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Research Article

Exploring Machine Learning Approaches for Time Series: A Bibliometric Analysis

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ABSTRACT:
Our paper analyzes 20 years of Machine Learning for Time Series forecasting research published in journals, books, papers. We analyzed the bibliographic collections and bibliographic services present on Scopus, the largest database of abstracts, citations of literature and quality web sources, which includes scientific journals, books and conferences, extrapolating the quantitative relationships between documents and their elements. Through this analysis, we analyzed the main information on the structure of the data, such as total citation by country, the documents with the highest number of citations, the most productive authors, the most important keywords. We also obtained graphs of the most productive authors, the average total citations per year, the annual scientific production and the average number of citations of the article per year, as well as an evolution of the topics and a thematic map.

Keywords: Machine Learning for Time Series, Bibliometrics, Forecasting, Topic analysis, Collaboration.

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INTRODUCTION

Nowadays, the large quantity of advanced data available online, involves the need to use machines that are able to learn and analyze. Studies based on machine learning have allowed scientists, scholars and companies to predict events and, therefore, to have competitive advantages, anticipate possible risks etc. For a long time, time series forecasting was based only on linear statistical methods, like ARMA, ARIMA,[1] Exponential Smoothing, [2] etc. However, these are linear models, while the nature of the time series structure can be linear, nonlinear, or a combination of the two. Linear predictive models explain the relationship between variables through linear correlation. This involves a limitation in applying these methods to real cases as it is difficult to model a nonlinear relationship between the variables, as it would lead to inaccurate predictions. In order to overcome these limitations, nonlinear statistical models have been developed and proposed over time. Scholars have focused on the use of automatic systems to improve the performance of forecasts. These systems generate models for prediction, update and improve the models themselves, as well as allow the prediction of multiple time series without human intervention. The second reason of using Machine Learning for predictions is the last years' increasing trend of the digital data age, as there is a large amount of stored data for each activity, while the third reason is related to the expansion and development of statistical methods, whose implementation requires the existence of registered historical data. This work is based and developed on the above reasons. Machine Learning algorithms use big data to forecast future trends, by constantly learning and improving their analytical skills day by day on their own. A machine learning network behaves like an intelligent system which shapes future prospects using the past. Machine learning, initially used in computer sciences, is now used by scholars of any area, from medicine to economics, mathematics, environmental science, biochemistry, arts and humanities, neuroscience, energy, astronomy, dentistry, veterinary etc. As there is not any scientometric analysis of Machine Learning application to time series forecasting that provides scholars with an analysis of the scientific work on the field and considering the growing interest of scholars in machine learning research and its evolution, it is interesting and necessary to analyze the field. This analysis will enable researches identify niches of opportunities for possible future research, knowing the emerging issues and the main topics.

In this paper we analyze the evolution of the machine learning for time series forecasting using literature based on the analysis of the content of the past 16 years of machine learning for time series forecasting research published in the scientific journals, books or papers.

Other bibliometric studies on machine learning based on quantitative data were published recently. Rincon-Pationo *et al*.,[3] has provided, through a bibliometric analysis, an overview of the scientific work about machine learning during the period 2007-2017. The study applies science mapping analysis with the SciMAT tool based on results extracted from Scopus. Bhattacharya[4] has applied Bibexcel software on data obtained from articles containing the string "machine learning or supervised learning or unsupervised learning or reinforcement learning" creating a Co-occurrence matrix for the co-word analysis. Yu *et al*.,[5] analyzed the scientific work about support vector machine (SVM) with particular reference to China.

The paper is structured as follows

First, a brief overview of the development of time series forecasting using the machine learning is provided. This is followed by a description of the methods used in the analysis of data generated by Scopus, then we present the results of the analysis of the scientific papers. Finally, we discuss about possible future developments of machine learning for time series forecasting literature.

Scope and Objectives

This study aims to verify if the introduction of Machine Learning techniques for time series forecasting was related to a temporary trend or an effective computational necessity.

The objective of this article is the analysis of the evolution of Machine Learning techniques for time series forecasting research in 20 years, using bibliometric and scientometric methods to try to identify:

1. An overview of accademic research on the application of Machine Learning techniques for time series forecasting;
2. The publication trend;
3. The most productive authors and their origin countries;
4. The most important themes related to Machine Learning application for time series forecasting.

