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Innovative Livestock: A Survey of Artificial Intelligence Techniques in Livestock Farming Management

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ABSTRACT: Modern technology has recently become a meaningful part of all life sectors, as software, sensors, smart machines, and expert systems are successfully integrated into the physical environment. This technology relies in its work on artificial intelligence techniques to make the right decisions at the right time. These technologies have a significant role in improving productivity, product quality, and industry outputs by significantly reducing human labour and errors that humans may cause. Artificial intelligence techniques are increasingly being integrated into animal husbandry and animal revolution management because they provide advantages and means that serve agriculturalists. These techniques monitor the emotional state of animals, milk production and herd management, feeding habits, the movement of animals, and their health status. AI-powered sensors can monitor the health of livestock and detect early signs of illness or stress to which they are exposed. Also, these techniques contribute to assisting agriculturalists in customising feeding programs, reducing waste, and improving product quality. This article will discuss the role of artificial intelligence techniques in animal control, farm management, disease surveillance, and sustainable resource optimisation practices.

Keywords: Artificial intelligence, Machine Learning, Livestock, Agriculturalists, Farm management

1. INTRODUCTION

Artificial intelligence is a science that has witnessed significant growth in recent years. This growth is considered an incredible journey characterised by remarkable progress, continuous innovation, and assistance to individuals in many different aspects of life [1–3]. The term artificial intelligence is not unique, as the roots of this science go back to the mid-twentieth century, when pioneers such as Alan Turing laid the theoretical foundations of this science and described that machines could contain practices like human intelligence. The actual emergence of artificial intelligence with the development of computers in the 1950s. At that time, artificial intelligence witnessed prolonged development and did not have sufficient ability to help humans. But in the nineties, with the significant development of computing power, algorithms, and data availability, this science became the basis in many fields, including medical, military, educational, and many others. Machine learning is one of the branches of artificial intelligence, as it is considered a major turning point in developing the capabilities of computer systems and integrating them into many sectors [4] [5]. Artificial intelligence is

witnessing the emergence of many terms, including big data, cloud computing, multimedia computing, powerful graphics processing units (GPUs), and intelligent systems. These terms aim to accelerate the work and development of artificial intelligence and construct robots that work like the human mind. The most famous artificial intelligence technique is convolutional neural networks, one of the deep learning architectures distinguished by their ability to recognise images and process natural language. Healthcare is one of the most critical sectors that seek artificial intelligence systems to develop the electronic environment for hospitals and medical clinics [6–8]. Significant disagreements recently have been about the bias of artificial intelligence systems because these systems may not work perfectly with little or insufficient data. The main objective of this science is to develop machines that have excellent capabilities like human abilities, such as thinking, decision-making, and solving complex problems [9] [10]. Many researchers in the domain of artificial intelligence seek to develop algorithms that contribute to business development, study data behaviours, and find new patterns that assist in making the right decisions. Experts in computer science, neuroscience, and brain science seek to develop machines, integrate them into many areas of life, and make them work as humans do. Figure 1 illustrates an imaginary form of machines in the future.

FIGURE 1. Imaginary form of machines in the future [downloaded from google].

