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## ARTIFICIAL INTELLIGENCE IN BIOMEDICAL ENGINEERING: DISEASE PREVENTION

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**Abstract:** This project developed a qualitative, theoretical and bibliographic research whose results are related to introductory concepts of Artificial Intelligence. It was considered a case study of the application of AI to promote optimizations in the face of COVID-19. This case was used in order to investigate the benefits that AI can bring to disease prevention. The data for the study were extracted from the internet, from scientific articles, theses, dissertations and books. Three moments were necessary to guarantee a structured research, the first being the dedication to the study of introductory concepts of AI and Research Methodology, in order to define their relevance for the project. The second moment turned to a study focused on the applications of AI in Biomedical Engineering in general. For the third moment, two articles were used as the basis for a case analysis of the application of AI in the control of epidemiological outbreaks. The knowledge acquired throughout the research, the non-relevant themes, the current situation of AI in disease prevention and the importance of the study for the advancement in the area of Health were highlighted.

**Keywords:** Artificial Intelligence, Biomedical Engineering, Health, COVID-19.

## INTRODUCTION

The Scientific Initiation (CI) project is based on the importance of academic training, whatever their area of study, intellectual development, and bases for scientific research. This IC aims to introduce the study of Artificial Intelligence (AI) and possible applications in Biomedical Engineering using Mathematics. These assumptions aim to expand knowledge, which is often not introduced in an explanatory or detailed way during graduation and which can serve as a fertile knowledge base for the student in training and the job market. Therefore, this research aims to: select, study, synthesize knowledge of AI in

order to identify applications in the areas of Biomedical Engineering. The expansion of the targeted knowledge makes a CI project complementary to undergraduate training.

The emergence of AI itself took place in 1956, during the *Dartmouth* Conference, a historic moment in which researchers defined that each aspect of learning or other forms of intelligence could be described in a way that a machine could simulate. This is the central idea of the Fourth Industrial Revolution, in which data processing systems are created to reproduce human cognitive functions faster and with high analytical capacity (LOTTENBERG; DA SILVA & KLAJNER, 2019). In addition, the time was also marked by increased data processing speed, cost reduction and connections between technological devices.

With the advancement of the *internet* and its worldwide reach, in the second half of the 1990s, the potential of AI reached its maximum, starting the digital revolution. Several sectors were benefited, especially the health area, as it was discovered that AI systems would be able to make diagnoses, indicate treatments, operate equipment and perform useful activities for doctors, managers and patients (LOTTENBERG; DA SILVA & KLAJNER, 2019).

Kaufman (2022) dedicates a chapter to the protagonism of AI in health, aimed at combating COVID-19, stating that “with COVID 19, the health sector has been balancing short-term urgencies with the restructuring of the sector in the face of new technologies, when he particularly mentions AI.” (p.183).

Therefore, it is understood that sciences that rely on technologies are on the rise, resorting to them to identify non-visible patterns and indications of the probability of contamination. In this scenario, the role of AI stands out, which can contribute to screening

and supporting medical decisions, adding speed (KAUFMAN, 2022).

The development of this CI reinforced the role of research, in particular in controlling the COVID-19 pandemic, increasing the interest in searching for data. It also made it possible to verify the applications of AI systems in the area of Biomedical Engineering, elucidating its relevance to improve the health area. Some examples of the use of AI in Health stand out in:

- Study of new drugs, X-ray and ultrasound readings, identifying image patterns and helping professionals in the area to identify possible anomalies (tumors, cancers, inflammations, etc.) in patient diagnoses, which can be improved with analysis of genetic data and medical records (BORBA, undated).
- Emergence of electronic medical records, telecalls, cloud data, remote monitoring of vital signs and software capable of assisting in hospital management, aiming at care safety, improving the patient experience and reducing waste (DRG Brasil, 2021).
- Personal assistants who can act as coaches, reminding the person that they need to take their medicine and indicating which medicine they need to take, suggesting healthier food intake and sports practices (SAS, undated).

