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MACHINE LEARNING APPLIED IN MEDICINE SECTOR : THE CHALLENGES AND PERSPECTIVES

RANYA KHADDOR[1], MAHACINE AMRANI [2], JAMAL BRIGUI [3]

[1,2,3] Laboratory of Valorization of Resources and Chemical Engineering of Abdelmalek essaadi university

Tangier, Morocco

E-mail: [1]ra.khaddor@gmail.com, [2]m.amrani2@uae.ac.ma, [3]jamalbrigui@yahoo.fr

ABSTRACT

In this study we address the application of Machine learning for medical diagnosis. A thorough analysis of various scientific articles in the domain of intelligence artificial application in the medical field has been conducted. However, to promote bioinformatic studies and research, several companies and scientific research development are keeping the challenge by improving and designing new useful applications applied on the selected sector fields. In this paper we hope to present the art of state of several works corresponding to the medicine field. Then, we aim to showcase the current state-of-the-art in various works pertaining to medicine. Our study resumes the analysis of the existing works of intelligence artificial applied to medicine and bioinformatics fields. Despite progress, significant challenges remain in various sectors and research domains. By conducting a comparative analysis of select works, we identify common characteristics and present our findings through a detailed discussion.

Keywords: *Medicine, Machine learning, Deep learning, Design, Classification, Bioinformatics, Healthcare*

1. INTRODUCTION

This guide provides details to assist authors in preparing a paper for publication in JATIT so that there is a consistency among papers. These instructions give guidance on layout, style, illustrations and references and serve as a model for authors to emulate. Please follow these specifications closely as papers which do not meet the standards laid down, will not be published.

Since their appearance, human have been creating different types of tools and machines to do various exercises in a simple way. Their creativity and the challenge of humans let them to invent several ways to do. These machine enables them to meet various needs including industries, computing, and travelling. However, Machine learning is the one among them. According to Arthur Samuel Machine learning is defined as the field of study that gives computers the ability to learn without being explicitly programmed [1].

Machine learning is a computer programming technique that uses statistical probability to give computers the ability to learn on their own without explicit programming. For its basic purpose, machine learning "teaches" computers - and subsequently, to act and react - as humans do, improving their learning style and knowledge autonomously over time. The ultimate goal would be for computers to act and react without being explicitly programmed for these actions and reactions. Machine learning uses development programs that adjust each time they are exposed to different types of input data. [1]–[6]

Machine Learning can be defined as an artificial intelligence technology that enables machines to learn without first having been programmed specifically for this purpose. Machine Learning is explicitly linked to Big Data, since to learn and grow, computers need data streams to analyze and train on.

As a result, Machine Learning, which essentially comes from Big Data, precisely needs the latter to function. Machine Learning and Big Data are therefore interdependent.

This paper provides a review and a study of application using ML in medicine, and it can moderately contribute to the existing literature review.

To do with we have some questions that we used as a guideline:

- How various is the application of ML in medicine?
- Does ML have a future?

This paper includes three principal sections. In the first section the research methodology is described. Then, we review machine learning application in medical sector. Finally, all collected diseases with their corresponding methodology are discussed, conclusions are drawn, and future research is suggested.

2. TEORETICAL BACKGROUND

In last few years the development of computer and science has several challenging impacts in a number of relevant sectors. However, Medicine have also benefit from this relevance by using a variety of success keys of this sector. Indeed, Machine learning approach give to researchers an arm to reduce costs and to solve the life of many people if we use it correctly.

Modeling by using machine learning is not a new methodology. Octave Leven spiel even stated that modeling stands out as the primary development in scientifical engineering [7].

In this research we find a variety of explanations of Machine learning. We will in this part of this paper to talk about Machine learning definition, sector of application, application of this technique in medicine sector, relevant related works, strengths, weakness, opportunities, and threats.

2.1 Machine learning

Machine learning is a combination of three important layers, as shown in Figure 1 the data, representations, and models. Data Layer is used as the first layer in a ML in order to train the model.

