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“Extreme Learning Machine for Business Sales Forecasts: A Systematic Review”

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Extreme Learning Machine for Business Sales Forecasts: A Systematic Review

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Abstract Technology in business is vital, in recent decades technology has optimized the way they are managed making operations faster and more efficient, so we can say that companies need technology to stay in the market. This systematic review aims to determine to what extent an Extreme Learning Machine (ELM) system helps sales forecasts (SF) of companies, based on the scientific literature of the last 17 years. For the methodology, the systematic search for keywords began in the repositories of Google Scholar, Scielo, Redalyc, among others. Documents were collected between 2002 and 2019 and organized according to an eligibility protocol defined by the author. As an inclusion criteria, the sources in which their conclusions contributed to deepening the investigation were taken and those that did not contribute were excluded. Each of the results represented in graphs was discussed. The main limitation was the little information on the subject because it is a new topic. In conclusion, an ELM system makes use of both internal and external data to develop a more precise SF, which can be used not only by the sales and finance area but also to coordinate with the production area a more exact batch to be produced; this has a great impact on the communication and dynamism of companies to reduce costs and increase profits.

Keywords Business sales forecast · Extreme learning machine · Systematic review

1 Introduction

Technology has great relevance in commercial operations; its main role in business is to boost growth and improve operations. Without technology, companies will almost certainly not be able to survive in today's competitive and globalized market.

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Currently, the great concern of organizations lies in having accurate inventories in their stores. Faced with this problem, there are several techniques that a company can use to acquire the amount of inventory necessary to allow it to reach or exceed the sales target. Here, it is important to note that these techniques can be performed regardless of business turnover, billing size, the nature of the company, or its scope (whether local or international). One of these alternatives, and the most used to present better results, is the projection of sales forecasts, which is basically a forecasting system for a future event that by its nature is uncertain and random, whose responsibility falls on all areas of the company, the same that are fed with information so that the forecasts are more accurate [1]. Forecasting is a multifunctional process and, therefore, its management requires the same type of tools as the management of other multifunctional processes. The forecasting process involves staff from many functions, and not everyone knows the forecasting process in its entirety. Production planning, inventory management, and forecasting should be understood as a whole before it is possible to set justified objectives for an individual part of it [2]. In recent decades, computer science has transformed work in almost every sector of the economy. We are at the beginning of an even bigger and faster transformation due to recent advancements in machine learning (ML), a branch of artificial intelligence capable of accelerating the pace of automation, bringing implications for the economic flow and the workforce in the future of global trade [3]. In an effort to keep improving, extreme learning machines have been developed, an emerging ML technique that has become an area of research in recent years due to the significant contributions made by numerous researchers around the world. The objective of this study is to determine to what extent an extreme learning machine system helps companies' sales forecasts, based on the systematic review of the scientific literature of the last 17 years. Studying these tools has relevance, and influences directly and indirectly, on the profits of a company, since these tools have a great impact on communication and dynamism between areas, helping to reduce expenses, therefore, to increase profits, and to position themselves better against the competition with stronger and more accurate demand estimates. This systematic review is structured as follows: First, we describe the methodology with the inclusion and exclusion criteria; subsequently, we detail the fields of the chosen sources, included and excluded, we present the results and discuss each one of them, with the limitations that we had for the investigation; and we close with the conclusions.

2 Methodology

2.1 Information Search Process

In this paper, a systematic review (SR) of the scientific literature in the last 17 years, between 2002 and 2019, was carried out, taking as a guideline the research and analysis of the theoretical basis of this methodology. SR as scientific research in which the

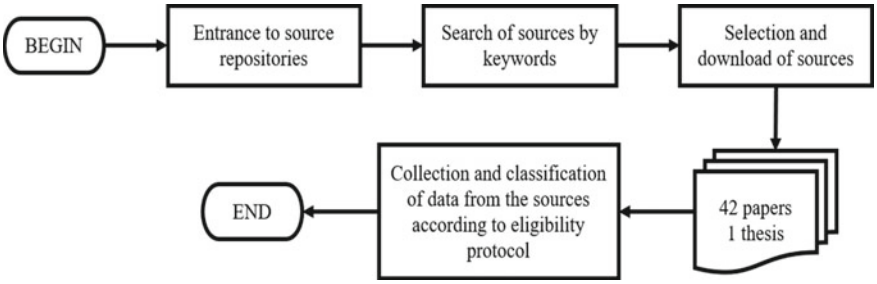

Fig. 1 Flowchart of the information search process

units of analysis are the original primary studies, from which it is intended to answer a research question clearly formulated through a systematic and explicit process [4].