The identification of the most productive authors, countries and their performance, the evolution of the annual scientific production, the most relevant sources, as well as a thematic evolution over the years and the most significant keywords, at successive periods, related to time series forecasting, will help possible future studies on this field. This work also includes a co-word and co-citation analysis as a common bibliometrics network analysis tool.

Development of Machine Learning for Time Series Forecasting Research

The forecasting methods are based on the idea that the past affects the future. So, a continuity of the activity trend is assumed, the existence of a trend in the data collected so far. Predicting the trend of an economic phenomenon allows companies to have a competitive advantage on planning, organization and the adoption of company policies within the market in which they operate. The same reasoning can be extended to any other subject, from medicine to environmental sciences, from agriculture to industry, from financial markets to tourism. Therefore, there has been continuous research for the development of statistical methods for the prediction of the future trend of various phenomena.

The study of the analysis of time series was born from the need to understand the dynamics of the fluctuations of the data generated by a given model. For a long time, the analysis of time series was based only on statistical methods. Among the most used, the models of Box-Jenkins; ARIMA, ARMA, SARIMA, Holt-Winters,[6] Exponential Smoothing,[7] etc.

However, these are linear models, while the nature of the time series' structure can be linear, nonlinear, or a combination of the two. Linear predictive models explain the relationship between variables through linear correlation. This cannot be done for nonlinear time series. Most of the real problems are presented in nonlinear form. This involves a limit in applying these methods to real cases as it is difficult to model a nonlinear relationship between the variables.

In order to overcome these limitations, nonlinear statistical models have been developed and proposed over time, such as the bi linear model[8] and the TAR model.[9] These models, however, present a high complexity as they require the intervention of specialists to evaluate the predictions generated by the models, as well as complex mathematical calculations. For this reason, scholars focus on the use of automatic systems to improve the performance of forecasts. These systems generate forecasting models, update and improve the models themselves, as well as allow the prediction of multiple time series without human intervention.

Models based on the ability of machines to learn can be used for time series forecasting. These models are studied by Artificial Intelligence (AI). AI includes the techniques that allow machines to simulate human intelligence. Artificial intelligence, as a result of the development of information technology, has made it possible to develop models with planning, learning, reasoning and problem-solving skills.[10] Compared to traditional forecasting techniques, artificial intelligence has given:

- the possibility of processing a significantly higher range of data;
- better predictive capabilities;
- high adaptability: algorithms or models can evolve when new data is introduced to them. Algorithms can learn and adapt their output to the new information.

AI includes Machine Learning (ML), which includes algorithms that allow continuous learning of machines and Deep Learning (DL), which allows machines to learn and implement models without the intervention of specialists, through multiple layers neural networks. These networks work in a similar way to the human neuron's networks.

Machine Learning includes mechanisms that allow computers to learn from experience. This can lead to the improvement of the performance of an automatic system over time, without the need to intervene step by step to write codes containing instructions, without having to program a specific code. Machine Learning is the application of algorithms in machines, imitating the neural activity of man for the solution of various problems. Through the techniques of Machine Learning, the machines not only implement the actions following the instructions of the algorithms, but are also able to "reason". So, they are given the ability to continuously improve while performing their tasks.

The idea of using computer learning based methods dates back to the mid-twentieth century. In 1964, Hu used Artificial Neural Networks (ANNs) for weather forecasting. This attempt, however, turned out to be quite limited due to the lack of an instructive algorithm for multi layer networks. In 1986, Rumelhart introduced the posterior propagation algorithm, involving a wide use of ANNs to make predictions. Later, Farber and Lapedes conducted a study concluding that ANNs can be used to make predictions on nonlinear time series.

Over the past thirty years, non-linear non parametric methods that fit into the logic of ML have been widely used. They use only data from the past to define a dependency between the past and the future. In [11] provided a detailed analysis of the predictions of the uni variate time series through artificial neural networks (ANN). In 1994, Kuan and White revised the ANN models used in economic and econometric studies and established various theoretical forms for artificial neural networks.[12] What characterized all these studies was the limited number of time series used. The first study to have used about 3000 time series was the one of Makridakis and Hibon in 2000.[13] Their study included an automated artificial neural network (AANN). Later, other models such as Support Vector Machine, Decision Trees and Nearest Neighbor Regression were used.