## ACTIVITIES DEVELOPED

That The research was developed according to the guidelines and recommendations of the advisor presented via emails, *WhatsApp* and meetings on the *Microsoft Teams platform*, since the COVID-19 pandemic made face-to-face meetings impossible. Discussions often took place to present what had already been done and receive analysis and criticism of the content presented, so that it was clear how the

project must proceed. In addition, the choice of the bibliographical approach happened since it would not be possible to carry out technical visits, meetings with professionals in the area studied or participate in lectures on the foreseen subjects, due to the guidelines of social distance. Therefore, the project followed the method of bibliographic investigation, in a perspective of qualitative research.

From August to October 2021, studies were carried out on “Research Methodology”, based on the reading of Luna (2009) and discussions with the advisor. The studies served as a knowledge base to carry out research in an assertive and coherent way, guiding a planned path so that the research can be completed and the project meets the conditions required by the scientists. The familiarization with the use of a methodology with a view to results, happened as the research developed, it was possible to understand the importance of scientific methodology in the curriculum of an undergraduate, who now has a foundation to understand how the processes take place. gathering information, developing and publishing a project.

In addition to deepening the methodology to guide the development of the project, the bibliographical survey on the concept of Artificial Intelligence was carried out from October to December 2021. For this, scientific articles, dissertations, theses, books and websites were *analyzed*. The study addressed the emergence of AI, the different times through which it traveled until it reached the present day, its functionalities, the concept of *Machine Learning* and applications for the health area, emphasizing its correlation with Biomedical Engineering.

During the same period, we intend to understand the principles of *fuzzy logic*, a mathematical concept suggested by the advisor (MARRO; CAVALCANTE; BEZERRA & NUNES, 2010). The aim was to

check the application of this concept focused on Artificial Intelligence in the field of Biomedical Engineering, especially in disease prevention, the research line of this project. Although it was not possible to perceive this application, the study carried out was useful, even if initial.

In the following months, the development of the research focused on reading and studying the articles “Scientific Prospecting on the Epidemiology and Prevention of Covid-19 Allied to Artificial Intelligence” (FREITAS et al., 2020) and “An analysis on the development of *digital* technologies in health to face COVID-19 in Brazil and in the world” (CELUPPI *et al.*, 2021) (used as a complement), which address the themes of AI, Health and disease prevention, making them ideal for my CI project. The book “Demystifying artificial intelligence” (KAUFMAN, 2022) was published when the choice of articles was defined, and the reading of some of its chapters allowed us to reinforce the importance of choosing the theme of the use of AI in the control of COVID-19. The developed study made it possible to know some solutions that AI devices could generate to deal with pandemics, controlling and preventing epidemiological cases, such as COVID-19.

## **DISCUSSION OF RESULTS AND LITERATURE REVIEW**

The activities that were part of this CI project were intended to acquire knowledge about introductory concepts of Artificial Intelligence and understand some of its applications in the area of Biomedical Engineering and Health, with a focus on disease prevention. For the first part, synthesized and presented in the partial report, theoretical studies and discussions were carried out addressing the research methodology and concepts of Artificial Intelligence.

## **RESEARCH METHODOLOGY**

In this item we report the studies carried out on the subject and the choice of methodology that guided the research.

With regard to the calendar part, it was initially necessary to study and understand the principles that make up the research methodology, applied to develop the project in a coherent, concise manner that would achieve the proposed objectives. For this, the book “Research planning: an introduction” (LUNA, 2009) was used, which allowed, in principle, to substantiate the definition of research. Basically, the research methodology gains meaning from the moment the researcher interprets a reality and produces new content based on it, so that it is relevant in the area of study. For this, there are basic elements that characterize the development of the research. Firstly, a question must be formulated regarding the theme, bearing in mind that the answers sought prove to be new and significant. Based on this, what information is needed to generate such responses and the best sources to study them are determined. The next step is to define the set of actions that must be followed to reach the available information, which includes establishing a treatment and analysis system for pre-existing data. With the structured line of reasoning, it is possible to formulate the answers to the questions established at the beginning of the research, concluding if they are reliable, to avoid the feeling that the answer could have been obtained independently of the research and the data analyzed. Finally, there is an indication of the generality of the results, that is, to stipulate the extent of what was found, so that it is explained and delimited to what extent they can be extended to situations not contemplated in the research.