The objective of this investigation was to determine to what extent does an ELM system helps the SFs of companies, described in the scientific literature of the last 17 years. For this, Google Scholar, Scielo, and Redalyc were used as repositories, mainly, in which the following keywords (and their pair in Spanish) were used individually and in combination: sales forecast, machine learning, and extreme learning machine; from the results, theses and papers were selected and downloaded for the elaboration of this review. Figure 1 shows a flowchart of the information search process.

2.2 Inclusion and Exclusion Criteria

Original papers and theses published based on indexed scientific data, in English, Spanish, and Portuguese, between 2002 and 2019, were included, which:

- It defines the theoretical basis of SF, ML, and ELM,
- It describes the importance of an SF in the processes of a company,
- It compares the efficiency between SF models and how to make them,
- It compares ML and ELM system models for forecasting,
- It determines how an ML and ELM system affects the processes of a company,
- And it determines the suitability of using ELM systems for SFs.

Sources whose conclusions did not meet any of the points of the inclusion criteria raised by the author were excluded, and were not included for the deepening of this research. Figure 2 shows a flowchart of the inclusion and exclusion criteria.

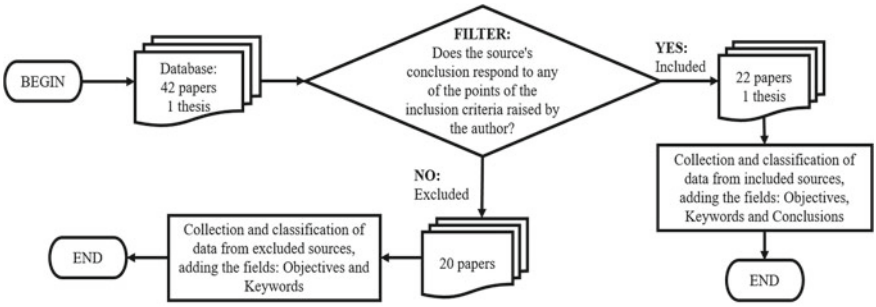

Fig. 2 Flowchart of the inclusion and exclusion criteria

3 Results and Discussion

The searches for sources were carried out based on the variables, for which the keywords were used, this helped to deepen the topic and clarify the objective raised in this research. However, there are few previous research studies on the specific subject, because its inquiry has recently gained momentum in recent years. In addition to this, most of the articles only had paid access, so we had to turn to people who had purchased articles to have full access to them. Most of the sources were in English, which was not inconvenient because the language is mastered; however, with articles in Portuguese, there was a slight difficulty in understanding, despite the use of Google Translator, due to little mastery of the language.

The search for sources in the repositories was virtual and yielded a total of 43 documents extracted from Google Scholar (20), Scielo (14), Redalyc (5), Hindawi (2), Taylor & Francis (1), and World Scientific (1), through the individual and combined use of keywords. These documents are distributed in 42 papers and only (1) thesis. To this total, a filter was applied according to the defined inclusion and exclusion criteria. The sources selected by inclusion criteria, which was determined by the relationship of the sources with the objective of this investigation, were the following: [2, 3, 5–25]. In total, 23 sources were included to deepen the topic according to the period between 2002 and 2018. Therefore, the sources not considered by exclusion criteria were: [26–45]. In total, 20 sources were excluded.

Figure 3 shows the number of sources by periods of years, and most of the publications are concentrated in 2015 with a total of eight (8), followed by the years 2014 and 2017 with five (5), and 2011 and 2019 with four (4). The series of events that ocurred in 2015 prompted the study and use of ML: Amazon launched its own ML platform [46]; Microsoft created the "Distributed Machine Learning Toolkit," which enabled efficient distribution of ML problems across multiple computers [47]; Elon Musk and Sam Altman, among others, founded the non-profit organization OpenAI, endowing it with US$ 1 billion to ensure that the development of artificial intelligence has a positive impact on humanity [48].

