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The Challenges of Machine Learning in Software Development

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Abstract

A documentary review was carried out on the production and publication of research papers related to the study of the variables Machine Learning and Software Development. The purpose of the bibliometric analysis proposed in this document was to know the main characteristics of the volume of publications registered in the Scopus database during the period 2017-2022 by Latin American institutions, achieving the identification of 307 publications. The information provided by this platform was organized through graphs and figures, categorizing the information by Year of Publication, Country of Origin, Area of Knowledge and Type of Publication. Once these characteristics have been described, the position of different authors on the proposed topic is referenced through a qualitative analysis. Among the main findings made through this research, it is found that Brazil, with 153 publications, was the Latin American country with the highest scientific production registered in the name of authors affiliated with institutions of that nation. The Area of Knowledge that made the greatest contribution to the construction of bibliographic material related to the study of Machine Learning and Software Development was Computer Science with 256 published documents, and the most used Publication Type during the period indicated above were Conference Articles with 52% of the total scientific production.

Keywords: *Intelligent Systems, Artificial Intelligence, Machine Learning, Software Development.*

1. Introduction

A world marked by globalization, advances in the technology sector grow exponentially, these evolutions have resulted in the development of software, hand in hand with machine learning, have emerged as an essential pillar which projects unprecedented advances and efficiencies. These promises come with a number of challenges that developers and organizations must face in order to realize the full potential of machine learning in software development. The correlation of these two transformative forces together generates a series of difficulties which must be carefully solved, innovative benefits projected and the complexities of the parties involved taken into account.

The difficulties faced by these sectors must be addressed in a comprehensive manner, which are based on technical, ethical and organizational dimensions. Technical challenges

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arise from the complexity of designing, implementing, and maintaining machine learning models within the dynamic and iterative nature of software development. The ethical challenge revolves around the responsible use of AI, addressing biases in data and models, and ensuring transparency and fairness. Organizational challenges involve adapting workflows, upskilling teams, and establishing effective collaboration between data scientists and traditional software developers.

One of the technical challenges is the inherent complexity of learning models. Unlike traditional software, which bases its operating system on the logic it programs explicitly, the opposite of machine learning models which learns from a series of data and with these predictions or decision-making are made based on patterns identified through the analysis of information. This introduces a level of opacity and unpredictability, making it difficult to debug and understand the inner workings of these models. Ensuring the reliability and robustness of ML algorithms becomes a critical concern, especially in safety-critical applications.

A lack of high-quality resources is another challenge that developers often face. Machine learning models rely heavily on a range of large-scale datasets and various formats for effective training. Acquiring, cleaning, and managing such datasets can be a time-consuming and resource-intensive process. Likewise, the presence of biases in training data can lead to biased models, perpetuating and even exacerbating social inequalities. Addressing these gaps requires an effort to be able to recognize, mitigate and/or monitor them throughout the development lifecycle.

Ethical challenges are of great importance in the integration of machine learning into software development. On the other hand, the responsible use of artificial intelligence by developers triggers a series of responsibilities which are based on algorithmic decision-making and its possible social impact of its creation. It is imperative to ensure that machine learning models comply with ethical standards and legal regulations. Striking a balance between innovation and ethical considerations requires a proactive approach, including the development of ethical frameworks, ongoing monitoring, and ongoing education within development teams.

Organizational challenges come to the fore when companies revolutionize, leaving behind traditional paradigms and venturing into a machine learning model. Traditional software development practices may need to be adapted to accommodate the iterative and experimental nature of machine learning. The input of data scientists and software developers becomes important, as it requires an interdisciplinary understanding of each other's workflows and requirements. Establishing effective communication channels and seamlessly integrating machine learning into existing development processes are critical to success. For this reason, this article seeks to describe the main characteristics of the compendium of publications indexed in the Scopus database related to the variables Machine Learning and Software Development, as well. Such as the description of the position of certain authors affiliated with institutions, during the period between 2017 and 2022.