The most significant trend concerning neural networks was moving from an interpretation of the functioning of neural networks inspired by biological processes, to an interpretation based on the results deriving from the theory of recognition of statistical models.[13]

Artificial neural networks are able to model a considerable number of nonlinear methods with high precision and to process a large amount of data, thanks to their way of operating in parallel with the incoming variables. ANNs are data-based, self-adaptive methods that learn from simulated examples and are able to recognize functional connections between data that would be difficult to identify with traditional forecasting methods.[12] The fact that ANNs were able to understand any input-output nonlinear relationship and to use that knowledge to respond to future cases led to their use in areas such as visual recognition, language processing, process control, biomedical engineering etc.[12] Furthermore, ANNs have more elastic and functional forms than traditional statistical methods.

MATERIALS AND METHODS

In this paper we have used 4.728 papers, articles, books from Scopus, published during the period 2000-2020. Then we applied the search string "Machine Learning" and "Time Series" to Search section, searching and extracting all research papers that had this string in title, abstract or keywords. Downloaded data were examined with RStudio, using the package Bibliometrix . We took only research articles in English in the following fields: Computer Science, Mathematics, Decision Sciences, Social Sciences, Business, Management and Accounting, Economics, Econometrics and Finance. RStudio software was used for preparing the bibliometric data and creating descriptive statistics. It was also used for constructing co-occurrence and collaboration matrix of authors.

A bibliometric parameter analysis was conducted through the R package "Bibliometrix",[14] which allows an overview on main information on considered publications, such as type of documents, most productive countries and authors, most cited documents, countries' and authors' co-occurrence, as well as the annual scientific production trend. A cluster analysis was used to conduct a multiple correspondence analysis method (MCS), to examine the relationship between keywords,[15] as well as a conceptual structure of the research in Machine Learning, using a conceptual structure map and a topic dendrogram that shows the hierarchical relationship between 21 topics.

A thematic evolution analysis was obtained through a co-word analysis. The considered 12 years time span was divided in 3 periods (2000-2005, 2005-2010 and 2011-2012), to better understand the evolution of the research in successive periods. This map helped us identify the major topics of research in Machine Learning.

We also constructed a thematic map of clusters of keywords through a co-word analysis,[16] that were considered as themes mapped in a two-dimensional space; centrality and density, to better identify whether a thematic is important and well-developed for the structuring of the research, as well as the emerging and disappearing themes.

RESULTS

Trend of Bibliometric Parameters

Our first findings respond to our to our main question about the overview of the academic research of the application of Machine Learning techniques for time series forecasting. From 2000 to 2020, 4.728 studies on machine learning for forecasting time series were published, according to Scopus, taken from 1,814 different sources. 65,14% of them are conference papers (2,648) and articles (1,614). Furthermore, the analysis considered books (0.15%), book chapters (1.05%), conference reviews (5.38%), reviews (0.33%) and editorials (0.07%). 13.04% of documents are single-authored (617), for a mean of 2.58 documents per author, while there are almost 2.63 authors per document and 3.35 co-authors per document, for the multi-authored documents. The collaboration index between authors is 2.63. The answer to our second question is given by the results represented by Figure 1. It represents the evolution of the number of publications, average number of article citation per year and total citation number per year during the time span.

The annual scientific production shows an increased number of published articles, books and documents during the period 2000-2008, from 10 to 94, an exponential growth during 2009-2019, from 76 to 1,075 and a decreased number of publications during 2019-2020, compared to the previous period, with 795 published documents until June. The period of time between 2009 and 2019 is the most productive in terms of published articles because the subject has attracted a large number of scholars, as it had still many unexplored aspects. The annual growth rate has varied throughout the time span. It was about 2.65% each year from 2000 to 2003, while during 2004-2008 grew to 95.12%, with a mean annual growth rate of 23.6%. The expansion slowed down during 2008-2009 (-19.1%), 2014-2015 (-1.8%) and 2019-2020 (-26%). The growth peak was between 2016 and 2019, with an increase of more than 803 published articles, with a mean annual growth rate of 51,64. The annual scientific production rate of increase for the considered time span is 24.5%.

