Volume 22, January-December 2024, ISSN: on request

MONOGRAPH

CIENCIAS UNIVERSITARIAS

Journal site: https://revistas.unah.edu.cu/index.php/cu Cu-ID: https://cu-id.com/cu/v22e07

THE ARTIFICIAL INTELLIGENCE IN BOVINE REPRODUCTION

LA INTELIGENCIA ARTIFICIAL EN LA REPRODUCCIÓN BOVINA

NEYLIS CHÁVEZ MILLARES*, ROYMAN GONZÁLEZ RIVAS, YUSNEY MARRERO GARCÍA, LILIBETH MERCEDES GONZÁLEZ RUIZ

Universidad Agraria de la Habana "Fructuoso Rodríguez Pérez" (UNAH)

** Author for correspondence: Neylis Chávez Millares. E-mail: neylis@unah.edu.cu*

Abstract

Today, livestock farming faces the challenge of increasing production to meet the growing demand for animal products. In this context, bovine reproduction represents a multifactorial process that requires informed and strategic decision making to increase reproductivity and economic benefits. The objective of the present research is to analyze the potential of Artificial Intelligence to improve decision making in bovine reproduction. The application of several techniques of this discipline, such as Machine Learning, Artificial Neural Networks, Deep Learning, Support Vector Machines and Decision Trees, is analyzed. These technologies can be applied to different areas such as: genetic selection, heat and disease detection, artificial insemination and animal health monitoring. The use of these techniques is conditioned by three fundamental factors: the characteristics of the organization, the proposed objective and the particularities of the data set, which must be taken into account when deciding which technique to use. Therefore, the application of intelligent technologies allows the sustainability of the livestock sector by reducing costs, increasing milk and meat production in order to improve efficiency and profitability, guaranteeing animal welfare during the processes.

Key words: decision making, livestock, intelligent technologies, food safety

Resumen

Actualmente, la ganadería enfrenta el reto de aumentar la producción para satisfacer la creciente demanda de productos de origen animal. En este contexto, la reproducción bovina representa un proceso multifactorial que exige la toma de decisiones informada y estratégica para incrementar la reproductividad y los beneficios económicos. El objetivo de la presente investigación es analizar el potencial de la Inteligencia Artificial para mejorar la toma de decisiones en la reproducción bovina. Se analiza la aplicación de varias técnicas de esta disciplina, como el Aprendizaje Automático, las Redes Neuronales Artificiales, el Aprendizaje Profundo, las Máquinas de Soporte Vectorial y los Árboles de Decisión. Estas tecnologías pueden ser aplicadas a diferentes áreas tales como: la selección genética, la detección del celo y enfermedades, la inseminación artificial y el monitoreo del estado de salud de los animales. El empleo de estas técnicas se ve condicionado por tres factores fundamentales: las características de la organización, el objetivo propuesto y las particularidades del conjunto de datos, los cuales se deben tener en cuenta en el momento de decidir cuál técnica utilizar. Por tanto, la aplicación de tecnologías inteligentes permite la sostenibilidad del sector ganadero al reducir costos, aumentar la producción de leche y carne con el fin de mejorar la eficiencia y la rentabilidad, garantizando el bienestar animal durante los procesos.

Palabras clave: toma de decisiones, ganadería, tecnologías inteligentes, seguridad alimentaria

Introduction

Livestock farming is a primary factor in guaranteeing food security, which is why animal health and well-being have become key elements for sustainable development (Sustainable Agriculture Sector Program (NAREN), 2020). However, this situation represents a challenge for livestock farmers. The disproportionate increase in the human population worldwide makes food increasingly difficult.

Received: June 18, 2024
Accepted: October 01, 2024
Conflict of interests: The authors of this work declare no conflict of interest.
AUTHORS CONTRIBUTION: The authors participated in the design and writing of the work, in addition to the analysis of the documents.

In the last 10 years there has been a growing demand for products of animal origin, which is evident in the exponential growth of herds. At the same time, new generations are less and less interested in this sector. Due to this situation, workers in the area have decided to include more sophisticated and less invasive techniques to maintain livestock practices and facilitate work, such is the case of Artificial Intelligence in livestock reproduction (Melak et al., 2024). With the application of innovative and intelligent technologies it is possible to achieve greater control of livestock without the need to increase the institution's staff.

Currently, the livestock sector is aimed at increasing milk production and genetically improved reproduction, in other words, they need cattle with dairy and meat genes. From this situation arises the need to include Artificial Intelligence techniques to improve precision and increase speed in livestock processes (González et al., 2018). Therefore, the research objective is proposed to analyze the potential of Artificial Intelligence to improve informed decision making in bovine reproduction.

