

A BIBLIOGRAPHIC REVIEW APPROACH ON THE USE OF ARTIFICIAL INTELLIGENCE IN AGRICULTURE

UMA ABORDAGEM SOBRE REVISÃO BIBLIOGRÁFICA SOBRE O USO DA INTELIGÊNCIA ARTIFICIAL NA AGRICULTURA

UN ENFOQUE DE REVISIÓN BIBLIOGRÁFICA SOBRE EL USO DE LA INTELIGENCIA ARTIFICIAL EN LA AGRICULTURA



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ABSTRACT

Currently, much has been discussed about the use of artificial intelligence in various areas of knowledge, such as economics, medicine, engineering, industry, and also in different segments of agribusiness. In the agricultural context, this technology is present from the machinery used in the field, which is increasingly automated and intelligent, to systems and software aimed at the management of rural properties. It is observed, therefore, that the advancement of machine learning and other artificial intelligence tools has been significantly contributing to the transformation and modernization of the agricultural sector. These technologies enable greater efficiency in production, better decision-making, optimization of the use of natural resources, and increased productivity. As a result, they further strengthen the relevance of agriculture within the Brazilian economy, a sector that plays a fundamental role in the country's economic growth. In this context, the present study aimed to carry out a bibliographic review on the application of artificial intelligence in agriculture, seeking to identify its main applications, benefits, and contributions to development and innovation in the agricultural sector.

Keywords: Artificial Intelligence. Agribusiness. Industry 4.0.

RESUMO

Atualmente, muito se tem discutido sobre o uso da inteligência artificial nas mais diversas áreas do conhecimento, como economia, medicina, engenharias, indústria e também nos diferentes segmentos do agronegócio. No contexto agrícola, essa tecnologia está presente desde os maquinários utilizados no campo, cada vez mais automatizados e inteligentes, até os sistemas e softwares voltados para a gestão das propriedades rurais. Observa-se, portanto, que o avanço do aprendizado de máquina e de outras ferramentas de inteligência artificial vem contribuindo significativamente para a transformação e modernização do setor

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agrícola. Essas tecnologias possibilitam maior eficiência na produção, melhor tomada de decisões, otimização do uso de recursos naturais e aumento da produtividade. Como consequência, fortalecem ainda mais a relevância da agricultura dentro da economia brasileira, setor que desempenha papel fundamental no crescimento econômico do país. Nesse contexto, o presente trabalho teve como objetivo realizar uma revisão bibliográfica acerca da aplicação da inteligência artificial na agricultura, buscando identificar suas principais aplicações, benefícios e contribuições para o desenvolvimento e a inovação no setor agrícola

Palavras-chave: Inteligência Artificial. Agronegócio. Industria 4.0.

RESUMEN

Actualmente, se ha discutido ampliamente sobre el uso de la inteligencia artificial en diversas áreas del conocimiento, como la economía, la medicina, las ingenierías, la industria y también en los diferentes segmentos del agronegocio. En el contexto agrícola, esta tecnología está presente desde la maquinaria utilizada en el campo, cada vez más automatizada e inteligente, hasta los sistemas y softwares orientados a la gestión de las propiedades rurales. Se observa, por lo tanto, que el avance del aprendizaje automático y de otras herramientas de inteligencia artificial ha contribuido significativamente a la transformación y modernización del sector agrícola. Estas tecnologías permiten una mayor eficiencia en la producción, una mejor toma de decisiones, la optimización del uso de los recursos naturales y el aumento de la productividad. Como consecuencia, fortalecen aún más la relevancia de la agricultura dentro de la economía brasileña, sector que desempeña un papel fundamental en el crecimiento económico del país. En este contexto, el presente trabajo tuvo como objetivo realizar una revisión bibliográfica sobre la aplicación de la inteligencia artificial en la agricultura, buscando identificar sus principales aplicaciones, beneficios y contribuciones al desarrollo y la innovación en el sector agrícola.

Palabras clave: Inteligencia Artificial. Agronegocio. Industria 4.0.