The book also provided relevant information for the researcher’s preparation before a research project. First, it must

become adequate to the conditions under which the research will be carried out, so that it becomes aware of restrictions on available technology, time allocated to the project and financial resources. After considering its feasibility, it is important to be clear and as detailed as possible about the problem raised for the research, as it will serve as a guide for the development of the project and represents the researcher's intentions.

The hypotheses raised also deserve attention, since they can be easily confused with the problem itself, and, in fact, represent only assumptions regarding the possible results.

With regard to the definition of the methodological procedures of the research itself, it was understood the need to carry out a literature review, an important part of the scientific work that can be searched in: articles in libraries provided by Capes (Coordination for the Improvement of Level Personnel Superior), publication summaries, references to previously published articles and bibliographic survey services. In case the appropriate literature is not found through the mentioned ways, the researcher can also resort to consultations with specialists in the area or to analogies, which characterizes the search for similar problems and related areas. Finally, the researcher must establish the method of scientific research that he will follow to elaborate his project, namely: qualitative or quantitative.

The first was used in this CI and has subjective character, that is, part of theoretical bases inspired by the human sciences, seeking information in theoretical documentation of previously obtained data. And so, in this CI project, the collection, interpretation and conclusion of the data were guided by the reading and dissection of articles, books and scientific reports. It was an investigation based on bibliographical analysis. The quantitative

method follows a mathematical and statistical character, so that the results can be quantified and dimensioned exactly.

The work dedicated to the study of research methodology served as a basis for the preparation and development of this CI project, so that it was relevant to acquire knowledge regarding the structure of a scientific work, whose theoretical foundations, researched sources, action plans, objectives to be achieved and conclusions must follow a pattern in order to guarantee a well-structured research.

Finally, it is important to state that the project followed the qualitative nature of the research and was guided by bibliographic investigations. The analysis was restricted to two articles, given the topicality of the topic, which dealt with the use of AI in the control of COVID-19.

## **ARTIFICIAL INTELLIGENCE**

For the study of Artificial Intelligence (AI), the initial intention was its conceptualization through the investigation of origins and definitions. This is because notions of AI are often not introduced in an explanatory way during graduation and can serve as a fertile base of knowledge for the student in training and who aims to enter the job market. Therefore, the main objective of the research was to collect and study the concepts, theories, contents and other sources of AI knowledge that can contribute to problem solving and optimization within the areas of Biomedical Engineering and Mathematics.

In order to analyze the definition of AI and concepts related to it, the documents "Artificial Intelligence and Biomedical Engineering: Perfect Marriage or Eternal Lovers?" were used. (BARRETO, undated) and "ARTIFICIAL INTELLIGENCE" (MACHADO, 2011). Basically, AI can be considered as a problem-solving methodology whose objective is



to create artifacts capable of reproducing intelligent behavior. Barreto (undated) traces an important timeline for understanding what the notion of AI was in the past and what happened to make it the tool it is today. The history of AI ranged from times like Prehistoric (before 1875), when nothing was known about the mechanisms of the mind and there was great appeal to the supernatural, the Dark Ages (1969-1981), when there was withdrawal from AI researchers and the media presented the creation of intelligent beings as something bad (referring to computers that would dominate the world, for example), and the Contemporary era (1987 - present), a moment in which there is an expansion of AI applications, considered Modern AI (MACHADO, 2011), penetrating the most diverse fields of activity: computer networks, symbolic manipulation in mathematics, use in image exams, research in oil fields, and the creation of intelligent databases. However, according to Machado (2011), the first official mention of the expression “Artificial Intelligence” officially took place in 1956 during a summer conference at *Dartmouth College*, NH, USA, a period followed by great enthusiasm and many expectations. As at the time there was no knowledge about the principles that underlie intelligence or about the practical limits of the processing capacity of computers, there were instances of exaggerated promises and respective disappointments.