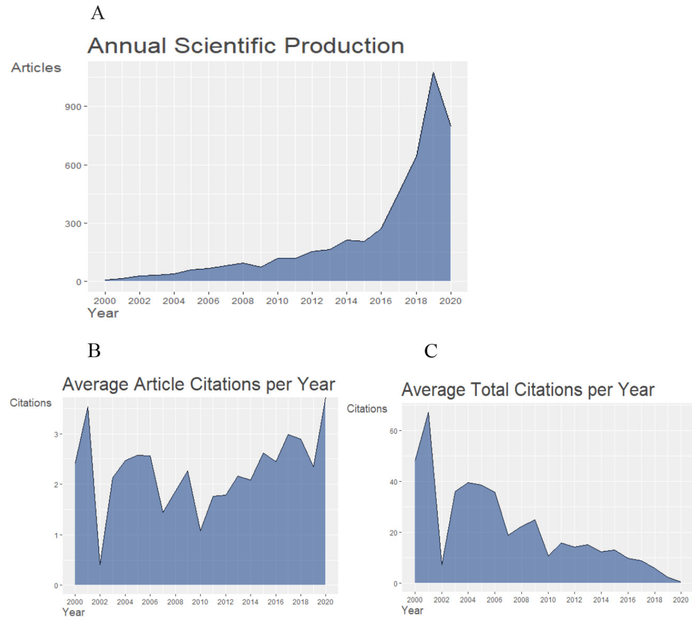

Figure 1: Evolution of bibliometric parameters: A. Annual scientific production, B. Average article citations per year, C. Average total citations per year.

The exponential trend of academic research work in Machine Learning for time series forecasting shows that the introduction of Machine Learning techniques for time series forecasting is not a random or temporary phenomenon, but a crucial need for statisticians who work in various fields and thematic, which indicates the expansion of ML techniques for time series forecasting in terms of areas of application and diversity of fields.

Contribution by top 10 sources

Machine learning for time series forecasting research during the past 20 years has been published under 1,814 sources, 1,271 of whom appear on top 10 sources titles. They have contributed with 70.06% share of total publications from 2000 to 2020.

Lecture Notes in Computer Science has the highest number of published documents (481), sharing nearly 10.17% of publications, followed by ACM International Conference Proceeding Series with 162 publications (3.42%), 151 in IEEE Access (3.19%), 106 in Advances in Intelligent Systems and Computing (2.24%). The remaining 6 sources (Communications in Computer and Information Science, Expert Systems with Applications, Proceedings of the International Joint Conference on Neural Networks, CEUR Workshop Proceedings, Applied Soft Computing Journal and Neural Computing and Applications) share a total number of publications equal to 371 and share 7.85% of published documents.

Figure 2 represents top 10 sources with the highest number of publications on Machine Learning for time series, where

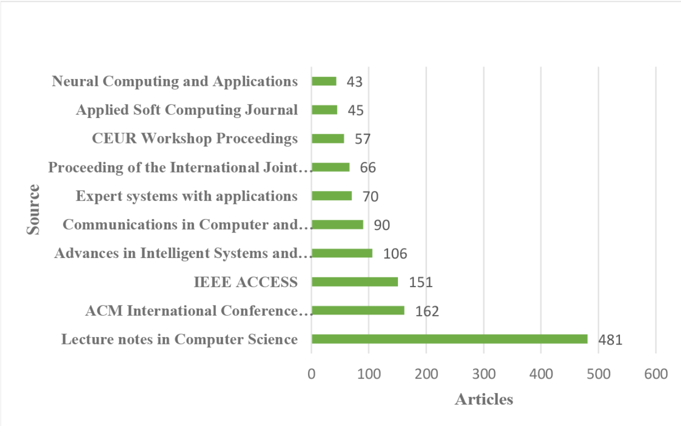

Figure 2: Number of publications by top 10 source titles.

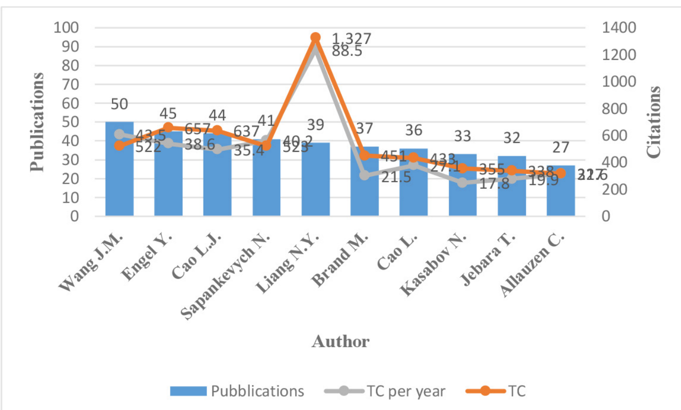

Figure 3: Number of publications, total citations and total citations per year of 10 most productive authors.