1 INTRODUCTION

In an ever-evolving world, complexity is undeniably prevalent. The challenges that society must face continue to expand in various dimensions, such as the economic, social, and environmental aspects of sustainability. These multifaceted demands require the ability to make informed decisions based on vast amounts of data and information. For example, optimizing profitability must be achievable while maintaining a strong connection with an extremely demanding market and consumers (PINHEIRO et al., 2021).

Envision a future where farmers have analytical tools at their disposal to enhance their decision-making process about crops and livestock; where management practices and combinations of inputs are dictated by physical conditions, biological factors (e.g., pests, diseases), and economic sustainability. Looking at the real world, it's clear that we still have a long way to go. Take pesticides, for example – they are still being sprayed all over the field, not just the affected areas or plants (RUSSO, 2020).

Although agricultural areas have noticeable differences in factors such as fertility and moisture, inputs are applied without taking into account these variations, causing unnecessary waste and environmental damage. The problem is that the tools used to make decisions do not recognize the fact that agricultural systems are subject to non-linear interactions, with multiple variables at play. As they move forward, it becomes evident that it is essential to have a deeper understanding of how various elements interconnect to affect each other in agricultural operations (MEGETO et al., 2021).

To increase the ability to predict and prescribe solutions, improved methodologies are required. Artificial intelligence (AI) could revolutionize this area by offering an area of study that incorporates machines with human-like thought processes, such as rationality. By leveraging these technologies, sophisticated systems absorb knowledge from previous encounters, allowing them to perform actions much faster and more efficiently than humans ever could. With its ability to process large amounts of data continuously, AI can outperform humans in identifying year-round occurrences such as disease, drought, and weed competition, as well as predicting productivity, profitability, and weather patterns (BORBA et al., 2022).

AI-integrated machines can relieve workers of heavy tasks by providing fast and sophisticated results. However, the potential risks of AI need to be anticipated and treated like any innovative development. Because AI relies on connectivity, cybercriminals can manipulate it, producing significant disruptions, damage, and damage. Criminal activity can disrupt the proper functioning of autonomous drones, planters, or harvesters, resulting in irreversible damage. Design errors stemming from a fascination with technology, prioritizing

productivity and profitability over ecological sustainability, are also a cause for concern, as the pursuit of prudent economic outcomes often requires a combination of both (FERNÁNDEZ, 2020).

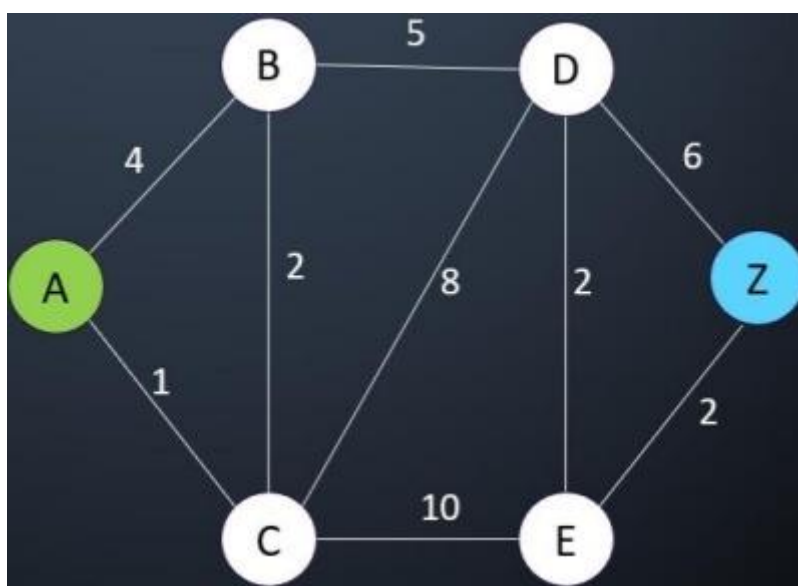
In short, Artificial Intelligence in agriculture is a topic of great relevance amid the wave of technological advances that are bringing more efficiency to the field. In agribusiness, AI has been incorporated into agricultural operations to manipulate data, generate estimates, or even perform image recognition, and the importance of this study is to show the great importance that this technology has for Brazilian agribusiness. In this context, the objective of the present study was to verify artificial intelligence applied to agriculture, aiming to verify how its tools have been used to improve crop monitoring, pest monitoring, etc.