1. Artificial Intelligence in Livestock Farming

The use of Artificial Intelligence in livestock farming has made it possible to optimize various processes, both productive and reproductive, such as herd movement, animal health, reproduction, milk and meat production, among others. The implementation of these technologies increases the possibility of improving livestock management, of monitoring the animal in real time.

Artificial Intelligence provides numerous benefits, which can have a significant impact on the management of the institution. Some of these benefits are: optimization of decision making, early detection of diseases, improvement in livestock breeding and reproduction, efficiency in the use of resources and improvement of animal well-being (Bovine Genetics, 2020). Livestock farming, although it is considered a pillar for food, is still behind other sectors, so the application of intelligent techniques marks an important advance in its development (Bayona et al., 2024).

2. Artificial Intelligence in Bovine Reproduction

The integration of Artificial Intelligence and bovine reproduction provides a new perspective in livestock farming. The computer systems associated with this discipline serve as support tools for the livestock sector specialist. Therefore, livestock reproduction has benefited from these tools in different processes, some of these are:

There are numerous applications in this field in bovine reproduction, some of these are:

- Genetic improvement: allows optimizing the selection and reproduction of animals with desirable characteristics. In the case of cattle, animals with a dual purpose, milk and meat production, are desired (Marizancén and Artunduaga, 2017).
- Heat detection: identifies the optimal moment to perform artificial insemination (Strappini et al., 2015).
- Reproductive health monitoring: precisely manages bovine reproduction, contributing significantly to animal well-being, since it uses techniques that are not aggressive or invasive for the animal (Curti et al., 2023).
- Artificial insemination: evaluates the effectiveness of artificial insemination and suggests improvements in the techniques used, with the purpose of increasing the success rate (Terrero and Morejón, 2014).
- Analysis of reproductive data: improves the management and optimization of reproductive processes (Terrero and Morejón, 2014).

Overall, these advances provide enormous benefits for both the entity and the animal. Among the benefits are:

1. Improves the success rate of artificial insemination and productivity by allowing early detection of diseases.
2. Reduces costs as it identifies estrus (estrous period or heat) more accurately, optimizing artificial insemination and, therefore, reducing operating costs.
3. Promotes animal welfare (Melak et al., 2024).

Currently, Artificial Intelligence has a lot to contribute to livestock farming and bovine reproduction. It is a field that is still under development. Trends in this branch of computing are transforming bovine reproduction. These are aimed at real-time monitoring, accurate detection of heat, advanced genetic analysis, automation of processes, prediction of reproductive results and analysis of data for decision making (García et al., 2020 ; Fuentes et al., 2022; Moreira et al., 2023).

3. Artificial Intelligence Techniques used in Bovine Reproduction

To decide whether a technique is appropriate or not for a given objective, three fundamental aspects must be taken into account: the characteristics of the organization in which the technique is going to be applied, the proposed objective and the particularities of the data set. For example, if the data set is limited, simple techniques such as Support Vector Machines or Decision Trees should be used which, unlike other techniques such as Artificial Neural Networks, Machine Learning and Deep Learning, do not require large volumes of data to your training. Depending on the objective to be achieved, Artificial Intelligence techniques may vary.

For example, if the purpose of the research is to genetically improve a certain species, techniques such as Deep Learning, Machine Learning and Artificial Neural Networks can be used, because they can perform complex analyzes and provide accurate results. The same occurs for reproductive health monitoring, artificial insemination and reproductive data analysis. In the case of heat detection, the most suitable technique is Machine Learning due to its ability to identify complex patterns and improve accuracy. Other techniques that can be used in livestock reproduction are Support Vector Machines and Decision Trees that, although not the most appropriate, can be applied to achieve the proposed objective since they are simple techniques that can be used in simple analyzes (Berryhill et al., 2020).

Deep Learning is based on the use of Artificial Neural Networks. These networks are inspired by the functioning of the human brain and are composed of layers of artificial neurons connected to each other with multiple layers. The complexity of this structure allows the learning of complex patterns from unstructured data. Deep Learning is mainly used for recognition and prediction tasks, such as image classification, object detection or machine translation. Despite their success, the learning process of these models remains complex and not very transparent (Padial, 2019).

Machine Learning is characterized by its ability to learn from data without the need for explicit programming. Machine Learning algorithms are based on pattern recognition and decision making from large data sets, allowing them to improve their performance over time. Unlike human learning, which requires the capacity for reflection and self-analysis, this technique does not require this faculty and its models are capable of improving their performance over time as they are exposed to new data (Padial, 2019).

