

The Contribution of Adopting Artificial Intelligence to the Sustainable Development: A Review

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Abstract

New strategies arising from the accessibility of internet and the growth of all types of digital technologies have allowed to major gains and improved the development of many sectors. Machine Learning is one of the prominent technologies of Artificial Intelligence that ensure the improvement of many sectors in the international economy and encourage the decision making at all levels. In other sides, the current demands for sustainable development have led to a pressing need to encourage more sustainable land use and industrial development to maintain quality of life. To this end, governments, through the word, have tried to achieve the objectives of the millennium within the framework of the Development Goals Sustainable (ODS). The adoption of the Machine Learning tools to achieve the Sustainable Development Goals seemed to provide a new directions, perspectives and opportunities for this realization.

The present work seeks to investigate the adoption of various ML techniques in the Sustainable Development through a review in the literature. It allows discussing opportunities and challenges that ML gives for the realization of the Sustainable Development goals.

Keywords: Machine Learning (ML), Artificial Intelligence (AI), Sustainable Development, Sustainable Development Goals (SDG)

1. INTRODUCTION

Despite the long history of AI, the potential of AI as a mean of solving complex problems and searching information to solve Sustainable development objectives has not been fully exploited in the past. However, some efforts have been made to initiate AI applications, particularly ML techniques in the Sustainable Development Area. In this context, Sustainability has become a concept of great importance for corporate governance as it benefits in economy development and decision-making, together with sustainable issues [1]-[2].

The sustainable process is directly related to the aggregate impacts of economic, social and environmental factors, whether positive or negative. Furthermore, in practice, sustainability is generally reduced or replaced only by economic or environmental aspects [1]. Organizations are increasingly motivated to adapt to the so-called triple bottom line (sustainability tripod), which considers the ethical and social aspects of business, as well as the advent of globalisation, environmental pollution and

resource scarcity [3].

In this context, sustainability has become a concept of great importance for corporate governance as it benefits in policy development and decision-making, together with sustainable issues [2]. However, not all methodologies used for sustainability have been effective as they do not care equally between dimensions [4].

Given the importance and according to the researches carried out, the contribution of this work is to provide, from a literature review, an assessment of the contribution of ML techniques in the achievement of the Sustainable Development Goals. The methodology called Methodi Ordinatio was used to find relevant articles on the subject.

The article is organized as follows: Section II presents a background of ML techniques and Sustainable Development Goals. The materials and methods used in the research are presented in Section III. The section IV presents the conclusion of the paper.

2. BACKGROUND

A. Artificial Intelligence & Machine Learning techniques

Artificial Intelligence (AI) is defined as the set of theories, methods, techniques, sciences, technologies and algorithms that contribute to endowing machines with decision-making and action capacities traditionally attributed to high level mental processes. These include the ability to learn from one's experiences and adapt to changes in one's environment. As it developed by Andrew NG, Machine Learning can be defined as the process of including intelligence into a system or machine without explicit programming [5]. ML is a collection of methods that:

- Extract the useful information from data;
- Train a model on data and make decisions about unseen data without being explicitly programmed on how to do so.

Machine Learning algorithms differ in the learning methods adopted. They are classified to:

- Supervised learning: represents the process in which a computer program is trained by using known data. The output is also known and it aims to a final target that finds a link connecting the input data to output one and finally apply the learned rules to new data through examples of which we know the labels[6];
- Unsupervised learning indicates a system that is able to discover knowledge[6].The process has the capability to detect patterns and relationships between data without using labeled data[7].
- Semi supervised learning defines a technique that includes some labeled data with a large amount of unlabeled data[7].
- Reinforcement learning: in this process, the optimal solution is unknown to the system at the beginning of the learning phase and therefore must be determined iteratively [5].

A general configuration of the ML system is presented in fig.1[8].

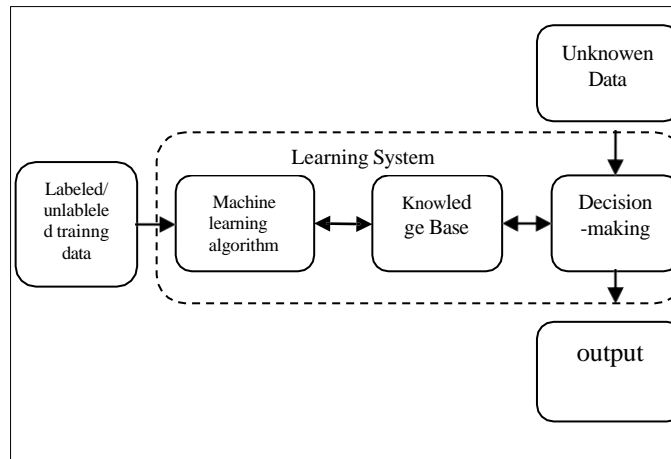


Figure 1 Machine Learning system configuration

In the recent years practical applications of machine learning (ML) have emerged in many sectors of economy.