2 THEORETICAL FRAMEWORK

2.1 ARTIFICIAL INTELLIGENCE

British mathematician Alan Turing (Alan Turing) was one of the pioneers who wrote papers on computational intelligence through his book *Computational Machinery and Intelligence* in 1950. In his article, the mathematician developed the Turing test, which is a way of specifying that the performance of intelligent machines is better than that of humans. This test is informally called an imitation game by Turing himself (KAUFMAN, 2019).

One of the common definitions of artificial intelligence is as a branch of computer science responsible for automating intelligent behaviors. Since intelligence is expressed as a form of calculation, formalization and mechanization are subsequent steps. Gottfried Wilhelm introduced a system of formal logic when designing machines that perform tasks automatically. The steps of this mechanical solution can be represented as movement by the study of a tree or figure. In Figure 1, there is a representation of a decision diagram (DA SILVA; MAIRINK, 2019).

Figure 1*Example Graph*

Source: DA SILVA; MAIRINK, (2019).

The construction of graph theory also contributed to the emergence of the concept of state-space search, which is an important technology in artificial intelligence. The chart is used to construct the problem to be solved. The nodes of the state-space graph represent the possible steps of solving the problem, and their arc involves reasoning, the steps to follow to solve the problem. The solution to this type of problem is obtained by investigating the state-space diagram, which is a path to a solution. In this way, they represent a powerful tool to specify the complexity of the problem to be solved and the efficiency of the analysis of the solution strategy (PEIXOTO; SILVA, 2019).

From the 18th to the 20th century, science and mathematics became the academic prerequisites for the research and development of artificial intelligence, but it was not until the beginning of digital computing in the 20th century that artificial intelligence became scientifically viable. It is now possible to implement a formal reasoning system on a computer and empirically test its ability to demonstrate intelligence (DONEDA, et al., 2018).

2.2 MAIN ASPECTS OF ARTIFICIAL INTELLIGENCE

Many current artificial intelligence logics are elaborated through a set of modular components and rules of behavior, which do not follow a strict order when executed, but are activated in response to the specific situation of a given problem (BARBOSA, 2017).

There are several studies involving artificial intelligence for different applications. Connectionism is based on the functioning of logic and rational thought. People are working hard to get intelligence by building the architecture of the human brain. The neural network

model demonstrates the brain's ability to adapt to the world in which it finds itself, creating and modifying connections between neurons (MAIA FILHO; JUNQUILHO, 2018).

Another intelligent model based on biological tissues is related to the process of interaction between species that adapt to the environment. In this way, they apply the principles of biological evolution to the problem of finding solutions to difficult problems. This method does not seek solutions to problems through logical reasoning, but creates groups of competing responses and evolves them into a better solution for simulating biological evolution (CORVALÁN, 2020).

The social system represents another metaphor for intelligence, as it presents a joint behavior that allows dealing with problems that cannot be solved by just one member (OLIVEIRA, 2019). For example, while no one can accurately predict the amount of bread New York City will consume on any given day, New York's bakery system does the job as a whole, providing bread to the city with minimal waste (LOBO, 2017).

This metaphor in academia established the concept of IAD (Distributed Artificial Intelligence), which they interpreted as a very promising branch of artificial intelligence research, which is still little explored today. It is different from the classical model of artificial intelligence, because traditional research aims to analyze individual human behavior and its focus is on the representation of knowledge and reasoning methods. On the other hand, the IAD model is based on social behavior and its focus is on the actions and interactions between agents. This proposition introduces the concept of agent, which is characterized by reflecting the collective behavior of many simple individuals who interact with each other (PORTO, 2019).

3 ARTIFICIAL INTELLIGENCE IN AGRICULTURE

Since the turn of the century, big tech companies have pondered the idea of creating an automated field that can sustain itself through harvesting. The management of pre-planting, planting and harvesting has presented difficulties, leading to the emergence of Smart Agriculture. The idea is to link entire fields to one or more smart grids, using artificial intelligence and machine learning. Today, Digital Agriculture or Smart Agriculture is the preferred term to describe an agricultural management methodology that seeks the most productive production while minimizing crop losses and maximizing profit without expanding land (SEGOVIA; ROJAS; QUISHPE, 2021).