The growth of artificial intelligence contributes to the development of modern technology, the Internet of Things, and smartphone devices, as well as increasing and enhancing the cognitive capabilities of humans, saving them time and effort [11] [12]. The current century has witnessed the emergence of many applications and systems that rely on artificial intelligence capabilities, for instance, ChatGPT and many others [13–15]. Artificial intelligence algorithms depend on raw data in their work, as the more data there is, the better the performance of these algorithms in predicting and distinguishing patterns. It contributes to natural language processing by creating texts like to those spoken by humans, which has led to a significant transformation and development in interaction and communication between machines and users. Artificial intelligence is a general term that refers to using computer programs to embody intelligent behaviour with minimal human intervention. It can be defined as a computer technology that relies on the ability of the human brain to work and think. It has a learning advantage, meaning that it can provide solutions and scenarios for complex problems relative to traditional technologies. It can be integrated into many situations that the human mind will not face. Artificial intelligence techniques have a major role in storing information, learning using examples, producing information, classification, prediction, and integrating it into our daily lives, such as financial issues, agriculture, medical sciences, meteorology, sports, electronic games, film production, journalism, and many others. Therefore, integrating these techniques is of great importance to humans because it provides virtual assistants, recommendation systems, and answers to all user queries. Robotics and automation comprise the bulk of artificial intelligence tasks, as they are integrated into many industries and customer service. Moreover, these techniques have the potential to make great strides in drug discovery, climate modelling, and electronic medicine. These techniques are combined with modern technologies such as the fifth-generation network (5G), the Internet of Things (IoT), Blockchain, and others. The primary goal of this integration is to create systems that enhance efficiency and increase productivity. The increasing spread and development of artificial intelligence technologies, artificial neural networks, and automation technologies and their integration into many sectors, including the livestock sector, as these technologies help in creating modern methods that contribute to getting rid of traditional methods of raising livestock animals [16] [17]. Unfortunately, these technologies lead to a significant reduction in human labour, but they have an impact on increasing productivity and improving product quality. These technologies contribute to developing the outcomes of artificial intelligence in reducing interventions on animals and increasing business profits. Figure 2 shows the use of techniques in livestock farming.

The main contribution of this article is to provide influential information about the importance of artificial intelligence techniques in animal production and to review the essential features that can be used in animal husbandry. The rapid development of artificial intelligence raises concerns about business ethics, job displacement, and algorithmic bias. The future of artificial intelligence is at the top; despite the many challenges, it is a science that continues to rise. The cooperation of humans and artificial intelligence is crucial in creating interpretable mechanisms and establishing regulatory frameworks that ensure the integrity of the outputs of its techniques.

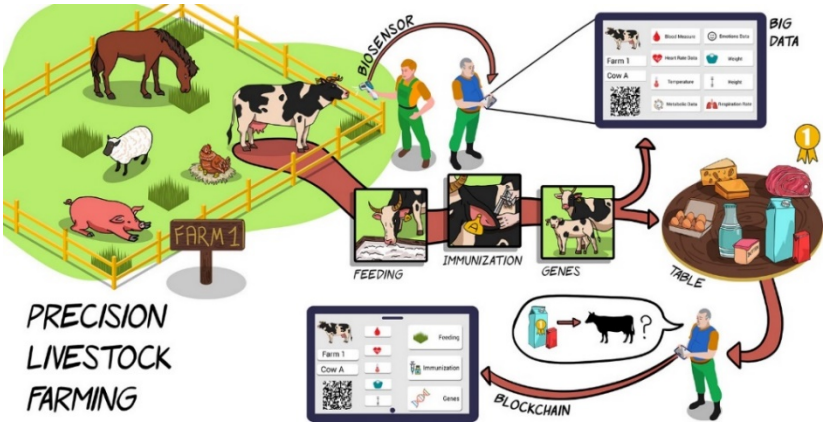

FIGURE 2. Using applications in livestock farming [18].