2. General Objective

To analyze, from a bibliometric and bibliographic perspective, the preparation and publication of research papers in high-impact journals indexed in the Scopus database on the variables Machine Learning and Software Development during the period 2017-2022 by Latin American institutions.

3. Methodology

This article is carried out through a research with a mixed orientation that combines the quantitative and qualitative method.

On the one hand, a quantitative analysis of the information selected in Scopus is carried out under a bibliometric approach of the scientific production corresponding to the study of the variables Machine Learning and Software Development. On the other hand, examples of some research works published in the area of study mentioned above are analyzed from a qualitative perspective, based on a bibliographic approach that allows describing the position of different authors on the proposed topic. It is important to note that the entire search was carried out through Scopus, managing to establish the parameters referenced in Figure 1.

3.1. Methodological design

Figure 1. Methodological design

Source: Authors.

3.1.1 Phase 1: Data collection

Data collection was carried out from the Search tool on the Scopus website, where 307 publications were obtained from the following filters:

TITLE-ABS-KEY (machine AND learning, AND software AND development) AND PUBYEAR > 2016 AND PUBYEAR < 2023 AND (LIMIT-TO (AFFILCOUNTRY , "Brazil") OR LIMIT-TO (AFFILCOUNTRY , "Mexico") OR LIMIT-TO (AFFILCOUNTRY , "Colombia") OR LIMIT-TO (AFFILCOUNTRY , "Ecuador") OR LIMIT-TO (AFFILCOUNTRY , "Argentina") OR LIMIT-TO (AFFILCOUNTRY , "Chile") OR LIMIT-TO (AFFILCOUNTRY , "Peru") OR LIMIT-TO (AFFILCOUNTRY , "Panama") OR LIMIT-TO (AFFILCOUNTRY , "Cuba") OR LIMIT-TO (AFFILCOUNTRY , "Uruguay") OR LIMIT-TO (AFFILCOUNTRY , "Venezuela") OR LIMIT-TO (AFFILCOUNTRY , "Costa Rica") OR LIMIT-TO (AFFILCOUNTRY , "Puerto Rico") OR LIMIT-TO (AFFILCOUNTRY , "Honduras") OR LIMIT-TO (AFFILCOUNTRY , "Dominican Republic")

- Published documents whose study variables are related to the study of the variables Machine Learning and Software Development
- Limited to the period 2017-2022.
- Limited to Latin American countries.
- Without distinction of area of knowledge.
- No distinction of type of publication.

3.1.2 Phase 2: Construction of analytical material

The information collected in Scopus during the previous phase is organized and then classified by graphs, figures and tables as follows:

- Co-occurrence of words.
- Country of origin of the publication.
- Area of knowledge.
- Type of publication.

3.1.3 Phase 3: Drafting of conclusions and outcome document

In this phase, the results of the previous results are analysed, resulting in the determination of conclusions and, consequently, the obtaining of the final document.

4. Results

4.1 Co-occurrence of words

Figure 2 shows the co-occurrence of keywords found in the publications identified in the Scopus database.