Depending on the learning task’s method, ML can be classified in a number of categories, and provides prominent algorithms as it showed in the table 1.

Table 1 Description of ML Algorithms

ML Algorithm	Description
Decision Tree	Classifies data into smaller subsets where each subset contains responses of one class
Bayesian network	assumes that the value of a particular feature is independent of the value of any other feature, given the class variable [7].
Regression analysis	A classical predictive model that expresses the relationship between inputs and an output parameter in the form of an equation
Support vector machine	seeks the hyperplane with the largest margin, that is, the largest distance to the nearest sample points [7].
Artificial Neural Network	are collections of interconnected “neurons” (called nodes) that work together to transform input data to output data [7].
Genetic algorithm	is an adaptive algorithm which is based on the theory of natural selection. It could be used for feature selection to find a subset of significant variables [8].
Deep learning	worked on almost raw data with little or no need for data pre-processing [9].

Through the literature, ML techniques have emerged and give powerful solutions for many sectors social, environmental or economic levels. ML played a crucial role in improving experiences of customers [10]. also, many companies have declared taking full advantages of ML in demand forecasting [11]. [12] indicates that the Reinforcement learning is destinate to solve decision-making problems in dynamic environments. Furthermore, ML techniques present help through virtual assistants such as chatbots to deal with many tasks that present time consuming previously [11].

B. Sustainable Development challenges

Sustainable development has been regarded as the common goal of development of both economy and society by all the countries of the world [13]. Sustainable Development adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. At its heart are the 17 Sustainable Development Goals (SDGs), which are an urgent call for action by all countries - developed and developing - in a global partnership [14]. They recognize that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve oceans and forests[14].

Priorities for ensuring sustainable growth of the world economy are distributed between countries and their groups unevenly. It is influenced by the global economic situation cycles, and also by potential and possibilities for realizing the achievements of information and technological progress.

The Sustainable Development Goals are presented as it showed in the fig.2 [14], taking the Moroccan case as an example:



Figure 2 Sustainable development goals (Moroccan case)

How to determine the ability of Sustainable Development is a key issue to be solved. In this perspective, Machine Learning is presented as techniques for extracting potentially useful information for generation of knowledge. In this sense, algorithms are able to analyze performance indicators, which would facilitate the development of sustainability[15].

3. MATERIALS AND METHODS

In order to investigate essential information related to the theme, a literature review was conducted. The steps for this process were made according to the methodology called *Methodi Ordinatio*[16].

A. Description of the stages of the methodology *Methodi Ordinatio*

Ordinatio

1) Step1: Establishing the intention of the research

It refers to the objective on which the theme is based. In this case, therefore, it is to identify, from a literature review, the most used techniques to assist in the sustainable performance evaluation process. Thus, the research questions were divided into primary question (QP) and secondary questions (QS).The following questions are reported:

QP: How are the uses of machine learning being applied to assist the assessment of sustainable development goals?

QS: What are the most commonly used techniques/algorithms in this theme?

2) Step 2: Preliminary Search in Databases

In this stage, the main keywords for the study are chosen. It should be noted that the selection of keywords and the identification of their relationship are crucial factors to provide reliable results, however the knowledge acquired is chosen based on the judgment of the authors[17].

For step 2, it is essential to use a reference manager. In that study, Mendeley was employed. Mendeley software helped in the organization of the found articles, as well as in the exclusion of duplicate articles. For this study, the following key words were used: "machine Learning", "data Analytics", "Sustainable development", "Sustainable Development Goals", and "Circular Economy".

3) Step 3: Defining the combination of keywords and databases used

For this stage, the databases and the combination of keywords were respectively: Web of Science (WoS), for their comprehensiveness, multidisciplinary and indexing only the most cited journals, considering their respective areas. According to WoS, there are more than 12,000 high-impact journals indexed on this basis. The time limit for the study was 2018 to 2021. Regarding the combination, two groups were formed:

4) Step 4: Final database search

The number of articles found through Stage 3 was 80 documents, including 52 journal articles, 8 review articles, 21 proceeding papers. For these values, the exclusion criteria of duplicate articles and those without relation with the subject were not accounted .