It is important to note that another critical concept, IOT (Internet of Things), exists to facilitate fast and secure communication between machines and users, ensuring the integrity of the information shared. Imagine an expansive field, linked to several machines capable of

detecting problems and providing various resolutions. However, if access to this information is only feasible through the physical approximation of the machines, this would consume as much time as manual field verifications (MENDES-MOREIRA; FERREIRA; DIAS, 2022).

This is where the Internet of Things becomes relevant, by allowing a seamless exchange between machine and user. This concept essentially involves the connection of machines to each other (machine-to-machine), as well as the user (machine-to-user). By establishing connectivity, the previous scenario is solved, and the collected data can be easily transmitted to a desktop or smartphone over any distance. Data science and artificial intelligence are poised to revolutionize the sector, granting farmers resources to optimize every square meter of available land (MEIRELLES; MOREIRA; COELHO, 2004).

Industry 4.0, with its focus on smart factories and smart manufacturing, has been greatly aided by advances in information and communication technologies, including the use of artificial intelligence. The outdated nature of traditional systems for more complex tasks has led to the utilization of on-board computing, real-time schematics, and resource scheduling strategies for improved manufacturing operations. Within the field of agriculture and industry 4.0, product testing has emerged as a key application (SANTOS, 2020).

When it comes to producing and developing items of greater complexity, automated testing becomes a vital tool. That said, there is a significant problem presented by the considerable delay in testing that occurs across multiple geographic networks, but fortunately a solution has emerged in the form of an automated testing system that can support testing in geographically dispersed environments. With this in mind, this particular subject presents a promising path for the development of algorithmic machine learning (XAVIER, 2020).

In addition, there is an underlying need for flexibility in all aspects of product development, while also recognizing that human learning is a valuable factor that cannot be overlooked. One solution to these limitations is to integrate artificial and human intelligence to work together in harmony, with a focus on the former mimicking human behaviors and reasoning through the use of pattern recognition, logical applications, and final conclusions (ADORNO, 2021).

3.1 CROP MONITORING

Precision agriculture is a management system that emerged for this purpose. However, precision agriculture, which was based only on miraculous technological solutions, is slowly evolving into a more promising situation that is truly revealing its potential and results. Its growth develops with technological advances, including: Global

Positioning System (GSP or GPS), Remote Sensing, Variable Rate Input applications, Geographic Information Systems (GIS or GIS), among others (PIRES et al., 2004).

To ensure optimal crop monitoring, drones equipped with high-quality cameras have emerged as the latest and most innovative solution. By utilizing the remote control, growers can effortlessly navigate through the entire plantation while the lens captures images in real-time. These images are then analyzed by an AI or stored in a database for further treatment. As a result, producers are equipped with all the necessary information to accurately assess the quality of their production (CONFORTO et al., 2016).

Figure 2

Analysis of the plant carried out through drones



Source: climatefieldview.com.br

Google has gone so far as to train its AI to recognize more than 5,000 distinct types of plants and animals, making it much easier to detect crop diseases and other problems. Thanks to this approach, results are achieved effectively and reliably, allowing producers to act with a greater probability of success. On another front, image sensors embedded in the soil allow continuous monitoring, efficiently avoiding unpleasant surprises at harvest time, such as pest and disease outbreaks (PÉREZ et al., 2019).

The application of pesticides depends on the level of pest infestation found in the area, which can be determined by the producer. By collecting images, the producer can make informed decisions about what agricultural input to use and how much to use it to optimize productivity on the farm. To reduce water and electricity use, technology is being tested to predict the amount of water each irrigator will need for irrigation. This can lead to increased productivity by ensuring that the appropriate amount of water is used (MORETI et al., 2021).

3.2 AUTOMATION OF AGRICULTURAL MACHINERY

Smart tractors incorporate familiar technologies such as autopilot, but their impact on agriculture is critical. The concept of an unmanned tractor alone can significantly reduce cultivation time and increase the consistency and accuracy of yields. Similarly, tractor developers are utilizing sensors linked to vast databases to minimize potential setbacks and maximize farmers' profitability (RUSSO, 2020).