Lecture notes in Computer Science tops the list with 481 articles.

Research Collaboration

The answer to our third question is given by the results of research collaboration, identifying the most productive authors and countries. Figure 3 shows the most productive authors with the respective number of articles, total citations and total citations per year The most productive author is Wang J.M., with 50 articles on machine learning for time series forecasting, whose works have received 522 citations, with a mean of 43.5 citations per year. Liang .Y. has the highest number of citations (1,327 for Classification of mental tasks from EEG signals using extreme learning machine"), with 39 published articles and 88.5 citations per year.

Figure 4 represents top 10 most productive countries and their respective number of publications, pointing out the relative number of single countries publications and the multiple ones, China has the largest number of published research documents (288), due to the importance they give to researches on Artificial Intelligence and its applications in various fields, 258

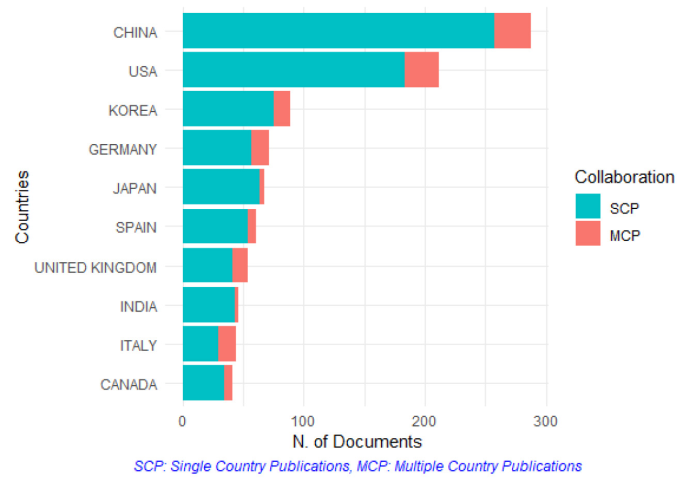

Figure 4: 10 most productive countries.

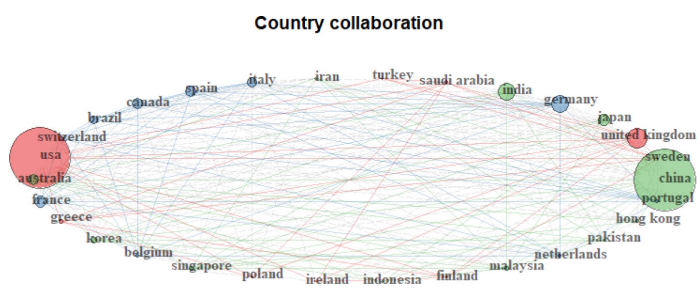

Figure 5: Country collaboration.

of which are written by Chinese authors, while the remaining 30 documents are written in collaboration with other countries' authors, with a MCP ratio of 0.10. It is followed by the USA, whose authors have written 86.32% of their articles and have collaborated with other countries' authors for only 13.68% of their publications. Italy has the highest MCP ratio (0.34), as its authors have collaborated with other nations' authors for the publication of 15 of a total of 44 publications, followed by the United Kingdom (0,24). Japan and India have the lowest MCP ratio values, (0.04 and 0.06).

The level of cooperation between the countries on research papers on machine learning for time series forecasting is shown in Figure 5. Countries research collaborations allows scholars to share their knowledge and the cooperation between countries can be seen through the construction of a country collaboration network.The network helps us notice that the USA and China are the main partners in international academic collaboration on machine learning for time series, followed by India, United Kingdom, Germany and Italy. The collaboration index between authors is 2,63.