In the 70s of the last centuries, AI ceased to participate exclusively in the academic environment and opened up perspectives for commercial and industrial applications (MACHADO, 2011). This occurred due to the emergence of the first Intelligent Systems, technology with intellectual performance equivalent to that of an adult human being. Basically, a system is called intelligent if it starts from the combination of AI with a

database, through a programming language (BARRETO, s/d). From this a mechanism was created: the computer would be able to capture data, combine them and return new data, showing itself as an active method of intelligence. Intelligent Systems can follow two lines of research: connectionist and symbolic. The first aims at building computational intelligence inspired by the interconnections of neurons, so that it is possible to simulate the components of the brain, a line of research that gave rise to neural networks. The second simulates human behavior in decision-making and problem solving, based on the operation through symbols and rules, since symbolic representations play a vital role in the human reasoning process. According to Machado (2011), a new line of AI research has recently emerged, in addition to those mentioned above, which is based on the observation of evolutionary mechanisms found in nature, such as self-organization and adaptive behavior.

After understanding the origins, definitions, lines of research and important times linked to AI, it is necessary to analyze some of its applications. For this, this CI project focused on studying the complementarity that exists between AI and the health area, seeking examples for a case study of disease prevention that were related to the field of Biomedical Engineering.

## **ARTIFICIAL INTELLIGENCE AND BIOMEDICAL ENGINEERING**

The union between the domains of Artificial Intelligence and Biomedical Engineering appears as “a possible marriage, in which AI finds a motivating field of application, provoking new methodological research and EB receives solutions capable of improving the quality of knowledge about life and the treatment of illnesses.” (BARRETO, undated, p. 1).

According to Barreto (undated), the first applications of AI in medicine date back to the 1970s, even when the technology was seen as “bold ignorance”. A major milestone at the time was the emergence of one of the first expert systems using AI, MYCIN. It was a computer consultation system to assist physicians in diagnosing and selecting therapy for bacterial blood infections. Its relevance was due to having more than 450 rules (MACHADO, 2011) and the introduction of two AI ideas: separation of the knowledge base with ways to manipulate this knowledge (inference engine), and application of certainty factors, for treatment of inaccuracy in diagnoses (BARRETO, s/d).

From 1990, when there was an explosion of AI due to the advent of the *internet*, several areas were benefited, mainly Health, as systems with AI attributes are suitable for making diagnoses, indicating treatments, operating equipment, etc. This becomes possible with the application of *Machine Learning*, a branch of AI that uses data and algorithms capable of making machines learn and evolve from this, so that it is enough to feed them with information to be able to perform parallel tasks automatically. Therefore, the union of the Health area with Biomedical Engineering and AI attributes is precisely due to the introduction of technologies to aid in clinical activities, such as screening, diagnosis, test results and treatments, since AI allows machines to combine information from similar cases through association (LOTTENBERG; DA SILVA & KLAJNER, 2019). According to Lottenberg, Da Silva and Klajner (2019, p. 35) “In the last two years, more data has been generated than in all of history [...] Of this amount of data generated, most is related to health.”, which demonstrates the relevance of applying AI to capture and process data.

Considering the importance of the

application of AI artifices in the well-established areas of Health and Biomedical Engineering, this research focused on the study of its attributes for the prevention of diseases. After a survey with the keywords: AI, Health, Biomedical Engineering and COVID-19, the articles “Scientific Prospection on Epidemiology and Prevention of Covid-19 Allied to Artificial Intelligence” (FREITAS et al., 2020) and “An analysis on the development of digital technologies in health to face COVID-19 in Brazil and in the world” (CELUPPI *et al.*, 2021).