Figure 3

Unmanned tractor



Source: chbagro.com.br

Through advanced technology and machine learning, the project is developing intelligent machines that can detect and reroute barriers, distinguish ripe and spoiled products, and increase the efficiency of agricultural operations. These machines even analyze soil conditions in real-time and provide recommendations to farmers for improvements (MEGETO et al., 2021).

Figure 4

System allows rapid diagnosis of the crop for the correct application of various products.



Source: www.farmfor.com.br

According to Pires et al. (2004), the tools used can be used individually or combined, depending on the financial resources available and the specific needs identified for each area. The entire cycle of precision agriculture involves not only field evaluation, but also data processing and the creation of prescription maps or properties for path correction. Several computational applications have been developed by research institutions and private companies to maximize the use of the collected data and obtain relevant information about the system. Each tool available operates according to its own unique principles. For example, organic matter sensors utilize optical properties of soil, nutrient sensors utilize ion-specific electrodes, soil salinity and moisture analysis is performed using electrical conductivity, and soil texture analysis is performed by studying acoustic properties of soil.

Pires et al. (2004) also state that among the various possible uses, the mapping of soils and crops to obtain productivity maps, application of input doses at variable speeds, orientation of air and land inputs and use in management decision support systems stand

out. The technology is also used to map and monitor areas infested by weeds, diseases, and pests to help take appropriate control measures. In some studies based on the differential reflection of radiation incident on vegetation, sensors can distinguish between soil and weeds and target those specific areas. This can reduce herbicide use, reduce production costs, and increase food production.

4 FINAL CONSIDERATIONS

Looking ahead, Digital Agriculture presents a practical solution that focuses on optimizing productivity while minimizing the use of resources, which is imperative to avoid potential risks and create effective proposals. The need for human intelligence in this process would require time and resources that we simply cannot do without. Recent studies show that in the coming years, the demand for food will increase globally, and consequently, technological advancements driven by artificial intelligence will arouse interest.

Techniques such as Deep Learning, Machine Learning, and IOT have played an essential role in the agricultural sector, identifying pestilences and diseases, reducing crop damage and losses, shortening the time it takes to harvest crops, collecting relevant soil data, and making informed decisions, which ultimately reduces environmental damage. The journey towards smart agriculture is never-ending as technology, and its applications continue to evolve every day, further advancing the agricultural technology market.

Across a range of disciplines, artificial intelligence (AI) is advancing in agriculture. With machine learning revolutionizing every corner of the economy, the agricultural sector is carving out its own territory in the production pipeline. Investments and adoption of AI are increasing, as its ability to interpret and analyze data surpasses that of humans, aiding in the acceleration of rapid processes. These developments are manifesting themselves in a variety of industries, including manufacturing, transportation, agribusiness, and real estate.

With the arrival of technology, there is an increasing need for fast and efficient processing of large volumes of data that the human intellect cannot meet. This is especially pronounced in the seed industry, from sowing to quality control testing, which requires careful analysis of multiple seed lots. Quality control tests look at germination, emergence, accelerated aging, electrical conductivity, cold test, and water content. All of this needs careful interpretation to ensure safe information about the seeds.

However, the high demand for lot analysis is impossible to meet with human intelligence, especially with regard to the commercialization of seeds and grains. The implementation of AI-based technology in various industries, including agriculture, has proven to be a valuable tool for streamlining operations and overcoming obstacles. With the ability

to detect soil contents, monitor crop growth, and even automate weeding and planting, farmers have been able to increase their yields and minimize resource use.

This improvement in efficiency has led to better quality crops and, as a result, faster time to market. AI enables farmers to collect and analyze vast amounts of data, providing solutions to their toughest challenges and enabling faster, more informed decision-making. In a field where innovation is essential, the integration of artificial intelligence has revolutionized the agricultural sector by increasing productivity and optimizing resource allocation.