Figure 6 shows corresponding authors' countries. American author's publications are the most cited (5,377 total citations with about 25.36 article citations), while Indian authors'

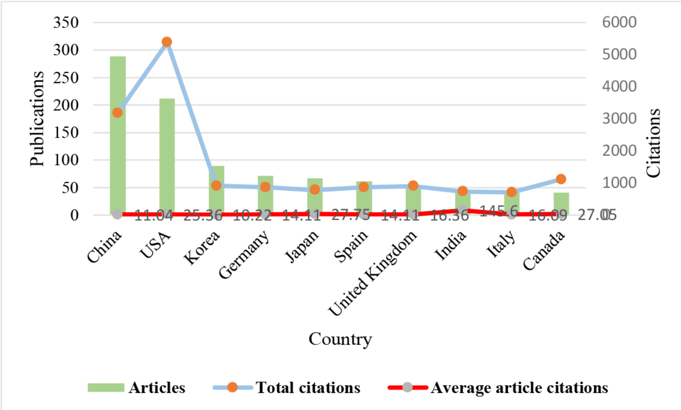

Figure 6: Top 10 corresponding author's countries number of publications, total citations and average article citations.

Figure 7: Keyword co-occurrences.

publications have the largest number of article citations (145.60).

Evolution of themes

As a response to question number 4, in order to better analyze the content of the publications we have used a co-word analysis on the authors' keywords. It counts and analyses co-occurrence of words to identify themes and relationship between them and understand how the keywords co-occur in the document. We have modeled the interaction between them building a co-occurrence network, so that we can understand the connections between the different keywords. Figure 7 shows the keyword co-occurrence network used for the co-word analysis, which is based on the principle that if two keywords are simultaneously present in an article, the intensity of their co-occurrence is an indicator of the connection between the topics and helps identify the conceptual structure and basic concepts addressed by the field. The bigger the node, the larger the number of documents containing the keyword. The network shows the most important keywords for each cluster, which are basically forecasting artificial intelligence methods. The centrality and size of the keyword indicates the importance of this concept and the spread of this method for time series forecasting.

The largest node is Learning Systems, put as a keyword in 1.154 articles, in the green cluster. This cluster includes other large nodes related to nonlinear methods of forecasting and time series analysis using automatic systems, like Neural Networks, Pattern Recognition, Mathematical Models, Support Vector Machine, Time Series Prediction, Forecasting and Kernel methods. Another large cluster, the red one, dominated by the keyword Time Series (used in in 403 articles), involves nodes related to techniques of time series classifications like Machine Learning, Artificial Intelligence, Clustering, Data Mining and Time Series Classification.The purple cluster includes nodes such as Support Vector Machines, Image Recognition, Classification, Regression etc, while the grey cluster includes Time Series Forecasting, Extreme Learning Machines and Prediction. We can observe that "Learning Systems" is a key connector to many papers, as it brings together different fields of research. It is followed by Support Vector Machine, a component of supervised learning, referring to algorithms given in input to machines during supervised learning. This keyword also highly influences machine learning research and is a connector for many papers, as well as other keywords like "Time Series", "Neural Networks" and "Forecasting".

Figure 8 shows the conceptual structure of the research on machine learning, where keywords, whose occurrences are greater than 10, are represented on a two-dimensional plane through MCA method. The horizontal dimension, which explains the 36,41% of variability, separates keywords related to time series forecasting, prediction and support vector machine (on the right side) from those emphasizing time series analysis, classification and clustering (on the right).[17]

The vertical dimension explains the 26,38% of variability and considers machine learning techniques and regression.

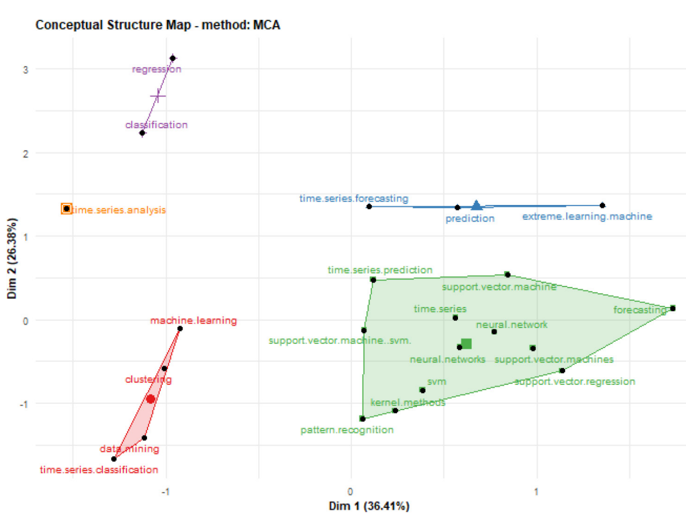

Figure 8: Conceptual structure map of ML research.