On the other hand, Artificial Neural Networks need to be trained since they learn from large data sets, without the need for explicit programming. Furthermore, they are made up of artificial neurons that process information and generate outputs from inputs and can learn complex patterns from unstructured data. This technique can adapt to new data, learn patterns, and make accurate predictions in unknown scenarios (Basogain, 1998).

However, Support Vector Machines are used as a tool for data classification in a wide range of applications. Their ability to find nonlinear hyperplanes, their robustness to overfitting, and their computational efficiency make them an attractive option for many machine learning problems. Support Vector Machines are widely used to classify images into different categories, such as faces, objects or landscapes. They can also be used to recognize patterns in voice signals and distinguish between different speakers or words, to classify texts into different categories, such as sentimental or news documents, and to analyze medical data, as well as predict the risk of diseases or response to treatments (Lee, 2010).

Decision Trees, for their part, are made up of nodes and branches, each node represents a question or a test about a characteristic of the data, and the branches that leave a node represent the possible values or answers to the question. Decision Trees are used to classify data into different categories, they have flexibility and robustness against outliers and missing data. The hierarchical structure allows you to clearly visualize classification rules and relationships between data characteristics, making them a powerful tool for data classification and analysis. Generally, this technique provides a quick response, is precise and does not require many resources to execute (Menes et al., 2015; Song and Ying, 2015).

Therefore, the correct selection of the technique depends on the domain of the scenario where you want to work. From the point of view of livestock reproduction, Artificial Neural Networks, and their branches, play a leading role since they can be applied to most of the activities carried out in the area. Currently, many people or researchers are integrating some techniques with others to complement each other or improve existing algorithms in order to increase their efficiency and precision.

4. Impact of the application of Artificial Intelligence associated with decision making in Bovine Reproduction

The techniques and tools proposed have influence on the decisions made in each of the livestock processes. Consequently, it can be said that Artificial Intelligence is positively transforming decision-making in the different areas of bovine reproduction. The application of computer techniques in this branch of livestock farming allows the analysis of large volumes of data with greater precision and speed than traditional methods, which guarantees livestock farmers making informed decisions about artificial insemination, genetic selection and early detection of reproductive problems (Kerton, 2012). It can also adapt reproductive strategies to the individual characteristics of each animal, which favors the improvement of the reproductive efficiency of the individual and the reduction of costs associated with bovine reproduction, such as the costs of failed artificial insemination and treatment of reproductive problems. and, therefore, the increase in the profitability of livestock operations. In addition, it provides facilities to help select animals with desirable characteristics for reproduction, such as greater fertility or resistance to diseases (Garro and Tallarico, 2022).

By integrating large volumes of data and advanced algorithms, Artificial Intelligence facilitates informed decision-making and the optimization of information management, which in turn contributes to increasing the profitability and reducing the environmental impact of livestock production. In general, this discipline has the potential to transform cattle farming, making it more

efficient, sustainable and profitable. The application of smart techniques in the sector is a significant step towards a sustainable future for food security.

Conclusions

Five Artificial Intelligence techniques were analyzed, of which the most used for decision making in the different areas of bovine reproduction are: Artificial Neural Networks, Machine Learning and Deep Learning. With the support of these technologies, results have been achieved in less time and with greater precision.

References

Basogain, X. (1998). *Redes Neuronales Artificiales y sus aplicaciones*. https://ocw.ehu.eus/pluginfile.php/40137/mod_resource/content/1/redes_neuro/contenidos/pdf/libro-del-curso.pdf

Bayona, J. S.; Serrano, M. K.; Navarro, A. Y.; Sarabia, J. J.; Ramírez, J. D.; y Galvis, J. J. (2024). IA aplicado en la ganadería. https://www.researchgate.net/profile/Margie-Serrano-Carrascal/publication/381227428_IA_APLICADO_EN_GANADERIA/links/666278ffb769e769191d65e2/IA-APLICADO-EN-GANADERIA.pdf

Berryhill, J.; Heang, K. K.; Clogher, R.; y McBride, K. (2020). *Hola, mundo: La Inteligencia Artificia y su uso en el sector público*. Asociación Mexicana de Internet. https://doi.org/10.1787/726fd39d-en

Curti, P.; Selli, A.; Pinto, D.; Merlos-Ruiz, A.; Balieiro, J.; y Ventura, R. (2023). Applications of livestock monitoring devices and machine learning algorithms in animal production and reproduction: an overview. *Animal Reproduction*, *20* (2). https://doi.org/10.1590/1984-3143-AR2023-0077

Fuentes, S.; Gonzalez, C.; Tongson, E.; y Dunshea, F. R. (2022). The livestock farming digital transformation: implementation of new and emerging technologies using artificial intelligence. *Animal Health Research Reviews*, *23*, 59-71. https://doi.org/10.1017/S1466252321000177