2. ARTIFICIAL INTELLIGENCE TECHNIQUES

Artificial intelligence includes methods that have significant importance and impact in many areas, including livestock farming, namely machine learning, deep learning, computer vision, robotics, and natural language processing. The most well-known technique is machine learning, which is a set of algorithms that allow computers to perform a set of cognitive operations based on examples and data without being explicitly programmed. These algorithms are sophisticated and designed to simulate human intelligence through a combination of practices and training on data (see Figure 3). Instances are relied upon to establish relationships between inputs and outputs. Moreover, these algorithms have been applied in many areas, including computer vision, biomedical applications, computational biology, and many others. Machine learning algorithms are divided into supervised algorithms (to teach the system and give a correct result) and unsupervised algorithms (the algorithms provide the system with many instances without responding). Supervised learning algorithms are generally applied to detect diseases such as COVID-19 and heart disease [19] [20]. Some people think that artificial intelligence and machine learning are the same thing, but there is a considerable difference between them, and it is impossible to link them. In fact, all machine learning solutions are artificial intelligence, but not all artificial intelligence solutions are machine learning. The other technique is deep learning, which relies in its work on representing learning data, as it allows algorithms to be trained to predict the outputs given to a dataset. Here, both supervised and unsupervised learning are used on training datasets to extract new features from the data. Moreover, deep learning algorithms improve their performance every time, improving the effects and outputs. These algorithms are applied in many fields, including image analysis, disease diagnosis, virtual reality, etc. These algorithms are characterised by ease of application and high accuracy in completing tasks and helping to make the right decisions. The most notable machine learning algorithms are artificial neural networks (ANN), which are utilised to explain many qualitative and quantitative issues like the human brain [21] [22]. This algorithm is implemented in classification, generalisation, feature identification and optimisation. This algorithm relies on the information obtained from examples to create experiments and test its power in classification and decision-making. The main components of this algorithm are information transmission, processing, and storage, and it is applied to solving many complex problems.

Computer vision is one of the most recognised artificial intelligence techniques that contribute to the development of computers [24] [25], extracting meaningful information from digital images and video and making recommendations based on that information. This technique is involved in cameras that are used instead of the human eye to perform analyses, create differences, and recognise objects through images or video clips. For example, they are used to recognise car numbers and distinguish between car plates and related items. Moreover, they are applied in agricultural automation and the development of agriculture and livestock breeding. Artificial intelligence seeks to develop robots and equip them with advanced algorithms so that they work and behave like the human mind. The term robot appeared for the first time in 1921 in a play entitled Rossum's Universal Robots by the Czech writer Karel Čapek. Language processing, speech recognition, and text analysis are challenging that artificial intelligence has faced in recent years. Natural language processing technology has emerged that enables machines to understand human languages and process them through an algorithmic method. This technique is crucial to analysing text and speech data completely and efficiently through theoretically motivated computational techniques to transform texts naturally. This technique can work on dialects, slang, and common grammatical errors in everyday conversations. Computers constantly need linguistic analysis applications to understand humans, communicate with them, and perform all tasks. Artificial intelligence seeks to develop applications

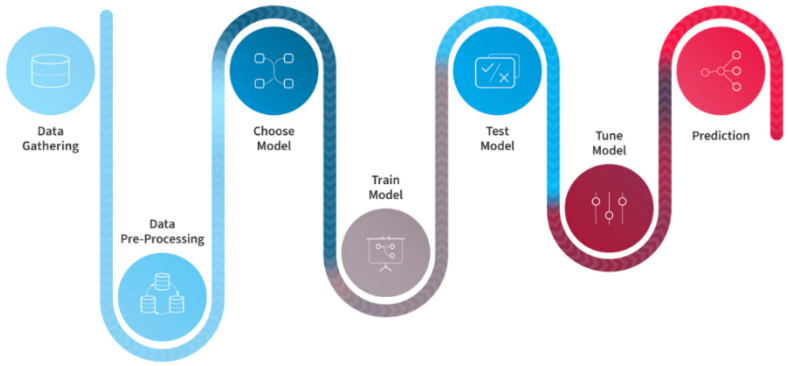

FIGURE 3. A framework of machine learning algorithms from the data gathering to the prediction stage [23].

capable of recognising speech and converting speech into text. In other words, it is sampling audio signals and making them meaningful using methods such as artificial neural networks and machine learning. It is often confused with voice recognition. While speech recognition focuses on translating speech from spoken form into text, voice recognition only aims to identify the owner of the voice.