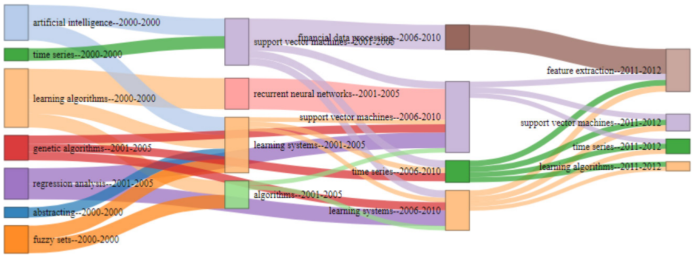

Figure 9: Thematic evolution 2000-2012.

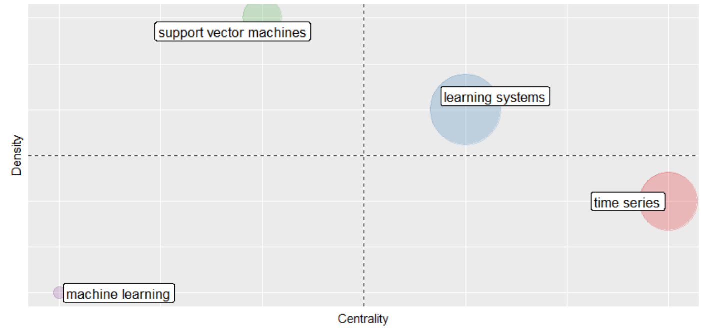

Figure 10: Thematic map.

Thematic evolution

Figure 9 shows a diagram of the topic evolution of research on ML from 2000-2012, in which different colors represent different thematic of ML.[18]

"Learning algorithms" always topped the list of the diagram in all periods (2000-2005, 2005-2010, 2011-2012). This fact emphasizes its importance in theme of time series forecasting over the years, as it has been a key thematic to most scientific work for almost a decade. It has evolved during the last two years (2011-2012) becoming part of the most important thematic too, like "Support Vector Machines", "Feature Extraction" and "Time Series". The keywords "Artificial Intelligence" and "Regression Analysis" also topped the diagram during the period 2000-2005, indicating that they were the major topics of research on ML. The keywords "Support Vector Machines", "Recurrent Neural Networks" and "Learning Systems" became the top topics in 2006-2010. This refers to the increasing trend of articles on speech recognition and natural language processing. Recurrent Neural Networks are a type of artificial neural network that can recognize data characteristics and use patterns for future predictions. "Support Vector Machines" included "Artificial Intelligence" and "Time Series", "Recurrent Neural Networks" replaced part of "Learning Algorithms", while "Regression Analysis" and part of "Fuzzy Sets", "Learning Algorithms"..

During 2011-2012, "Feature Extraction", which is important to effective model construction for pattern recognition and image processing, is used to identify key features in the data of the original data set to derive new ones, in order to detect features such as motion, shapes, edges, etc. In videos or digital images. It replaced "Financial Data Processing" and became the top topic during the last period. Finally, "Support Vector Machines", "Time Series" and "Learning Algorithms", that appeared as top themes during 2000-2010, became the second top topics in the last period.[16]

We can observe an increasing prevalence of artificial intelligence methods, such as Machine Learning and Deep Learning, in time series scientific research. That is because over time, we are moving more and more from supervised learning (Support Vector Machine is a component of supervised learning), to methods that allow machines to be independent, such as Deep Learning techniques.

So, if in the past technicians had to give an input algorithm to the machine to perform a certain process, now we have intelligent machines, which mimic the activity of the human brain, becoming able to perform an activity independently and use information gathered from previous experiences to be further improved.

Figure 10 shows a thematic map of clusters of keywords obtained through a co-word analysis. The clusters are considered as themes mapped in a two-dimensional space.[16]

Each theme is characterized by two parameters; centrality and density.[19]

Learning systems: (located in the upper-right quadrant) is well developed and important for the structuring of the research. It is known as motor-theme as it presents strong centrality and high density. It is related externally to concepts applicable to other themes that are conceptually closely related.

Support Vector Machines: (located in the upper-left quadrant) has well developed internal ties, but unimportant external ties and so are of only marginal importance for the field, as it presents high density and weak centrality. It can be considered as a niche theme of limited importance for the field.

Machine Learning: (located in the lower-left quadrant) is weekly developed and marginal. This theme has low density and low centrality, mainly representing emerging or disappearing themes.