## APPLICATION OF AI IN THE PREVENTION OF COVID-19

Starting in 2020, the COVID-19 pandemic originated in the city of Wuhan, Hubei province in China, after the spread of the SARS-CoV-2 virus (FREITAS et al., 2020). This scenario forced a radical change in the traditional model of patient care, since: “Health organizations had to renounce routine face-to-face care and invest in technological solutions to carry out non-face-to-face clinical follow-up of patients.” (CELUPPI *et al.*, 2021). Taking this situation into account, some effective and safe Artificial Intelligence solutions to minimize the impacts of COVID-19 were used:

- clinically monitored isolation via application, *software*, call or videoconference, aiming to contain the transmission of the virus (CELUPPI *et al.*, 2021).
- application of interactive health systems to facilitate contact between health professionals and patients (CELUPPI *et al.*, 2021).
- the use of statistical techniques for predicting incidences and vaccination, promoting control of epidemic and pandemic cases (FREITAS *et al.*, 2020).

- use of systems capable of learning from previous data to predict future scenarios and indicate coping measures (FREITAS *et al.*, 2020).

In 2020, Brazil had 14,938 Intensive Care Unit (ICU) beds and 95% of them were in use, which means that measures must be taken to ensure prevention and epidemiological containment in the face of the critical Brazilian scenario at the time. According to Freitas *et al.* (2020), “it is advisable to combine forecasting methods with the use of Artificial Intelligence, which may help to decrease the number of cases”. This depends on the Health Information System (SIS), which, according to Ferreira (1999, p. 7): “(...) is a set of components that act in an integrated manner, through mechanisms for collection, processing, analysis and transmission of the necessary and timely information to implement decision-making processes in the Health System”. Therefore, SIS collects data referring to health services and, in the case of COVID-19, AI resources could extract statistics from the system and improve its understanding, updating data and information in real time based on the restrictive measures implemented and the monitoring of crowds in specific locations.

In addition, data from the SIS could also feed intelligent machines to generate Pandemic Prediction and Control Systems using AI. Freitas *et al.* (2020, p. 553) indicates that: “By identifying the possible numbers of cases and the time that the numbers will be reached, strategies can be established to strengthen protective measures, evaluate the number of beds made available to critical patients, analyze the different groups that may be affected.

According to Freitas *et al.* (2020, p. 555), extensive data storage is useful for:

- monitoring systems for agglomerations, forecasts of new outbreaks, alerts on the

implementation of protective measures, such as isolation and distancing in certain regions, systematization of the appearance and monitoring of disease cases and timely provision of information to health managers.

Bearing in mind that the pandemic was a milestone in the technological revolution in the health sector, new strategies and adequacy of services were suddenly requested in view of the issue of social distancing. In the case of Brazil, several initiatives related to telemedicine were instituted (CELUPPI *et al.*, 2021), however, the applications mentioned here have been little explored so far, mainly systems for monitoring, control and epidemiological prevention of diseases, which would ensure progress in the prediction and prevention of pandemic cases, for example, with the use of databases of the most used systems, such as SIS, and AI training (FREITAS *et al.*, 2020 ). Although in practice there are already forecasting systems developed by professionals in the field, the introduction of AI techniques could reduce the margin of error, predict difficult behaviors and decrease the system’s response time.

According to Freitas *et al.* (2020), another possible aspect in the future for combating epidemiological cases is the use of robots trained via AI algorithms. This would be beneficial to reduce contact between professionals and the infected (in sample collection or in risky procedures) and to clean infected sites using ultraviolet light or electromagnetic waves.

In addition, the use of AI could also be applied to immigrants, so that an algorithm capable of screening travelers considered at risk of infection could be developed, indicating them as candidates for a diagnosis.

Finally, the study and analysis of specific articles for the COVID-19 pandemic led to the conclusion that AI attributes have high potential in coping with epidemiological outbreaks, since they could contribute to the



capture and processing of data in real time, expanding the accuracy of information and measures taken. However, it is a little explored technological field and there were no relevant advances in this case study, so the information described refers to the possibilities of applying AI and its respective results in disease prevention.

