highest number of articles and the highest number of citations, 29 journals were found that applied multivariate analysis. The most citations are in the IEEE Transaction on Biomedical Engineering journal with 12 articles and 1037 citations.

Table 1. Number of Journal Publications and Citations

NO.	SOURCE TITLE	QUANTITYARTICLES	NUMBER OF CITATIONS
1	IEEE Access	50	625
2	IEEE Communications Letters	43	47
3	IEEE Geoscience and Remote Sensing Letters	36	145
4	IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing	19	240
5	IEEE Latin America Transactions	18	23
6	IEEE Sensors Journal	16	229
7	IEEE Transactions on Automatic Control	12	478
8	IEEE Transactions on Biomedical and Health Informatics	12	1037
9	IEEE Transactions on Circuits and Systems for Video Technology	11	62
10	IEEE Transactions on Communications	11	273
11	IEEE Transactions on Control Systems Technology	10	156
12	IEEE Transactions on Cybernetics	10	434
13	IEEE Transactions on Geoscience and Remote Sensing	10	828
14	IEEE Transactions on Image Processing	9	423
15	IEEE Transactions on Industrial Electronics	9	128
16	IEEE Transactions on Industrial Informatics	9	170
17	IEEE Transactions on Information Theory	9	693
18	IEEE Transactions on Instrumentation and Measurement	8	259

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19	IEEE Transactions on Knowledge and Data Engineering	8	337
20	IEEE Transactions on Medical Imaging	8	181
21	IEEE Transactions on Neural Networks	7	296
22	IEEE Transactions on Neural Networks and Learning Systems	7	177
23	IEEE Transactions on Neural Systems and Rehabilitation Engineering	7	733
24	IEEE Transactions on Pattern Analysis and Machine Intelligence	7	540
25	Journal of Statistical Software	5	230
26	Journal of Computational and Graphical Statistics	5	306
27	Multilevel Analysis: Techniques and Applications: Second Edition	5	168
28	Multivariate Behavioral Research	5	475
29	Neural Networks	5	420

Source: Processed Research Data, 2025

Table 1 shows that multivariate analysis is applied in various journals with the most articles found in the IEEE Acces journal, which is an interdisciplinary journal covering various fields of science. Furthermore, multivariate analysis is also widely applied in the field of computer science IEEE Transactions on Neural Networks, IEEE Transactions on Neural Networks and Learning Systems, IEEE Transactions on Neural Systems and Rehabilitation Engineering, Journal of Computational and Graphical Statistics. In the field of Health, IEEE Transactions on Biomedical and Health Informatics, IEEE Transactions on Medical Imaging and many other journals.

RQ2 Most Influential Researcher in the Field of Multivariate Analysis

Table 2. Authors with the Highest Number of Citations

NO.	WRITER	NUMBER OF CITATIONS
1.	B. Aiazzi; S. Baronti; Mr. Selva	643
2.	N. your Rehman; D. P. Mandic	313
3.	D. P. Mandic; N. u. Rehman; Z. Wu; N. E. Huang	302
4.	Y. Ma; H. Derksen; W. Hong; J. Wright	270
5.	S. Chambon; Mr. N. Galtier; P. J. Arnal; G. Wainrib; A. Gramfort	219
6.	S. -H. Park; O. Simeone; O. Sahin; S. Shamai	214
7.	Diansheng Guo; Jin Chen; A. M. MacEachren; The Liao	206
8.	A. Bhattacharyya; R. B. Pachori	198
9.	B. Ghosh; B. Basu; Mr. O'Mahony	182
10.	N. C. Sagias; G. K. Karagiannidis	180