Time Series: (located in the lower-right quadrant) is important for the research field but not developed. This quadrant groups transversal and general basic themes, which have low density and weak centrality.[20]

DISCUSSION AND CONCLUSION

Our paper analyzes 20 years of research on Machine Learning for Time Series forecasting. Most of the published documents, which are in English, as a worldwide scientific language, are articles and communications in congresses, while the rest is material review, books and editorial. Considered areas were various (medicine, economics, mathematics, environmental science, biochemistry, arts and humanities, neuroscience, energy, astronomy, dentistry, veterinary, etc.), but what joins the subjects of our study was the fact that there was an exponential increase in the use of machine learning to forecast the performance of field indicators which included the topics addressed in scientific papers.

As it has been shown in the previous section, the analysis revealed a growth within the publications from 2010 to 2019, while we noticed a decreasing number of publications during the first semester of 2020, probably due to the pandemic situation. The annual scientific production shows an increase in the number of articles, books, documents published in recent years, with 1.075 articles published in 2019, the most productive year for scholars. The annual scientific production rate of increase is 24,5%. The exponential trend of academic research work in Machine Learning for time series forecasting shows that the introduction of Machine Learning methods for time series forecasting is not a random or temporary phenomenon, but a crucial need for statisticians who work in various fields and thematics. This reflects an increasing interest of researchers from the scientific community, which indicates the expansion of ML techniques for time series forecasting in terms of areas of application and diversity of fields.

The study that has received most citations is "Classification of mental tasks from EEG signals using extreme learning machine" published in the International Journal of Neural Systems in 2006, by the authors Liang N., Saratchandran P., Huang G.B., Sundararajan N.

This study identified the most proficient authors and countries, which might be helpful for a better cooperation between them for possible future research activities, as well as the top sources titles, which would be very helpful for the identification of the right sources for research communication. The qualitative thematic analysis gave us further information about the evolution of themes over the time, identifying the most important thematic and keyword clusters for the structuring of the research. The hierarchical cluster analysis highlighted five clusters representing the major fields of research involved in ML. Keywords such as "support vector machine", "time series prediction", "forecasting", "pattern recognition", "neural networks", "kernel methods", related to nonlinear methods of forecasting using automatic systems composed a cluster, while keywords such as "clustering", "data mining" and "time series classification", related to techniques of time series classifications were part of another cluster. The last cluster included keywords such as "regression", "classification", "time series analysis", related to classic forecasting techniques.

The thematic evolution of research on ML[14] showed that keywords such as "Support Vector Machines", "Recurrent Neural Networks", "Financial Data Processing" and "Learning Systems" became the top topics during the last period. Moreover, the analysis showed that there are many thematic connections between them. In addition, it shows an evolution of the use of machine learning for future predictions, from computer science, field in which it was widely applied initially, in medical sciences, finance, electronics, environmental sciences etc. This confirms our initial assumption over the fact that the introduction of Machine Learning techniques for time series forecasting was related to an effective computational necessity and was not a temporary random trend. We noticed an exponential trend of research on Artificial Intelligence methods for time series forecasting, with an expansion of Machine Learning methods for time series forecasting in the last decade. Thus, we can say that Machine Learning is essential for one-step or multi-step ahead time series forecasting. Considering the large amount of data available online and the struggle scholars face when analyzing them, we believe that the use of Machine Learning methods like Supervised Learning, Unsupervised Learning, Multilayer Perceptrons, Nonlinear Autoregressive Neural Networks, etc are a powerful tool to make their research activities easier.

As a future prospect, a possible and useful application of bibliometrics could be in a content analysis of publications on Machine Learning for Time series forecasting, to highlight quantitative indicators of the considered elements.

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Saliaj conducted the data analysis and created the tables and Figures. Nissi provided her expertise for the bibliometric analysis, as well as the creation of Figures and helped edit the manuscript.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest

ABBREVIATIONS

ARMA: Autoregressive Moving Average; **ARIMA:** Autoregressive Integrated Moving Average; **TAR:** Threshold Autoregression; **AI:** Artificial Intelligence; **ML:** Machine Learning; **DL:** Deep Learning; **ANN:** Artificial Neural Network; **MCA:** Multiple Correspondence Analysis; **MCP:** Multiple Comparisons Procedure.

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