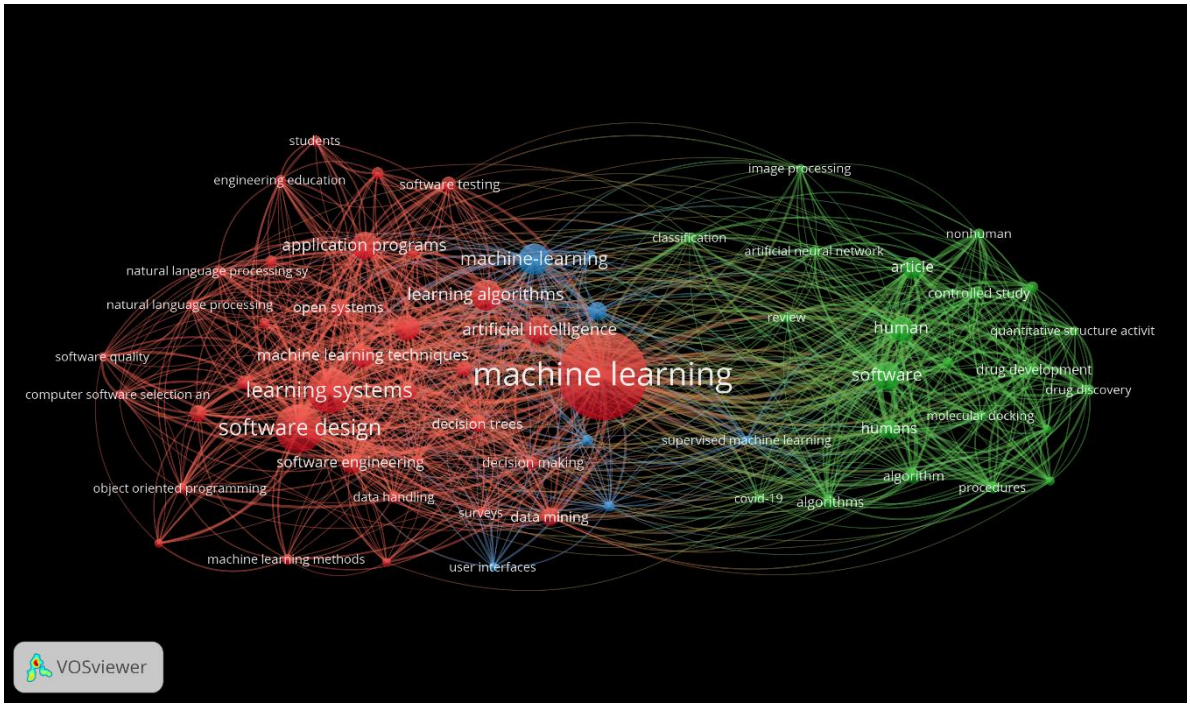

Figure 2. Co-occurrence of words

Source: Authors' own elaboration (2023); based on data exported from Scopus.

Machine Learning was the most frequently used keyword within the studies identified through the execution of Phase 1 of the Methodological Design proposed for the development of this article. Software Development is among the most frequently used variables, associated with variables such as Algorithms, Digital Technology, Decision Making, Global Development, Innovative Technology, Learning System, Programming Objective. The challenges of incorporating machine learning into software development are multifaceted and require a holistic approach. Technical complexities, ethical considerations, and organizational adaptations must be carefully navigated to unlock the transformative potential of machine learning while protecting against potential roadblocks. As the symbiotic relationship between machine learning and software

development continues to evolve, addressing these challenges head-on will be critical to shaping a future where intelligent systems augment and improve our software solutions responsibly and ethically.

4.2 Distribution of scientific production by year of publication

Figure 3 shows how scientific production is distributed according to the year of publication.