Source: Processed Research Data, 2024

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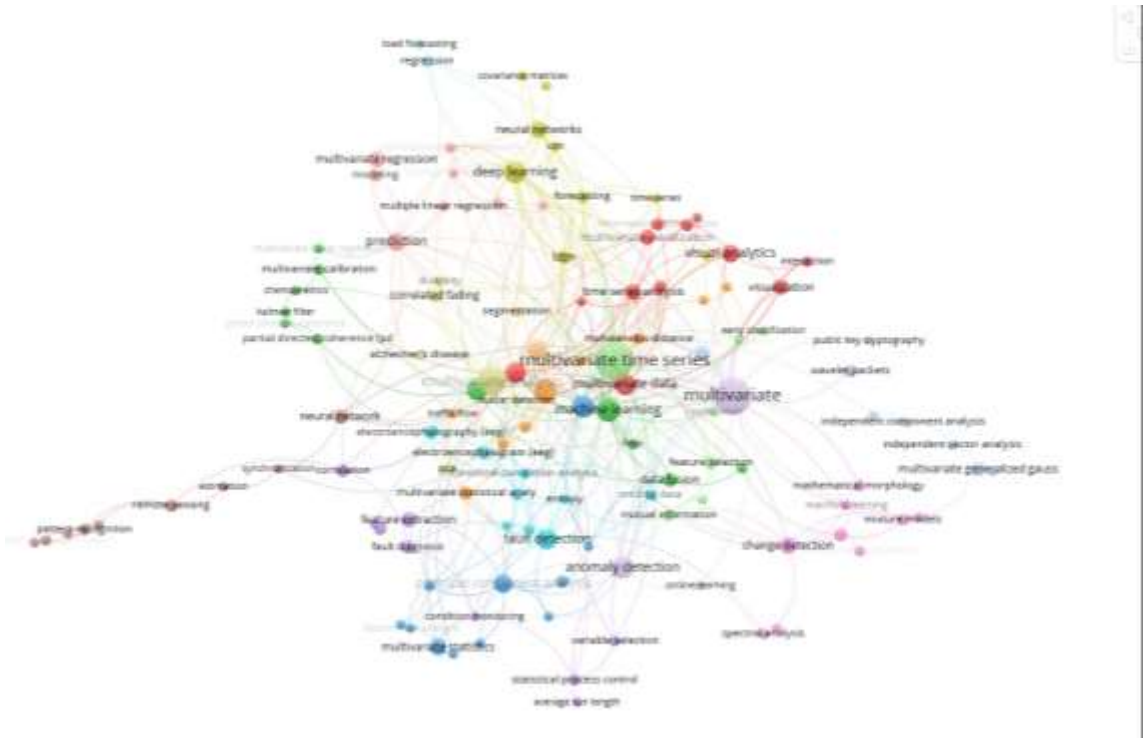
With the systematic method of literature review, the authors who contribute the most and have an influence on Multivariate Analysis research can be detected well. The best authors are seen from the most cited articles. Table 2, shows the authors who are cited the most in the Multivariate study be B. Aiazzi; S. Baronti; Mr. Selva; with a total of 643 citations writing about the multivariate regression adopted to improve spectral quality (Aiazzi et al., 2007). Furthermore, research conducted by N. your Rehman; D. P. Mandic with a total of 313 citations with the research topic Multivariate empirical mode decomposition algorithm (Ur Rehman & Mandic, 2011).

RQ3 Research Topics Chosen by Researchers in the Field of Multivariate Analysis

Broadly speaking, there are 3 divisions of research topics that can be taken in figure 3 below. The first topic that comes up is about Methods, the second is about Dataset Analysis, and the Application of Multivariate data.

The word Multivariate data (Dataset Analysis) is connected with several other keywords Visualization, Visual Analytics, Information Visualization, Time Series, Clustering, Diversity, Change Detection, Principal Component Analysis, Time-Frequency Analysis, Empirical Model Decomposition, Correlation.



Source: Processed Research Data, 2024

Figure 3. Lexical Network Analysis

The word Multivariate Time Series (Data application) is connected by several words, including variable Selection, Data Mining, Anomaly Detection, Machine Learning, Clustering, Regression, Prediction, Claasification, Copula, Forecaseting, Convolutional Neural Network, Deep leaning, Feature Selection, Mahalanobis Distance, Change Detection, Missing data, Time Series Prediction, Electroenchephalography (eeg). The topic that comes up the most is Multivariate Time Series forecasting, which researches

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the forecasting of time series data in a multivariate manner in various fields such as Health, multimedia, finance, biomedicine, computing, and others.