Therefore, the representation layer consists on how to represent data in the model. Even if the data is already in numerical format, the selection of the variables or features that will make up the model input can have a significant impact on the model performance. [4]

The last layer for a ML method is a modeling strategy. There is a large variety of machine learning models to choose from. Models can be presented in different forms, by classification or regression or by learning methodology such as unsupervised, supervised, active, or transfer learning as shown below in Figure 2. Generally speaking, the term “machine learning” can be applied to any method in which correlations within datasets are implicitly modeled. [6], [8]

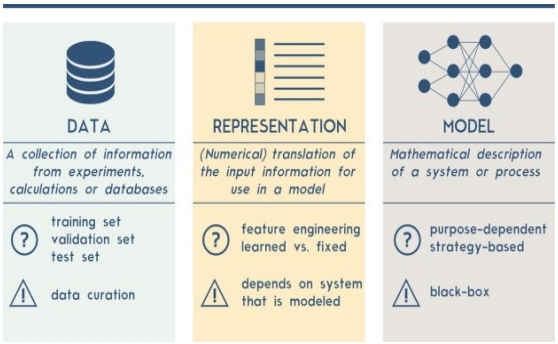

Figure 1. The DRM of machine learning representation

Several differences regarding the use of data exist between ML, DL, and traditional modeling. Firstly, ANN learn from data and train themselves, while this requires large scale of data. Second, the dataset is split into three sets: a training, validation, and test set. During the training phase, both the training and validation sets are employed, with only the data from the training set being used for fitting. The validation set serves as an unbiased dataset, offering an impartial assessment of model fit during the training phase. The test set, which consists of unseen data, evaluates the fit of the final model and is typically the primary measure of model quality.

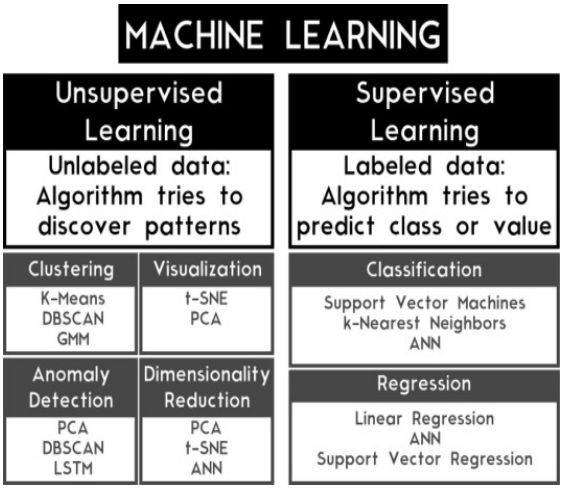

Figure 2. Machine Learning OVERVIEW

The Figure 2 present an overview of unsupervised and supervised machine learning algorithms [9] .

2.2 Machine learning applied in medicine

As digitalization continues to impact various industries, including healthcare, the ability to capture, share, and deliver data has become

increasingly important. To address the challenges of managing vast amounts of data, machine learning, big data, and artificial intelligence are being employed.

Machine learning has the potential to help healthcare organizations meet the growing demand for medical services, improve operations, and reduce costs. At the patient's bedside, machine learning innovations can aid healthcare professionals in detecting and treating diseases more efficiently, precisely, and with personalized care.

Examining the utilization of machine learning in healthcare underscores the potential of technological innovation to enhance patient outcomes through more comprehensive and efficient care strategies. Machine learning has numerous applications in the healthcare industry, affecting research, healthcare practices, and the pharmaceutical sector. At present, machine learning is primarily used in healthcare research, both in public and private settings. In the pharmaceutical industry, machine learning is a crucial component of research and development (R&D) strategies.

The huge volume of data processing and predictive analytics help uncover new molecules or speed up development phases. He is also present at the level of clinical trials to effectively identify the best treatments for each patient profile. Machine learning also offers the possibility of detecting a pathology earlier or of knowing which patients with a silent disease are likely to have a serious event in the short term. Machine learning is becoming more prevalent in radiology for medical image analysis in clinical settings. This technology speeds up and streamlines diagnostic processes, resulting in time savings for healthcare professionals.

ML is not there to replace the doctor but to support him in the analysis and interpretation of the huge volumes of data collected. In hospitals, ML and AI are used to simplify and optimize administrative tasks, including the patient's journey to hospital or care. New technologies are influencing the field of surgery by enabling simplified procedures for surgeons and reducing the incidence of errors. One example is the growing use of machine learning in robotics, which enhances precision in surgical maneuvers and enables remote operations.

Patient support solutions integrating machine learning are gradually emerging as virtual assistants to support patients throughout their care journey.