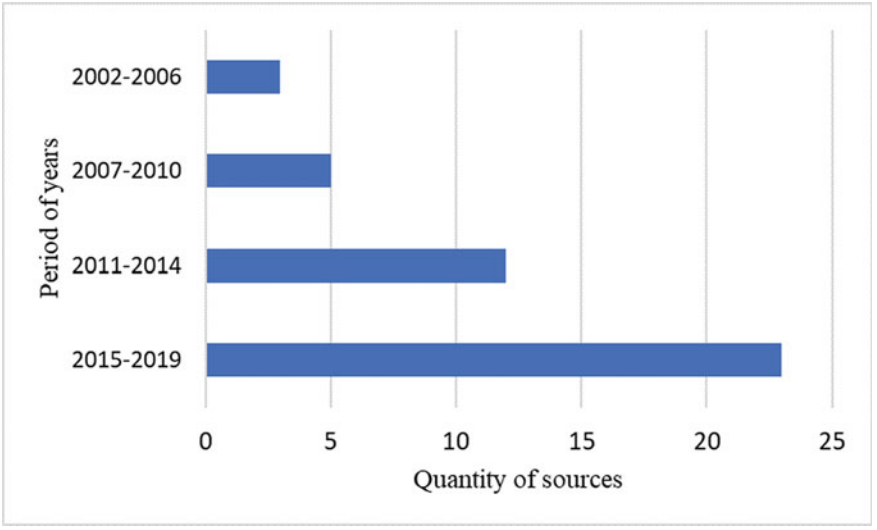

Fig. 3 Number of sources by periods of years

When the years of publication were grouped by time periods, it was clear that the subject of study has gained momentum in recent years. The events that accompanied the momentum of ML in these years were: In 2016, Google DeepMind beat professional gamer Lee Sedol in Go (considered one of the most complicated board games) by 4 games to 1, expert Go players affirm that the algorithm was able to perform "creative" movements that had not been seen so far [49]; in 2017, OpenAI trained chatbots or conversational agents, who invented their own language to cooperate and achieve their goal effectively [50]; soon after, Facebook also successfully trained agents to negotiate and even lie [51]; an algorithm also developed by OpenAI defeated the best players in 1-versus-1 matches of the online game Dota 2 [52]. The percentage of sources found by countries involved is Brazil with 23% of the total (11 papers), China with 18% (nine papers), and the USA with 10% (five papers) as shown in Fig. 4; and this is directly related to the contribution of these countries to the scientific ecosystem. The English language is the one that monopolized the results of the SR with 86% of the total sources (37 papers), followed by sources in Spanish and Portuguese with 7% each (adding six sources between them). To better understand this phenomenon, Carlo Duarte, oceanographer at King Abdullah University of Science and Technology in Saudi Arabia, explained in an interview with "El Mundo": "English is the vehicular language of science, as Latin was before and, for a while, the French. Proficiency in English is essential to access research results, which are mostly published in this language, and share the results of our own research" [53].

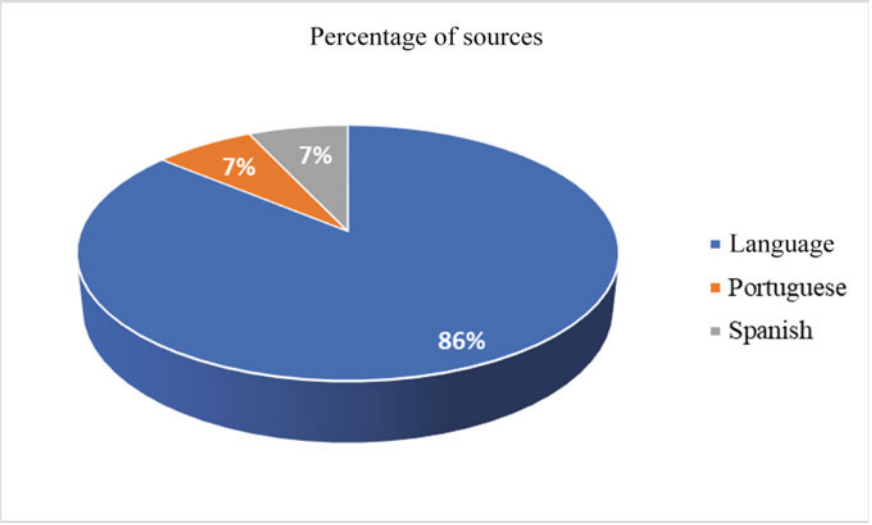

Fig. 4 Sources by language

4 Conclusions

A large-scale SF based on ELM has a reduced error in the square root of the forecast mean and improves its accuracy and speed; furthermore, an hybrid ELM model can effectively extract the underlying information from the sales data and improve SF performance by producing lower prediction error, and improves training speed more than other SF models.

This work aims to help companies understand the benefits of using a SF and implement an ELM system for it, in order to increase their profits and improve their internal processes. SFs are directly related to the increase in sales, because an accurate forecast is a fundamental basis for decision-making in the management of a company, providing relevant information to coordinate with the production area and thus reduce the loss of products without turnover, which translates into more products sold and fewer losses due to in-stock or expired products. It is understood that there is no specific SF model that is more beneficial than another, within the traditional models; but it is concluded that the use of ELM systems greatly improves the accuracy of SF compared to traditional models.

Although there is not much literature that refers explicitly to ELM systems for SFs, more than a limiter it is an opportunity for this paper to be an important contribution for people interested in the subject. That is why an in-depth study with real data from a company or a product is suggested to better understand how an ELM algorithm works in the efficiency of a SF and the cost–benefit of implementing it.

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