García, R.; Aguilar, J.; Toro, M.; Pinto, A.; y Rodríguez, P. (2020). A systematic literature review on the use of machine learning in precision livestock farming. *ScienceDirect*, *179*. https://doi.org/10.1016/j.compag.2020.105826

Garro, R.; y Tallarico, G. (2022). Ganadería de precisión: innovaciones tecnológicas que agregan valor a la ganadería. *IDIA21*, *2* (1), 21-27. https://repositorio.inta.gob.ar/xmlui/bitstream/handle/20.500.12123/12167/pubidia22_ano2_n1mayo_v4_p.21-27.pdf?sequence=1&isAllowed=y

Genética Bovina. (2020). Inseminación artificial: puntos a tener en cuenta en nuestras ganaderías. *Genética bovina colombiana*.°en https://revistageneticabovina.com/biotecnologia/inseminacion-artificial/

González, N.; Leyva, M. Y.; Faggoni, K. M.; y Álvarez, P. J. (2018). Estudio comparado de las técnicas de Inteligencia Artificial para el diagnóstico de enfermedades en la ganadería. *Sistemas, Cibernética e Informática*, *15*(2).Consultado el 8 de julio de 2023. °en https://www.iiisci.org/journal/pdv/risci/pdfs/CA178AR18.pdf

Kerton, L. (2012). *Sistema para el análisis y toma de decisiones sobre datos parametrizados*. [Tesis de Grado, Universidad de Ciencias Informáticas]. La Habana, Cuba. https://repositorio.uci.cu/jspui/bitstream/ident/TD_05601_12/2/TD_05601_12.pdf

Lee, Y. (2010). Support vector machines for classification: a statistical portrait *Methods Mol Biol*. https://doi.org/10.1007/978-1-60761-580-4_11

Marizancén, M. A.; y Artunduaga, L. (2017). Mejoramiento genético en bovinos a través de la inseminación artificial y la inseminación artificial a tiempo fijo. *Revista de Investigación Agraria y Ambiental 8*(2), 247-259. https://dialnet.unirioja.es/descarga/articulo/6285365.pdf. ISSN: 2145-6097.

Melak, A.; Aseged, T.; y Shitaw, T. (2024). The Influence of Artificial Intelligence Technology on the Management of Livestock Farms. *Hindawi*, *2024*. https://doi.org/10.1155/2024/8929748

Menes, I.; Arcos, G.; Moreno, P.; y Gallegos, K. (2015). Desempeño de algoritmos de minería en indicadores académicos: Árbol de Decisión y Regresión Logística. *Revista Cubana de Ciencias Informáticas*, *9* (4), 104-117. ISSN: 2227-1899.

Moreira, A.; Santos, F. K., dos; Machado, P. B.; Berghahn, L. G.; Campos, G. P., de; Araújo, C. V., de; Araújo, S. I.; y Menezes, F. L. (2023). Uso de Inteligência Artificial na Pecuária: Revisão de literatura. *Reseaarch, Society and Development*, *12* (4). https://doi.org/10.33448/rsd-v12i4.40777

Padial, J. J. (2019). Técnicas de programación «Deep Learning»: ¿Simulacro o realización artificial de la inteligencia? *Naturaleza y Libertad*, *12*. https://revistas.uma.es/index.php/naturaleza-y-libertad/article/download/6274/5798/20938. ISSN: 2254-9668.

Programa sectorial “Agricultura Sostenible” (NAREN). (2020). Ganadería y salud animal. *GIZ*. www.giz.de/en/worldwide/39650.html

Song, Y. Y.; y Ying, L. (2015). Decision tree methods: applications for classification and prediction. *Shanghai Archives of Psychiatry*, *27* (2). https://doi.org/10.11919/j.issn.1002-0829.215044

Strappini, A. C.; Norambuena, L.; y Matamala, F. (2015). *Importancia de la detección de celo utilizando métodos amigables con el bienestar animal* XXXVIII Reunión Científica Anual de la Asociación Peruana de Producción Animal, Perú.

https://www.researchgate.net/profile/Ana-Strappini/publication/287978184_Importancia_de_la_deteccion_de_celo_utilizando_metodos_amigables_con_el_bienestar_animal/links/567ac9b908aebccc4dfd598b/Importancia-de-la-deteccion-de-celo-utilizando-metodos-amigables-con-el-bienestar-animal.pdf.

Terrero, R.; y Morejón, R. (2014). GAVIAC, Sistema para la gestión y control del ganado vacuno y la inseminación artificial. *Revista Avanzada Científica*, *17* (3). https://dialnet.unirioja.es/descarga/articulo/5156800.pdf. ISSN: 1029-3450.