There are several applications of ML in medicine sector, like:

- Clinical decision support systems

Figure 3. Clinical decision support systems [10]

Clinical decision support systems, as shown in Figure 3, can analyze a large scale of data to identify a disease, define the next step in treatment, then determine potential problems, and ultimately improve overall efficiency.

- Smart record keeping

Ensuring that all patient records are regularly updated is challenging, as data entry is a monotonous task.

Figure 4. Smart record Keeping [11]

- Personalized medicine

Medical elements to generate customized treatment plans for patients by looking over patient data. Therefore, ML algorithms can identify optimal treatment options and predict treatment outcomes.

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- Machine learning in Medical Imagine

Traditionally, medical images like x-rays were presented in analog format, constraining their potential for identifying abnormalities, disease research, and case analysis. However, the advent of digital imaging has expanded the opportunities for analyzing this data type, particularly with the assistance of machine learning. Recent meta-analyses indicate that machine learning algorithms are comparable or even superior to human specialists, with deep learning algorithms achieving an 87.0% sensitivity and 92.5% specificity, and human clinicians achieving 86.4% sensitivity and 90.5% specificity [12].

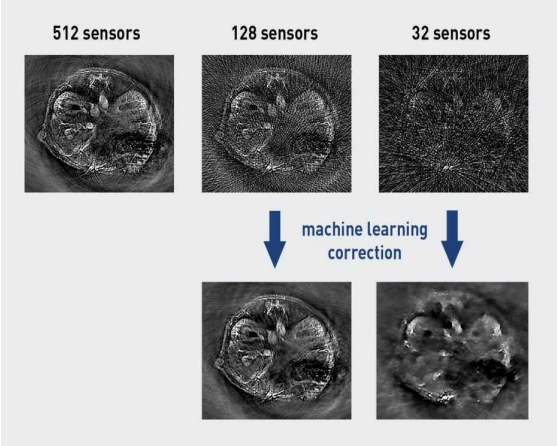

Figure 5. Machine learning in Medical Imagine [5]

- Robotic surgery

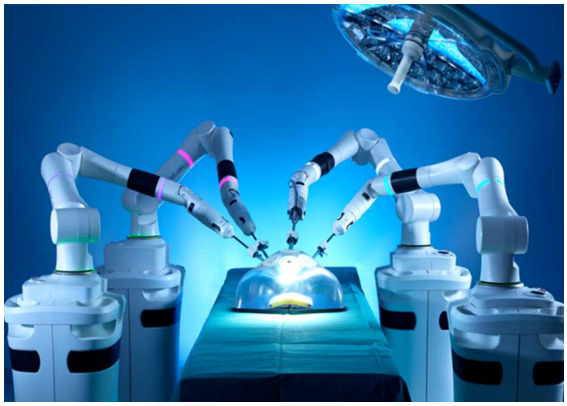

Figure 6. Robotic Surgery [13]

The da Vinci surgical system, illustrated in Figure 6, is currently used for robotic surgery. This system has a distinct design comprising specialized "arms" that can hold cameras and instruments, along with a magnified screen and console [14].

- Behavior adjustments

In healthcare, prevention is just as crucial as disease treatment. A key element of preventive medicine involves modifying behaviors to eliminate unhealthy habits and cultivate a healthy lifestyle.

- Predictive approach to treatment

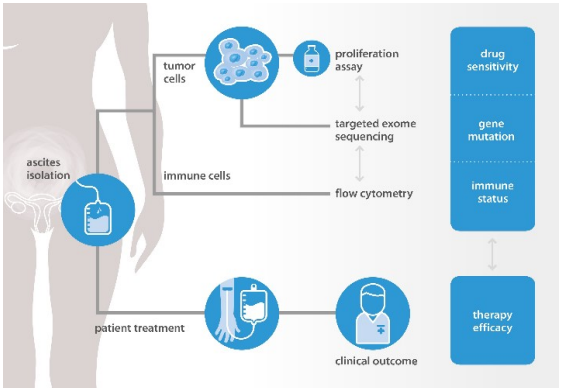

Figure 7. Predictive approach to treatment [15]

The early detection of serious diseases is critical in improving treatment outcomes and anticipating potential deterioration in a patient's health. Machine learning is increasingly recognized for its ability to predict such diseases in high-risk individuals. For instance, the Naïve Bayes algorithm can identify markers of diabetes, while machine learning can also aid in detecting liver and kidney disease, as well as tumors. This underscores the significance of machine learning in healthcare.