3. AI IN ANIMAL HUSBANDRY

Artificial intelligence methods have become an important tool with significant influence in organising and facilitating daily work in the development and growth of the animal revolution by providing solutions to problems and improving them [26] [27]. Developing artificial intelligence algorithms and applications has made the task easier for institutions and researchers to conduct studies and tests related to animal husbandry and find appropriate solutions to build this environment. Continuous improvement of animal behaviour and care directly impacts livestock nutrition, growth and productivity and supports agriculturalists in developing their work. Exploring the behavioural patterns of animals and monitoring their movement and health has a significant impact on increasing productivity, developing food industries, and reducing effort and time for agriculturalists. Likewise, animals feel stressed constantly, so it is crucial to find practices to reduce this stress in order to increase the animal's quality of life and productivity. Enhancing the genetic environment of animals requires a new approach that includes the use of artificial intelligence techniques to assist agriculturalists and companies in increasing productivity. In general, machine learning algorithms contribute to determining the amount of nutrients in dairy cow manure as well as predicting beneficial nutrients for livestock. Modern, low-cost technologies, namely electronic noses, are sensors through which simple or complex odours can be identified. This technology contributes to applications in the food industry, medicine, and monitoring the environment in which animals live. At the present time, this technology is only available for detecting the odours of livestock and poultry. Integrating artificial intelligence with this technology significantly impacts the measurement and analysis of unwanted odours on livestock and poultry farms. This combination contributes to developing a clean agricultural environment in which unwanted odours are controlled. Artificial intelligence contributes to measuring prenatal behaviours in dairy cows, as it can record data on the time of lying down, the time of standing, the number of transitions from standing to lying down, the number of steps and the total amount of movement in certain time intervals via sensors. These data are evaluated through machine learning algorithms, where birth times are determined 8 hours in advance. These technologies are of great importance because they will provide a significant benefit to animal welfare. Figure 4 illustrates the use of technology to control the movement and direction of cows.

Machine learning algorithms consider data behaviours to examine the effects of heat stress and milk yield while determining environmental temperature. Increasing the environmental temperature enables the activation of cooling systems and a change in the quantity and content of concentrated feed and water spraying. In addition, these algorithms estimate heart rate, respiratory rate, and body and eye temperature by using cameras with different features to evaluate milk production and cow quality. Predicting milk production is one of the tasks carried out by machine learning algorithms employing inputs obtained from the agricultural environment. These algorithms work in sync with the cameras to obtain all the valuable information for agriculturalists or companies, including body and eye temperature. This information can be used to increase animal welfare and biotic/abiotic stress. Artificial neural networks are the most significant algorithms for predicting milk production in dairy cows because they are more practical than other algorithmic models. This algorithm has a higher prediction method than other algorithms, such as multiple linear regression, and gives few errors. This

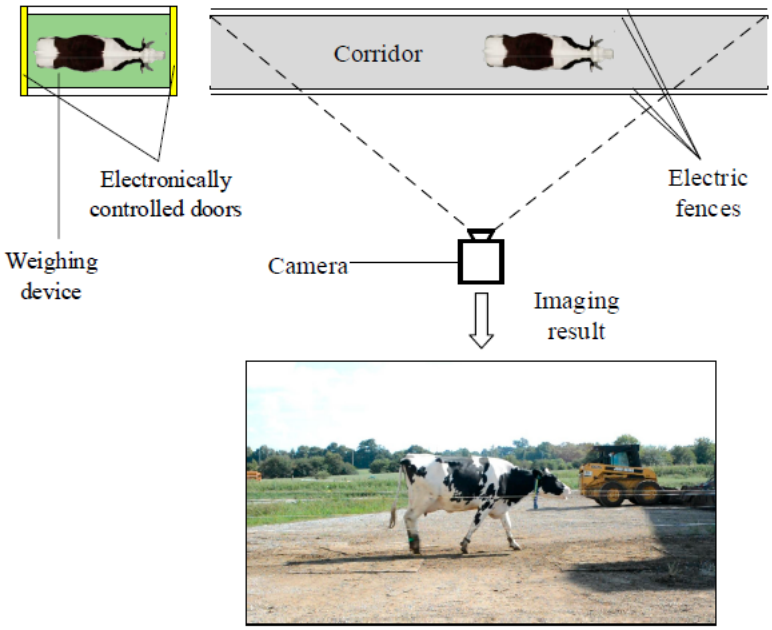

FIGURE 4. Cow management through modern technology supported by AI [28].

algorithm has a process of extracting, analysing, processing, and storing data in a special warehouse. Also, this algorithm is essential in detecting diseases such as subclinical mastitis.