What kind of research topics are chosen by researchers in the field of Multivariate Analysis

Figure 4. Multivarite Research Topics

Figure 5. Multivariate Time Series Research Topics

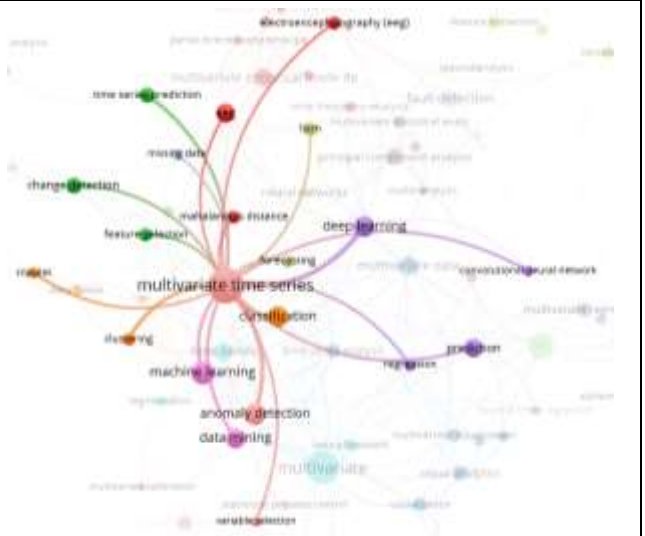


Figure 6. Multivariate Data Research Topics

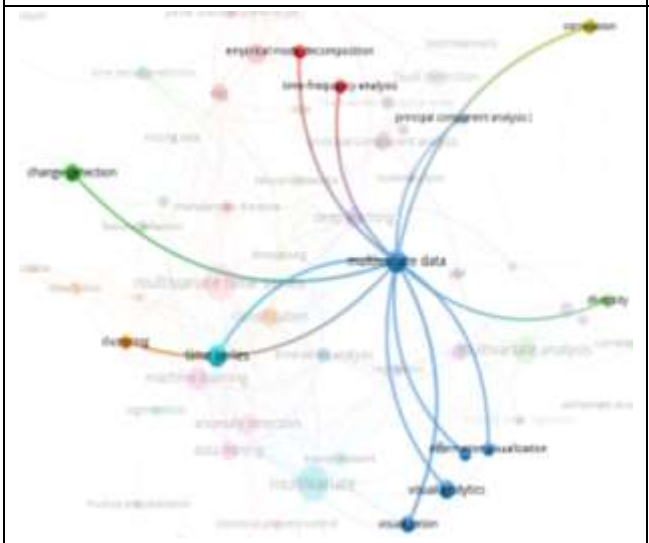
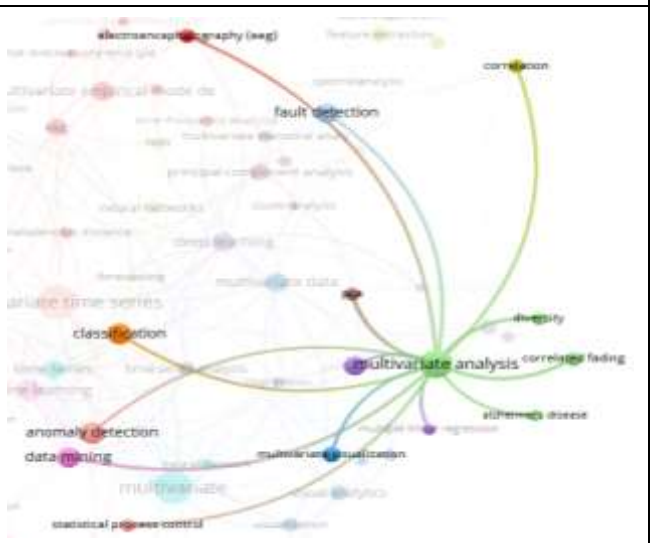


Figure 7. Multivariate Analysis Research Topics



Source: Processed Research Data, 2024

Meanwhile, the word Multivariate Analysis (Method) is connected to the words Statistical Process Control, Multivariate Visualization, Data Mining, Anomaly Detection, Alzheimer's Disease, Classification, Correlated Failing, Diversity, PCA, Fault Detection, Correlation, EEG. Furthermore, for multivariate topics related to the words Neural Network, Regression, Selection variables, anomaly Detection, Multiple Linear Regression, Prediction, Machine Learning, Time Series, Classification, Deep Learning, Missing Data, Fault Detection, Time series Prediction.