## **COLLECTION AND EVALUATION PROCEDURES**

The collection of data that allowed the research and development of this CI occurred through the compilation and consultation of bibliographic sources related to the theme of applications of Artificial Intelligence in the field of health and Biomedical Engineering, aiming at the prevention of diseases.

The information discussed was based on qualitative research, more indicated when the study is descriptive and what is sought is the understanding of the phenomenon as a whole, in its complexity (FREITAS; JABBOUR, 2011). Its fundamental purpose is the understanding, explanation, specification and interpretation of social phenomena. The method adopted by this type of research is inductive, that is, which starts from data to formulate a theory, valuing the value of the researched information. Therefore, we opt for definitions that fit the research process, for concepts obtained through relations and properties, for comparative analysis and for a small sample, chosen to be investigated, in addition to being necessary to consider the context in which the analyzed situation occurs. (SANTOS FILHO, 2009).

Adopting this line of research, the information that contemplated the development of this CI project was obtained through two bibliographic surveys.

Each one was directed towards a specific objective, the first of which contemplated the more general study of research methodology

themes, AI and AI applications in the field of Health and Biomedical Engineering, and the second was dedicated to the choice of articles that must be read and analyzed in this project.

For the first part, a bibliographical survey of sources relevant to the theme of CI was carried out, that is, those that contained relevant information about research methodology, definitions and origins of AI, *fuzzy logic* and cases of disease prevention using AI technologies. This was done in order to obtain the necessary theoretical knowledge to structure the project and meet the suggested proposals. The topics of AI, Biomedical Engineering and research methodology were extensively studied and addressed in the research. As for the principles of applying *fuzzy logic*, as much as obtaining this knowledge is useful and fulfills the objective of studying topics that go beyond graduation, it was possible to identify that its attributes would not be used for the study of AI attributions in the field of Health and Biomedical Engineering.

The second part consisted of the study of sources related to the application of AI in Biomedical Engineering. With this, it was possible to develop a theoretical basis on the relationship between the areas and how they emerged, in addition to their benefits, explained in the examples cited.

The third and last part aimed to search for practical applications of Artificial Intelligence in disease prevention. This consisted of reading and analyzing two articles, both on how attributes of AI and digital technologies could help in decision-making to face the epidemiological scenario of COVID-19.

## CONCLUSION AND CRITICAL DISCUSSION

As the use of AI in disease prevention is a topic that is little explored and currently practiced, the information discussed in this project sought to know, detail and determine scenarios that would benefit from its attributes. Based on the knowledge described and the analysis of the cases brought by the articles used, it can be said that the research allowed us to understand the advances that AI applications would bring to infection control, case monitoring and forecasting of new outbreaks.

As much as the use of AI was analyzed only for COVID-19, the study was relevant due to the pandemic scenario that we continue to face, characterizing a current topic. It was also important to understand that the possibilities brought by AI are applicable to any infectious disease scenario, as clarified in this project. In addition, the research made it possible to know the current scenario in this regard, especially in Brazil, where applications have not been much explored and there are several useful

aspects of AI to be analyzed and implemented in the health system. Therefore, this project contributed to identify the potential of using AI to fight infections, which currently has few applications in force. Therefore, it can be concluded that there is a lack of AI attributes in the commitment to disease prevention, since this proposal is recent, especially in the case of COVID-19

A proposal to deepen this theme in a future research, which could originate from this CI, would be, for example, the use of the bibliographic investigation brought by this project as a basis for an empirical research.

Therefore, cases in which there is application of AI in monitoring systems for agglomerations, forecasts of new outbreaks, alerts for the implementation of isolation and distancing in certain regions, monitoring of disease cases and providing information in a timely manner to managers could be considered. health, to name a few possibilities. Therefore, the continuity of this research could also cover the scope of Health and Biomedical Engineering, addressing empirical improvements promoted by AI in both areas.

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