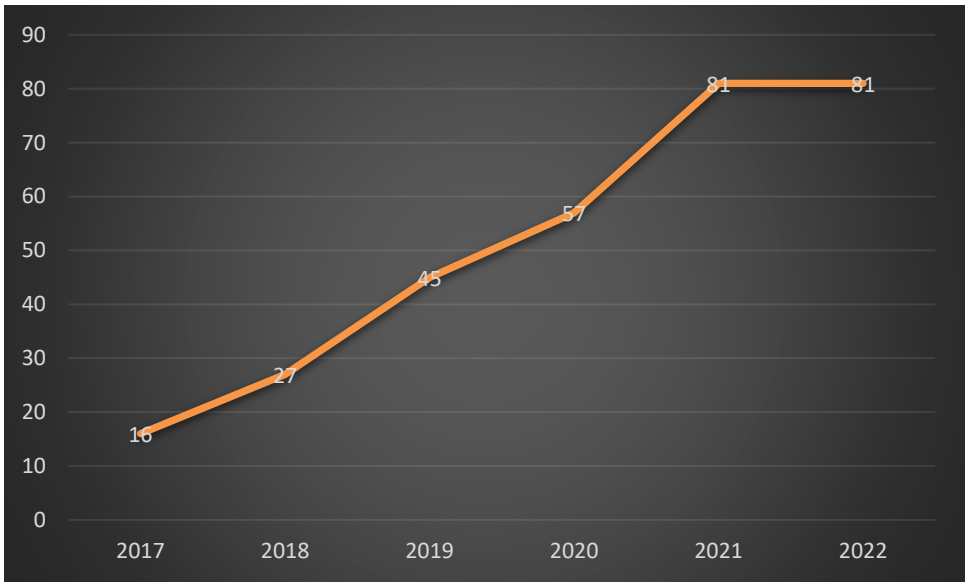

Figure 3. Distribution of scientific production by year of publication.

Source: Authors' own elaboration (2023); based on data exported from Scopus

Among the main characteristics evidenced through the distribution of scientific production by year of publication, the number of publications registered in Scopus was in the years 2021-2022, reaching a total of 81 documents published in journals indexed on this platform. This can be explained by articles such as the one entitled "Autonomous cloud detection system based on machine learning and COTS components on board small satellites" This article proposes a system for on-board processing of RGB images of satellites, which automatically detects the level of cloud cover to prioritize images and effectively takes advantage of the download time and the mission operations center. The system deploys a convolutional neural network (CNN) on a commercial off-the-shelf microcontroller (COTS) that receives the image and returns the cloud tier (priority). After training, the system was tested on a dataset of 100 images with an accuracy of 0.9 and was also evaluated with CubeSat images to evaluate the performance of a different image sensor. This implementation contributes to the development of autonomous satellites with on-board processing.(Salazar, 2022)

4.3 Distribution of scientific production by country of origin.

Figure 4 shows how the scientific production is distributed according to the nationality of the authors.

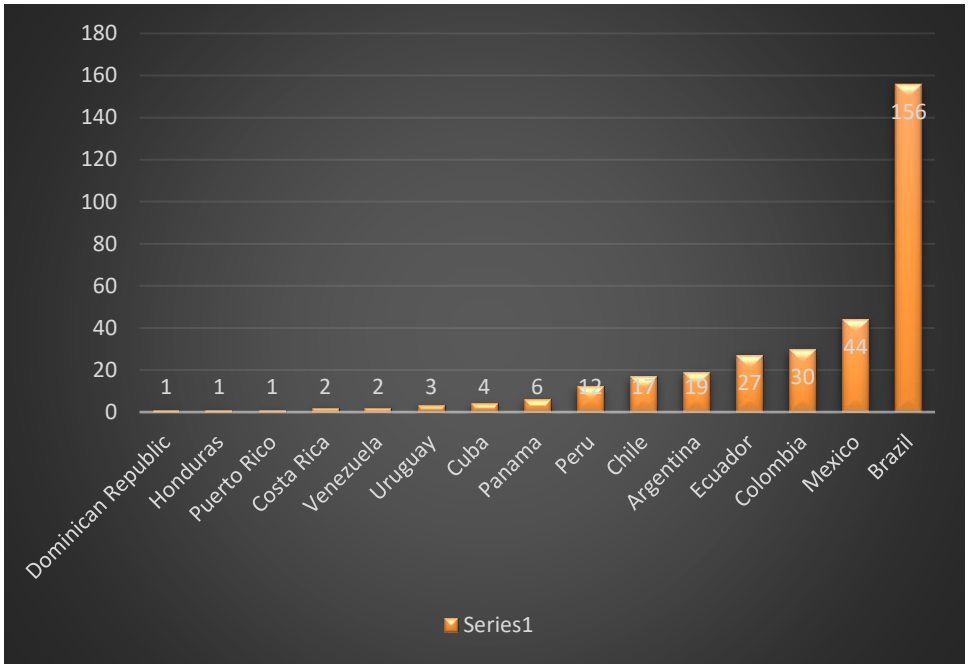

Figure 4. Distribution of scientific production by country of origin.