REFERENCES

- Adorno, S. (2021). Inteligência artificial. *Estudos Avançados*, 35, 3–3.
- Barbosa, M. M. (2017). Inteligência artificial, e-persons e direito: desafios e perspectivas. *Revista Jurídica Luso-Brasileira*, (6), 1475–1503.
- Borba, M., et al. (2022). Gestão no meio agrícola com o apoio da inteligência artificial: Uma análise da digitalização da agricultura. *Revista em Agronegócio e Meio Ambiente*, 15(3), 1–22.
- Conforto, D., et al. (2016). Inteligência artificial: As possibilidades de sistemas especialistas na agricultura. In VI Mostra Científica.
- Corvalán, J. G. (2020). Inteligencia artificial GPT-3, Pretoria y oráculos algorítmicos en el derecho. *International Journal of Digital Law*, 1(1), 11–52.
- Silva, J. A. S., & Mairink, C. H. P. (2019). Inteligência artificial. *LIBERTAS: Revista de Ciências Sociais Aplicadas*, 9(2), 64–85.
- Doneda, D. C. M., et al. (2018). Considerações iniciais sobre inteligência artificial, ética e autonomia pessoal. *Pensar – Revista de Ciências Jurídicas*, 23(4), 1–17.
- Embrapa. (2023). Discutindo agricultura de precisão: Aspectos gerais. http://www.cnpt.embrapa.br/biblio/do/p_do42.htm
- Fernández, F. (2020). Inteligencia artificial y agricultura: Nuevos retos en el sector agrario. *Campo Jurídico*, 8(2), 123–139.
- Kaufman, D. (2019). A inteligência artificial irá suplantar a inteligência humana? *Estação das Letras e Cores*.
- Lobo, L. C. (2017). Inteligência artificial e medicina. *Revista Brasileira de Educação Médica*, 41, 185–193.
- Maia Filho, M. S., & Junquilha, T. A. (2018). Projeto Victor: Perspectivas de aplicação da inteligência artificial ao direito. *Revista de Direitos e Garantias Fundamentais*, 19(3), 219–238.

- Megeto, G. A. S., et al. (2021). Aplicações de inteligência artificial na era da agricultura 4.0. *Revista Ciência Agronômica*, 51.
- Meirelles, M. S. P., Moreira, M., & Coelho, F. B. N. (2004). Uso de inteligência artificial em agricultura de precisão: Redes bayesianas e neurais. In *Agricultura de precisão para o manejo da fertilidade do solo em sistema plantio direto* (p. 175).
- Mendes-Moreira, J., Ferreira, C. A., & Dias, D. (2022). Inteligência artificial na agricultura. *INESC TEC Science & Society*, 1(4).
- Moreti, M. P., et al. (2021). Inteligência artificial no agronegócio e os desafios para a proteção da propriedade intelectual. *Cadernos de Prospecção*, 14(1), 60.
- Oliveira, A. (2019). *Inteligência artificial*. Fundação Francisco Manuel dos Santos.
- Peixoto, F. H., & Silva, R. Z. M. (2019). *Inteligência artificial e direito* (Vol. 1). Alteridade.
- Pérez, J. L., et al. (2019). Impacto de las tecnologías disruptivas en la percepción remota: Big data, internet de las cosas e inteligencia artificial. *UD y la Geomática*, (14).
- Pinheiro, R., et al. (2021). Inteligência artificial na agricultura com aplicabilidade no setor sementeiro. *Diversitas Journal*, 6(3), 2996–3012.
- Porto, F. R. (2019). O impacto da utilização da inteligência artificial no executivo fiscal: Estudo de caso do Tribunal de Justiça do Rio de Janeiro. *Direito em Movimento*, 17(1), 142–199.
- Russo, I. F. D. (2020). O impacte da inteligência artificial na sustentabilidade ambiental: Uma agricultura sustentável (Tese de doutorado). Universidade de Lisboa.
- Santos, R. (2020). Inteligência artificial em prol da agricultura. *Agroanalysis*, 40(12), 30–31.
- Segovia, J. S. B., Rojas, F. A. D., & Quishpe, M. W. V. (2021). Estudio del uso de técnicas de inteligencia artificial aplicadas para análisis de suelos para el sector agrícola. *RECIMUNDO*, 5(1), 4–19.
- Xavier, R. A. (2020). As vantagens e desvantagens da inteligência artificial na agricultura. *Kur'ytyba: Revista Multidisciplinar de Educação, Ciência e Cultura*, 12(1).