5) Step 5: Filtration Procedures

The filtering procedures were used to eliminate repeated articles, in addition to those articles that had no link with the theme. In this regard, the Mendeley software assisted in the process of deleting duplicates. In relation to the articles that were unrelated, the titles and abstracts were read and, later, it was started for full reading in order to confirm the alignment with the subject. For this study only journals with an impact factor were searched. The impact factor is a measure used to assess the relevance of a journal over time[18] and is calculated from the average citation per article for a journal over a two- year period [19]. After filtration, 33 articles were considered for analysis

6) Step 6: Identification of the impact factor, year of publication and number of citations

For each article, we analyzed the impact factor of the journal (Journal Citation Reports - JCR), the year of publication, in addition to the number of citations. All articles were organized in the Excel environment.

7) Step 7: Classifying articles using Inordinatio

To define the relevance of the articles, the ordinatio equation was used[16]. The equation combines impact factor, year of publication and number of citations[16]. Both articles were classified in order of relevance, considering the metrics mentioned. The final result is presented through Table 2, according to the level of importance.

- Group 1: ML related words: “machine learning”; “data analytics”.
- Group 2: Words related to "Sustainable development", "Sustainable Development Goals", and "Circular Economy".



Figure 3 FINAL RESULT AFTER USE OF METHOD DI ORDINATIO

8) Step 8: Locating the works in full format

At this stage, all articles determined by Step 5 (33 articles), or by the journal’s website or by the Google Scholar website were located. In this stage, that there are some titles very similar to those of the articles defined or chosen in journals other than that identified previously, therefore, it is essential to pay attention to these issues, to avoid analyses.

9) Step 9: Systematic reading and analysis of articles

Finally, in the last stage, a systematic reading of the articles is performed, as well as its analysis. It should be noted that the choice of all articles is at the discretion of the researcher, and the researcher may choose the five or ten most relevant articles. For this study, we chose to read and analyze the 33 articles.

4. RESULTS

Authors in [20] are dealing with the implementation of Artificial Neural Network for saving the green agriculture. [21] described some of the threats of using ML techniques in two exemplary selected application areas: smart agriculture and smart health. Furthermore, [22] tried to compare the fuzzy optimization model and robust model decision-making for the sustainable development. It is clear that many works have tried to provide practical and conceptual frameworks to do adopting of ML techniques in the industry especially in the supply chain area, is the case of authors in [23] and [24].

Many works tried to analyze directly the use of Data Analytics in the achievement of Sustainable development Goals, as it was the case of [25].

[26] Analyzed the importance of big data in supporting sustainable manufacturing. Principal component analysis (Principal Component analysis - PCA) and random projection (Random project) were used in the collected data set, with the objective of identifying important factors for the construction of a

conceptual framework. An approach based on Bayesian analysis together with the Monte Carlo simulation for the assessment and classification of sustainable suppliers for the supply chain is also introduced[27], considering multiple dimensions of the sustainability tripod.

It is emphasized, from the mentioned works that the techniques can be used in different situations, such as for prediction, filtering, comparison, analysis, identification of patterns, classifications, among other utilities. The most commonly used in these studies was the use of predictive analyses (QP). Decision trees, association rules and cluster analyses helped in most of the studies analyzed (QS).

Decision trees are supervised models that can be used for both classification and regression[28]. However, it is necessary to follow some guidelines for its use, such as: sorting the data correctly; finding out which structure best fits its purpose; understanding the variables inserted in the context and building a self-adaptive model[28]. In addition, they have preference among other techniques, as they allow users to easily understand the behavior of the generated models[29].

5. CONCLUSION

This study sought to contribute, through a literature review, to the identification of different approaches of Machine Learning to assist in the assessment of the achievement of Sustainable Development goals. For this, it was necessary to use a review methodology and, also, the choice of databases that, in this study, was defined as: Methodi Ordinatio, Web of Science, Scopus and Science Direct, respectively. The period from 2018 to 2021 was set as the limit period of the research

From the work carried out, numerous utilities were perceived with the use of ML, such as: predictive analyses (the vast majority in this study); clustering; comparison; analysis; classification; identification of patterns, among others. It is also noteworthy that the most employed techniques were with the use of decision trees, association rules and cluster analyses for these studies. In addition, the studies found are concentrated in recent years, that is, they are current and can be deepened for future research.

Regardless of the sector analyzed, the selection of an appropriate technique is essential to understand the information generated, as well as to support the decision-making process. In this perspective, this article can contribute to serve as a basis to stimulate research on the real impacts that the methods addressed (ML techniques) can provide to the sustainable scope. In addition, to show that the discussion on this theme is current, important and fundamental, since sustainability is increasingly participatory for all countries in the world. In addition, it is of great interest to the Sustainable Development Goals, since they prioritize the use of computational methods to generate relevant and high-quality information.

It is recommended for future studies to encourage further research on the real impacts generated from the approaches studied ML in the sustainable context. The different approaches used by the articles studied can also be analyzed more precisely.

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