Source: Authors' own elaboration (2023); based on data provided by Scopus.

Within the distribution of scientific production by country of origin, registrations from institutions were taken into account, establishing Brazil as the country of this community, with the highest number of publications indexed in Scopus during the period 2017-2022, with a total of 156 publications in total. In second place, Mexico with 44 scientific papers, and Colombia occupying the third place presenting to the scientific community, with a total of 30 documents among which is the article entitled "Detecting reviews of relevant applications for the evolution and maintenance of software through multimodal learning in a single class" this article investigates methods to detect reviews of relevant applications considering scenarios with small sets of labeled data. We evaluate unimodal and multimodal representations, different levels of labeling, as well as different domains and languages of application review. Method: We present a one-class multimodal learning method for detecting relevant revisions. Our approaches have two main contributions. First, we used learning from a class that only requires tagging relevant app reviews, thus minimizing tagging effort. Second, to handle the fewest tagged reviews without hurting ranking performance, we also present methods to improve feature extraction and review rendering. We propose the Multimodal Autoencoder and the Multimodal Variational Autoencoder. The methods learn representations that explore both textual data and visual information based on the density of the reviews. Density information can be interpreted as a summary of the main themes or groups drawn from the reviews.(Gôlo, 2022)

4.4 Distribution of scientific production by area of knowledge

Figure 5 shows the distribution of the elaboration of scientific publications based on the area of knowledge through which the different research methodologies are implemented.

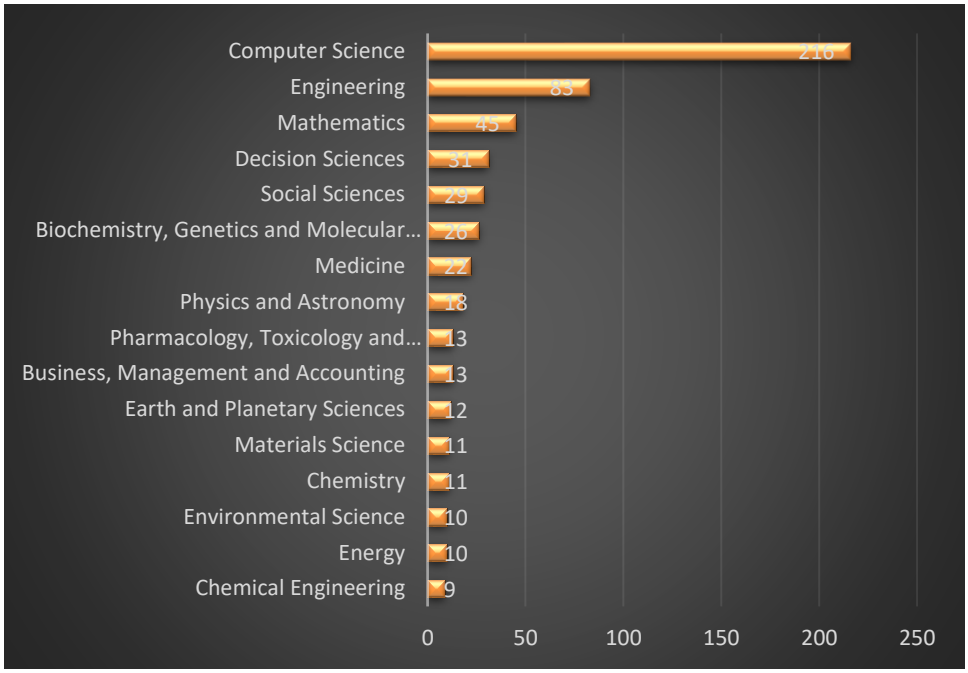

Figure 5. Distribution of scientific production by area of knowledge.

Source: Authors' own elaboration (2023); based on data provided by Scopus.