Applying artificial intelligence techniques to study body parts, increase age, and analyse images through computer vision. These techniques are utilised to calculate changes in animal weight, regularly estimate the body weight of livestock, and generate practices that guide animals to be weighed using a customised weighing system. Weight gain is analysed through images captured from cameras and analysed through machine learning algorithms. Drones or similar tools are used to take aerial photographs on a wide geographical scale to identify or count animals growing in large pastures, provide agriculturalists with information about the animals, and monitor their movement. The CNN algorithm is utilised to detect and classify objects from many images, giving higher accuracy and sensitivity and faster processing ability. This algorithm classifies images and identifies categories within the image to detect and identify livestock spread over large areas. Other ways to identify animals include paints, tags, ear tags, radio frequency chips installed on the neck and feet or transmitters and receivers, and sensors placed on their bodies used to identify animals. These can be changed from time to time so as not to affect the animal's health. In addition, machine learning algorithms can be trained to extract information from animal sounds, such as determining the age and sex of the animal and its unusual states, such as pain, anger, separation from the calf, hunger, or thirst. Information is collected from sensors and monitoring systems. The sound is then filtered to obtain valuable information. These measures are helpful for agriculturalists to monitor their animals and their well-being. The CNN algorithm detects sheep reproduction under different conditions and studies sheep behaviour within the agricultural environment. The Yolo algorithm is used to detect faces and recognise emotions in real-time, determine the emotional states of the animal, and determine whether the animals are aggressive, calm, or neutral (see Figure 5). This algorithm contributes to animal welfare and generates interactions between humans and animals.

Artificial neural networks are practical in determining cow activity, employing data including environmental temperature, locomotor deviations, progesterone release, and estrus evaluation. Through these data, the cows that are most active in milk production and those that are least or moderately active are identified according to the state of their movement within the farm. Other factors determine the activity of cows, including temperature and humidity. Foot injuries and diseases such as mastitis negatively affect sheep's interests and lead to reduced productivity. Detecting sick animals in sheep flocks is very difficult. Farmers need techniques to assist them in detecting and controlling diseases. The presence of such techniques contributes to the well-being of the herd and increases production. Artificial intelligence techniques play a significant role in providing solutions for detecting and managing livestock diseases. These methods have the ability to analyse huge amounts of data in the form of images, sensor readings and health records to identify early signs of disease in sheep and cattle. These techniques have the ability to analyse images of animals and detect subtle changes in their appearance, behaviour, or posture that may indicate disease. Wearable devices or sensors are used to monitor vital signs in animals and identify abnormal behaviour. These technologies can provide farmers with potential health

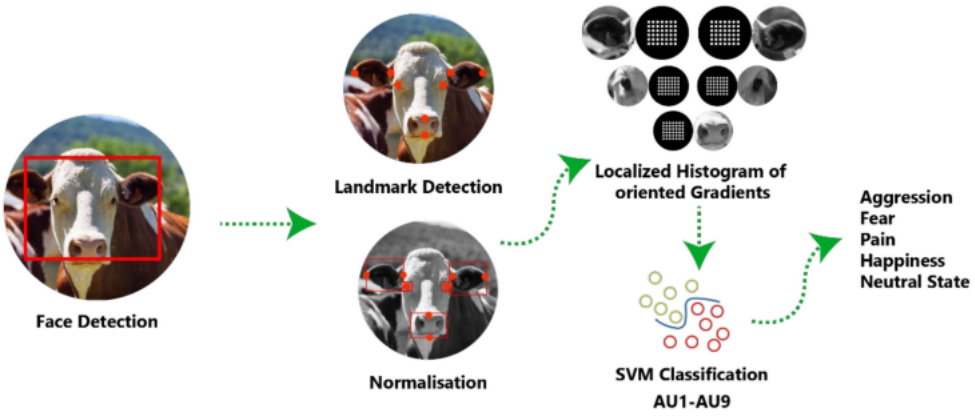

FIGURE 5. Using AI algorithms to detect cows' faces and determine their condition [29].