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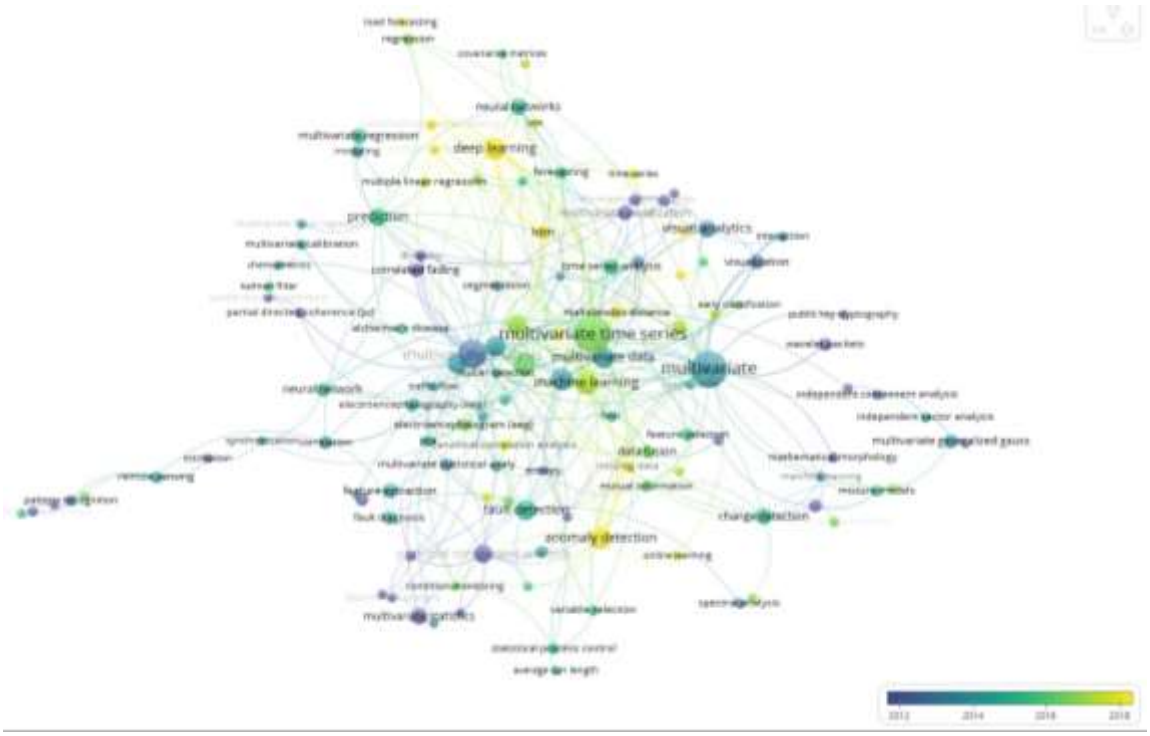
RQ4 Types datasets are most used for Multivariate analysis

Types of datasets that are widely used in multivariate research of time series data analysis, data mining, Deep learning, Forecasting, Machine Learning, missing data, variable selection, Time series Prediction.



Source: Processed Research Data, 2024

Figure 8. Temporal Network Analysis

Figure 8, shows the development of the research topic from year to year. Dark blue indicates the longest research topic while light yellow indicates the most recent research topic on multivariate analysis. The latest research topics shown are multivariate time series, Machine Learning, Deep Learning, Neural Network, Missing Data, Anomaly detection, online Learning. Time Series Prediction, Missing Data,

RQ5 What methods are often used for Multivariate analysis

From the results of the systematic analysis of the literature review, data were obtained about the methods that are most often used in the research. Based on the results of the review from (A-Review-of-Multivariate-Analysis-2u9l6a05k2, n.d.; James & McCulloch, 1990; Krzanowski, 2014) Multivariate analysis consists of several methods, namely Decision Theory & Bayes Inference, Discriminant Analysis, Explanatory (Clustering, Multidimensional Scaling, Graphical Methods), Regression, Canonical Correlation, Principla Componen Analysis, Factor Analysis (Explanatory Factor Analysis, Confirmatory Factor Analysis, Interpretation), Path Analysis & Lisrel, Testing Hypothesis, Discreate Multivariate Analysis.