- Data Collection

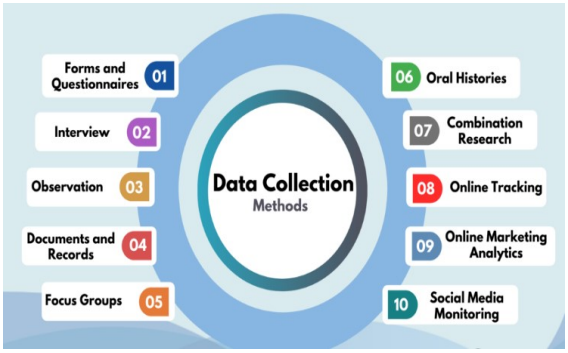

Figure 8. Data collection [16]

A crucial duty for doctors is to accurately record a patient's medical history, which can be challenging since patients may not possess the necessary information for diagnosis. However, by incorporating machine learning into healthcare management, medical professionals can utilize

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multiple indicators to determine the most pertinent questions to ask, resulting in a collection of relevant data and more accurate predictions for potential health conditions.

- Drug discovery and production

Figure 9. Drug discovery and production [17]

ML can utilize data on active drug components and their impact on the body to model these components for use in similar diseases. This approach can help in creating personalized solutions for patients with specific medical conditions or unique requirements. Additionally, ML tools can be combined with nanotechnology to enhance drug delivery and further improve patient outcomes.

- Elderly and low mobility groups care

Figure 10.Elderly and low mobility groups care [18]

The ML and medical industry can help low-mobility groups improve their daily lives with smart reminders and planning assistance, predict and avoid potential injuries by identifying common barriers and identify the optimal paths, and to get help as soon as possible.

Although these solutions are effective, they are not as widespread as necessary. However, Hospitals and laboratories are already taking steps to make it more widely available.

- Infectious disease outbreak prediction

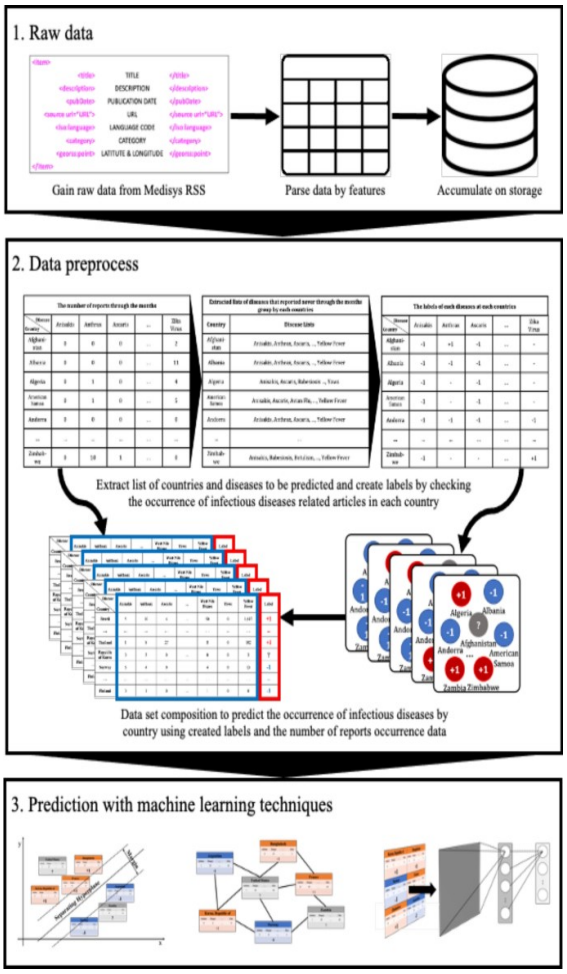

Figure 11. Infectious disease outbreak prediction [19]

The pandemic COVID-19 has proven that we are unprepared. Indeed, we must be prepared for an outbreak of such infectious disease of this magnitude. However, It is interesting to note that

experts in the region have informed the government of the possibility of such an event for years.