Computer Science was the area of knowledge with the highest number of publications registered in Scopus with a total of 216 documents that have been based on its Machine Learning and Software Development methodologies. In second place, Engineering with 83 articles and Mathematics in third place with 45. The above can be explained thanks to the contribution and study of different branches, the article with the greatest impact was registered by Computer Science entitled "Failure scenarios in acid water treatment units: simulation and diagnosis based on AI" the present work proposes to study the simulated dynamic behavior of a SWTU and develop an FDD system applying AI techniques with hyperparameter optimization. The simulation was performed in Aspen Plus Dynamics® and ran to create normal operation and six relevant failures, including occurrences in the process (e.g., flooding and contamination) and sensors. FDD was performed by data classification, and results were assessed primarily using precision and confounding matrices. Even after variable reduction, FDD was satisfactory with more than 87.50% accuracy across all AI techniques. RF and SVM with linear and Gaussian cores presented the best results, with more than 93% accuracy in training and testing, and had the shortest computation times. The level of the sink in the second column turned out to be the most relevant variable for the identification of faults.(do Nascimento Pereira Nogueira, 2022)

4.5 Type of publication

In the following graph, you will see the distribution of the bibliographic finding according to the type of publication made by each of the authors found in Scopus.

Figure 6. Type of publication.

Fountain: Authors' own elaboration (2023); based on data provided by Scopus.

The type of publication most frequently used by the researchers referenced in the body of this document was the one entitled Session Paper with 52% of the total production identified for analysis, followed by Journal Articles with 38%. Journals are part of this classification, representing 6% of the research papers published during the period 2017-2022, in journals indexed in Scopus. In this last category, the one titled "Human-Machine Collaboration to Paint Game Assets with Deep Learning" stands out. In this work, we investigate the use of deep learning algorithms to create pixel art sprites from line art sketches to produce artworks of sufficient quality to be used in a gaming product with little or no manual editing by human artists. This problem contrasts with well-known tasks studied in the literature, which are based on natural imagery, have massive data sets, and are much more tolerant of noise. In addition, we conducted a case study on the application of current technology to the drawing process of an upcoming game title, obtaining useful and positive results that can accelerate the development of the game, supporting the argument that the current image generation is state-of-the-art. It's ready to be used in some real-world tasks.(Rebouças Serpa, 2022)

5. Conclusions

Through the bibliometric analysis carried out in this research work, it was established that Brazil was the country with the highest number of records published in the Machine Learning and Software Development variables. With a total of 156 publications in the Scopus database. In the same way, it was possible to establish that the application of theories framed in the area of Computer Science, were used more frequently when addressing the existing challenges in machine learning on software development. First, there's the scarcity of labeled, high-quality training data. Machine learning algorithms rely heavily on large data sets to effectively learn and generalize patterns. Whereas, in software development, obtaining a series of data requires greater accuracy from the real world. This process requires exhaustive work since being able to collect this data requires high-quality technological resources and the lack of these can introduce biases for the models. Striking a balance between quantity, quality, and diversity of data poses an ongoing challenge in the search for robust and unbiased machine learning models. The traditional paradigm of software development is characterized by implementing logic and transparency, which allow developers to execute, debug, and improve code in an easier way. However, the interaction of machine learning models works differently, as complex

models hinder decision-making processes. This lack of interpretability can hinder the reliability of ML-based software, particularly in safety-critical applications where understanding model decisions is crucial. The rapid evolution of machine learning frameworks and libraries introduces compatibility issues and requires continuous learning for developers. These two forces allow a high level of adaptability on the part of software model developers, who must be at the forefront of the latest resources in programming tools and high techniques. Constant learning can be daunting, especially for smaller development teams or organizations with limited resources. Ethical considerations also loom large in the machine learning landscape in software development. The potential for bias in models, the unintentional spread of societal bias, and privacy concerns amplify developer responsibility. Finding harmony between innovation and ethical practices requires careful navigation and the establishment of industry-wide standards for responsible AI development.

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