Vol. 5 Issue-5, Jan 2025 (e-ISSN: 2582-8223)

Artificial Intelligence (AI) Significance in The Field of Animal Reproduction

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ARTICLE ID: 06

Introduction

AI has changed ICT industries by introducing new technologies like machine learning, deep learning, natural language processing, and robotic artificial neural networks. In other nations, farmers are highly skilled and key players in the economy. They seek advice from veterinarians; collect extensive live data for research which are processed by machine learning algorithms, resulting in valuable output that farmers utilize. AI-driven systems for observing animal behavior, identifying initial indications of illness, and environmental stressors impacting animal well-being through large number of data collection, data transfer, data storage, data analysis, and delivery of results have helped with various aspects of dairy farm management such as animal health, milk production, and reproduction. In addition to automating tasks, AI has also helped in reducing production costs and improving productivity. It has lessened animal stress through less human and animal interaction, and offered data-driven insights for improved decision-making. Additionally, this technology may possess greater accuracy than humans due to its ability to rapidly and efficiently analyze large quantities of data. This enables the recognition of patterns that are difficult to identify and decreases the subjectivity in analysis. The most common technologies farmers use to gather information about their animals is wearable sensors and computer vision techniques which depend on type of production system and number of animals. In case of sheep, goats, pigs, poultry, and fish, measurements are based on the entire group for the cost effectiveness.

Sensors

A device that measures or detects various biological, physiological and biochemical processes, alone or in combination by continuous monitoring of individual animal. The information gathered is processed by a machine through data collection, later analyzed with Machine Learning and Deep Learning algorithms to predict deviations or abnormalities for precise decision-making purposes. Sensors can be categorized into two main groups: attached and non-attached. The first one involves using devices on or in the body of the animal. On the other hand, unattached sensors are placed away from the individual, and data collected when the animal passes or stays near their location. In-line and on-line sensors fall under this second category. Sensor data is gathered continuously by in-line sensors that are usually positioned within the production system, such as monitoring the electrical conductivity of milk by robotic milking machines. Alternatively, on-line sensors analyze Somatic Cell Count by automated sampling using internet.

Accelerometer provides information about an animal's behavior, health, nutrition, and reproductive status. Radio Frequency Identification (RFID) is utilized in various ways within livestock production systems for the purpose of identifying, tracking, and managing animals. This technology ensures accurate data collection from individual animals and quick transfer to a central database, minimizing errors. Force and pressure platforms enable the evaluation of the force and pressure exerted by an animal on the platforms. It examines the walking patterns of animals, providing information on the forces applied during both dynamic and static positions. Environmental sensors are utilized to gauge temperature, humidity, and other factors which play a crucial role in monitoring greenhouse gas emissions, and managing animal well-being, disease control, and production. Important technology i.e. wireless intra-ruminal sensors, like the SmaXtec system which gather information on rumen motility, pH, and body temperature. This technology has the potential to provide knowledge for the early detection of metabolic diseases like ruminal acidosis.

Computer Vision

- These technologies, particularly image and video analysis, have gained traction for their ability to extract detailed data in a non-invasive manner.
- Their real-time application enables precise animal-level monitoring.

Key Challenges:

- ✓ The efficiency of these systems depends significantly on camera quality.
- ✓ The number of animals in the frame can limit the simultaneous analysis capability, particularly in crowded environments.

Infrared Thermal Cameras:

- These cameras provide a means to monitor temperature variations across an animal's body by detecting infrared heat radiation.
- This is particularly useful for identifying stress, fever, or localized infections.

3D Cameras:

- These cameras are instrumental in reconstructing an animal's anatomy to analyze structural or anatomical defects.
- They indirectly assess critical health and productivity parameters like weight and body condition score (BCS), which are indicators of an animal's nutritional and health status.
- This facilitates early detection of negative energy balance or other health concerns, aiding in timely interventions.

AI Applications in Animal Reproduction

It has garnered significant attention in recent years, as researchers and scientists explore the potential of this technology to enhance and optimize various aspects of reproductive processes

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in a wide range of animal species. Artificial intelligence has been leveraged to tackle various challenges in animal reproduction, from improving breeding strategies to enhancing the accuracy of diagnostic tools and predictive models. Estrus detection has been a major issue in large herds, AI or Machine Learning algorithms has simplified it with the automated estrus detection tools, such as activity monitoring (pedometers, activity meters, and 3D accelerometers), milk progesterone level measurement (Biosensors and Immunostrips), mounting behavior observation (sensor and video camera), vocalization recording (microphone), and body temperature measurement (temperature transducer and bolus placed in cow's reticulum), pressure-triggered mount detectors, temperature gauge, and radio telemetric transmission. Computer vision using Deep Learning techniques was used for estrus detection to visualize stand to be mounted animals which are in heat with 95% accuracy rate.

Artificial insemination is another domain where AI has found significant application. The use of AI techniques in the selection of high-quality spermatozoa and embryos has been the focus of extensive research, with the aim of improving the success rate of assisted reproductive technologies like ETT and OPU-IVF. Machine learning model was developed to accurately measure bull sperm motility in semen samples by using three CASA parameters (curvilinear velocity, straight line velocity, and linearity). Machine and deep learning algorithms are used to develop an AI tool that analyzes boar sperm to identify boars with low conception rates, so that boar with high genetic index can be used more efficiently in the herd. Many research studies used computer vision and machine learning/deep learning methods to evaluate embryo morphology and viability score, and transcriptomic data in combination to detect genes related to embryonic competency and viability for revealing possible causes of early pregnancy loss. These methods were capable of choosing viable embryos for implantation or cryopreservation, yielding better results than alternative methods. Furthermore, AI-driven models have been developed to optimize the timing and dosage of hormonal treatments, which can enhance the effectiveness of estrus synchronization and improve the overall reproductive performance of livestock.

While the integration of artificial intelligence in animal reproduction is still a relatively nascent field, the research conducted thus far has shown promising results. As the technology continues to evolve and become more widely adopted, the impact of AI on animal reproduction is expected to grow, leading to more efficient and sustainable animal farming practices, as well as the preservation of genetic diversity in threatened species

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