Today we have machine learning-based tools that can help detect signs of an outbreak early. Algorithms analyze satellite data, news, reports, images, videos and even social media to predict whether the disease has the potential to spiral out of control.

- Clinical Research

Figure 12. Clinical research [20]

Research and clinical trials are expensive. However, The safety of new drugs and medical procedures must be proven before they can be widely used. Furthermore, there are cases where the solution needs to be released as quickly as possible in the case of pandemic expansion like COVID-19 vaccines.

Luckily, there is a way to shorten the process using ML algorithms. It can be used to select the best sample for an experiment, collect more data, analyze ongoing data from experiment participants, and reduce data-based errors.

There are several applications using ML in Medicine industry. Below we present some of them:

- Microsoft Project Inner Eye
- Tempus
- PathAI
- Kareo
- Beta Bionics
- Kensci uses machine learning to predict illness and traetment
- Ciox Health
- Subtle Medical application uses ML and DL to produce clearer medical images for radiologists
- Pfizer
- Insitro

2.3 How Machine Learning enhances Healthcare?

Diagnosing patients quickly is important, but equally critical is ensuring accurate diagnosis as it constitutes a significant aspect of disease treatment. John Hopkins research reveals that medical errors result in thousands of fatalities annually. However, the integration of machine learning can minimize these fatalities by aiding the diagnosis process. Machine learning algorithms can analyze vast amounts of data to identify diseases accurately, especially in medical fields that rely on standardized procedures such as pathology. By merging machine learning with pathology management systems like ORNet Pathology, pathologists can speed up the diagnosis process by examining samples, marking points, adding annotations, controlling various devices, and sharing slide images with other specialists for consultation. In addition, ML and AI can monitor health epidemics by studying the spread of infections and predicting potential patterns, saving countless lives.

Machine learning is set to revolutionize healthcare in numerous positive ways. It will enhance diagnosis accuracy and treatment efficacy, while also enabling us to lead healthier, longer lives. In this regard, here are ten ways in which machine learning will bring positive change to healthcare.

- Improve the accuracy of diagnoses
- Speed up the diagnosis of diseases
- Early detection of diseases
- Personalize treatments for patients
- Improve patient outcomes
- Empower patients and caregivers
- Assist in Monitoring Health Epidemics
- Reduce the cost of healthcare
- Facilitate the Medical Data Collection
- Increase access to care

Major players in the healthcare industry, including Microsoft, Pfizer, and KenSci, are

introducing significant advancements in machine learning and artificial intelligence. This demonstrates the industry's increasing reliance on these technologies. As such, the future of healthcare looks promising as we anticipate even more groundbreaking innovations.

2.4 Ethics of employing ML in healthcare. [21]

Figure 13. Ethics of employing ML in healthcare

The emergence of artificial intelligence (AI) has given rise to a range of legal and ethical concerns for society. These issues include matters related to privacy and surveillance, as well as bias or discrimination in decision-making processes. Additionally, there is a philosophical challenge regarding the role of human judgment in the face of increasing reliance on AI [22] [23] [24] .

As shown in Figure 13, the ethics of using machine learning in medicine industry are:

- Representation and inclusiveness
- Patient safety
- Transparency and informed consent
- Autonomy problems
- Confidentiality and data security

The challenges of Machine Learning in the Medicine Industry are:

- Creation of ML tools adapted to the medical workflow
- Lack of quality data to build accurate algorithms
- Assemble large teams with broad skill sets in one place

Overall, machine learning has the potential to revolutionize the medical sector by improving patient outcomes, reducing medical errors, and speeding up the drug discovery process. As the technology continues to improve, it is likely that we will see even more applications of machine learning in medicine in the coming years.

3. DISCUSSION AND FUTURE WORKS

There are two important approaches to define when using machine learning and applying it to the medical sector. First, classification which includes narrowing potential outcomes by mapping data to outcomes. Second, gathered physiological data that includes images and data from other sources which used to identify and diagnose tumors or other diseases.