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Table 2. Writer

Yes	Method	Article
1.	Analysis Regression Method	Several papers discuss the regression method of analysis for multivariate data. (Arenas-Garcia et al., 2013; Crino & Brown, 2007; Dell'Acqua et al., 2015; Durichen et al., 2015; Georga et al., 2013; Marchant et al., 2016; Miao et al., 2013; Ming-Da Ma et al., 2010; Ren et al., 2020; Shanableh, 2012; H. Wang et al., 2016; Ya Su et al., 2012).
2.	Multivariate Correlation Method	In addition, there is also a paper that discusses the correlation method (Ahmed & Mandic, 2012; Anderson et al., 2012; Durichen et al., 2015; Naveed & Rehman, 2020; Park et al., 2013; Vallet et al., 2012; H. Wang et al., 2016; Ye et al., 2016)
3.	Clustering Method	There is also a Clustering method approach (Ahmad & Brown, 2014; An & Liu, 2019; Cappers & Van Wijk, 2018; Diansheng Guo, 2009; He & Tan, 2020; Javed et al., 2015; Karami et al., 2012a; Li et al., 2019; Lu & Huang, 2020; Markley & Miller, 2010; Teng-Yok Lee & Han-Wei Shen, 2009; Yu et al., 2020).
4.	Principal Component Analysis Method	Furthermore, the method commonly used in multivariate analysis is the Principal Component Analysis method (Ahmad & Brown, 2014; Alduais et al., 2017; Ermolova & Tirkkonen, 2012; Fujiwara et al., 2021; He & Tan, 2020; Karami et al., 2012b; Peruchi et al., 2020; Sun et al., 2020; Yu et al., 2020)
5.	*Explanatory Factor Analysis, Confirmatory Factor Analysis, Interpretation)*	
6.	*Explanatory (Clustering, Multidimensional Scaling, Graphical Methods)*	
7.	*Path Analysis & Lisrel*	

Source: Processed Research Data, 2024

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CONCLUSION

Based on the analysis carried out, the following conclusions can be drawn the focus of this study is to see the development of multivariate statistical analysis research from 2000 to 2025. This study tries to identify fundamentally and thoroughly about the development of multivariate analysis related to which journals are the most significant, the most influential researchers, what research topics are developing, the types of datasets, and the methods used in multivariate analysis. Bibliometric analysis is used to look systematically based on relevant information from scientific publications, multivariate analysis articles accessed through IEEE Explore and Scopus. In the bibliometric analysis stage using Vosviewer, as many as 483 journals were analyzed for the number of citations, analysis of interconnected keywords and others.

The development of the trend of multivariate analysis is applied in various fields of science with various applications, such as in the fields of Health, medicine, computer networks, taransport, biology, engineering and many others. The most developed methods of multivariate analysis are regression methods, correlation methods, factor analysis and analysis component principles. The goal is to simplify complex data or models into something easier to analyze. The most widely used types of datasets are multivariate time series data types and time series forecasting. And the direction of multivariate analysis research in the future that will continue to develop is multivariate time series and multivariate forecasting.

It was found that the most significant journals were IEEE Transactions on Biomedical Engineering, IEEE Transactions on Geoscience and Remote Sensing. The most influential authors are B. Aiazzi; S. Baronti; M. Selva; with a total of 643 citations writing about the multivariate regression adopted to improve spectral quality. Emerging Research Topics Multivariate Time Series Forecasting. Methods that often appear are Regression, Correlations, Clustering, Principal Component Analysis. There are still many literature studies that have not been carried out in this study that can be followed in the next research such as the framework study of each multivariate analysis model.

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