information in real time. Moreover, historical health records and genetic data are diagnosed, disease risks are predicted, and preventive measures are taken in the event of any spread of the disease, as happened during the spread of a disease such as COVID-19, avian influenza, and others. Artificial intelligence techniques, including computer vision, capture images to express the state of health of the animal, as facial expressions are a measurement of changes in the face or muscle groups that appear as a result of a response to an emotional stimulus and are likely an involuntary response to the pain experienced by sheep or cows (see Figure 6). Facial expressions are considered one of the most important indicators of the intensity of pain experienced by the animal, as facial detection systems can detect the possibility of a disease or a vital matter that requires immediate intervention by a veterinarian or agriculturalist. This practice will increase the efficiency of care because it does not need regular monitoring by agriculturalists or veterinarians before treatment. Machine learning algorithms can identify feelings of pain in sheep, especially from their faces. Eventually, artificial intelligence techniques can classify sheep or cows according to their breeds, as this classification can be performed based on machine learning algorithms and deep learning architectures. The economic sustainability goal of the agricultural industry is to improve animal welfare and make informed decisions about disease prevention and management, leading to healthier herds and increased productivity.

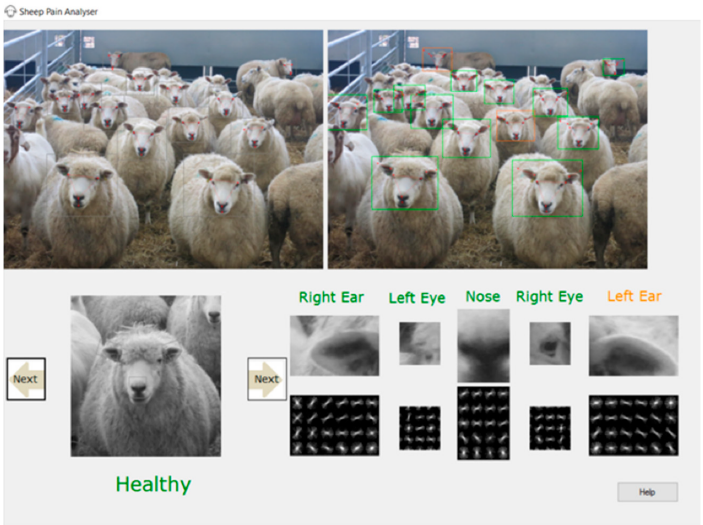

FIGURE 6. Developing a system for detecting painful facial expressions in sheep [30].

4. CONCLUSIONS

Artificial intelligence techniques solve many complicated processes with ease and high accuracy and accomplish many tasks that serve humanity. These techniques are a system programmed like the human mind in carrying out tasks and solving problems. The significant developments witnessed in computer systems, sensors, and robots have made tasks more accessible for many humans to accomplish more tasks. These techniques are applied in many sectors, including agriculture. Artificial intelligence is increasingly being utilised in areas such as the emotional states of animals, feeding habits, milk production, disease states, facial recognition, counting and classification, tracking the spread of zoonotic diseases and many others. These techniques contribute to eliminating human errors and assisting agriculturalists and veterinarians in maintaining an animal for a more extended period and increasing productivity. Moreover, integrating these technologies into the real world increases animal welfare and reduces agriculturalists' burden and costs.

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CONFLICTS OF INTEREST

The author declares no conflict of interest.

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