Table 1. Analysis of articles in Machine learning applied in healthcare domain

Disease	Method	DataSource
Dermoscopic analysis, a biopsy and histopathological examination [25]	Deep convolutional neural networks	Computed tomography (CT)
Diagnosis of Alzheimer's [26]	CNN	Neuropsychological
Existing automatic methods for cataract grading utilize a predefined set of image features [27]	CRNN	Fundus images
Parkinson's disease patients[28]	CNN	Fundus images
Automated breast cancer [29]	CNN	Mammography
Breast Cancer diagnosis [30]	CNN	Fundus images
Alzheimer's disease data sharing [31]	GAAIN Automated Data Transforme	Neuropsychological
Nuclei Detection on Breast Cancer Histopathology	Deep convolutional neural networks	Computed tomography (CT)

Images [32]		
Dermatologist-level classification of skin cancer with deep neural networks [33]	Deep convolutional neural networks	Computed tomography (CT)
Fast and robust segmentation of the striatum using deep convolutional neural networks [34]	CNN	MRI
Covid 19 [35]	CNN	GitHub and Kaggle
Thyroid disease [36]	Naïve Bayes, KNN, and SVM algorithm	UCI data repository site
Skin Cancer [37]	SVM and KNN	Collected from ISIC 2017 datasets with 1000 instance
liver fibrosis [38]	Random forests, MLP, logistic regression algorithm.	Collected by Ain Shams University, Faculty Medicine at El Demerdash Hospital.
Cardio Vascular[39]	Random Forest, Decision Tree, Logistic Regression, SVM, and KNN algorithms.	NDDK
Lung cancer[40]	SVM, Random Forest, ANN algorithms	UCI machine learning repositor
Prostate cancer [41]	SVM, Decision Tree, and MLP algorithm	github.com
Hepatitis (A, B, C, and E)	KNN, random forest, and naïve Bayes algorithm	Real data of hepatitis patients [3]
AI is increasingly supporting clinical practice.[42]	deep learning	
Approaches based on artificial intelligence are particularly promising, with numerous applications and significant enthusiasm in the field of research[43]	CNN	Clinical Images
Network analysis by systemic text excavation of the concept of personalized psychiatry and precision[44]	CNN	

As presented above in Table 1 all reviewed articles aimed at identifying diseases that used various ML algorithms since 2018. However, a summary of twenty-one reviewed articles, including disease type, method, and data source.

In the reviewed research, many algorithms have been used, like:

- logistic regression,
- K-means,
- decision tree,
- K nearest neighbor,
- random forest,
- SVM
- …

Furthermore, these algorithms have been applied to standard datasets in a variety of diseases.

Generally speaking, SVM and Logistic regression is the only binary classifier whereas K-means for multi-clustering and decision tree, random forest, KNN, naïve Bayes, and CNN are capable of classifying into more than two classes.

However, all algorithms seem to work well when using the smallest dataset, while using a large dataset is better to use deep learning algorithms such as CNN.

The synthesis of the data was carried out in a simple way. Collected data shown that convolutional neural networks (CNN) are the most used machine learning method.

It is expected that artificial neural networks will develop further in the future, thus managing to perform more complex tasks.

The detailed description and classification of all the previous articles presented in the Table 1 above can be useful for researchers developing new application by raising the awareness of the different possibilities. While we cannot make hard predictions on the future of machine learning for medicine, we expect two different directions: new, innovative application, and trying to present difficult process to be developed as a service.

After comparing twenty-one papers for different models, it is evident that a number of algorithms have good accuracy in predicting, such as Random Forest, K Nearest Neighbors, SVM, and Decision Tree.

Therefore, the accuracy of the same algorithm can differ from one to other dataset according to different factors that affect the accuracy and performance of the model. Furthermore, in this review the model accuracy and performance can be increased by using a different algorithm to produce an ensemble model.

4. CONCLUSION

In the last ten years, Machine Learning (ML) has emerged as a new option in the medical industry. ML is gaining popularity among medical engineers due to its speed, flexibility, and user-friendly applications. To improve the reliability and value of ML models, the following suggestions can be implemented.

The first suggestion is to provide good quality data and open-source models. These resources encourage researchers to use ML and allow them to focus on their research topic instead of programming and data collection.

The second recommendation is to create interpretable models. However, new models for medical applications can be inspired by existing algorithms.

Lastly, investing in profound algorithmic education is essential. ML models should be credible models, and this can only be achieved by being cautious when using the model outside of its training set.

One limitation of this paper is the absence of meta-analysis of quantitative data. However, given the scope of this research, this limitation does not affect the review's quality. In future works, it is suggested to categorize the theoretical background, as the paper lacks a detailed explanation of how machine learning functions.

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