

APPLICATION OF ARTIFICIAL INTELLIGENCE IN ANIMAL PRODUCTION

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ABSTRACT

This paper reviews potentials of artificial intelligence (AI) in animal farming. Machine Learning (ML) as a component of AI that is very useful in Animal Science was described. Artificial neural networks (ANNs) and neuro-fuzzy was linked with AI. The many applications of AI, ML, ANNs and neuro-fuzzy in data analysis, dairy production, growth performance and animal breeding and genetics were reviewed. These new tools are capable of transforming animal agriculture to meet the expectation of demands that is being placed on this important sub-sector of agriculture. Nigerian Animal Scientists and livestock farmers are encouraged to start looking at incorporation of AI in their researches and management of livestock.

Keywords: Artificial intelligence, machine learning, farm animals, data analytics

INTRODUCTION

The biological functions that result in the production of meat, egg, milk and all other useful products from farm animals are numerous, complex and inter-connected (Costa, 2009). Animal Science is focus on understanding these functional links in other for continuous production of these essential products. The advances in the field of Computer Science in recent times had resulted into the development of a new body of study called Data Science. It is the domain of study that deals with vast volumes of data using modern tools and techniques to find unseen patterns, derive meaningful information, and make useful decisions. Data science uses complex machine learning algorithms to build predictive models. Artificial Intelligence is used in the field of Data Science for its operations (Sharma, 2019). Many recent applications of these approaches show an increased interest in animal science research (Rojas-Downing *et al.*, 2017). The techniques involved in artificial intelligence will be needed if the expected bloating population of Nigerian and other African countries must be fed quality protein sourced from farm animals.

By 2050, Nigeria is forecast to have 400 million people, meaning it will overtake the United States as the world's third-most-populous country (The Economists, 2020). To meet the exponential increase in demand for high-value foods, including meat, milk and other livestock products as a direct consequence of the huge population growth, farmers need to adopt sustainable and efficient animal production practices to exponentially increase animal production and productivity. With advancement in sensor technology and big data, there is now possibility to observe and measure patterns on a very large scale, from which powerful insights and decisions can be derived. Artificial intelligence including machine learning and simulations afford the use of tools and techniques to simplify the process of creating these insights and ultimately drive growth. Application of artificial intelligence for analytic and predictive purposes of farm animal productivity will be needed to stimulate growth and development of input-output systems of farm animal production. This paper was therefore aimed at reviewing the essentials of artificial intelligence as applicable in the field of Animal Science.

THE CONCEPT OF ARTIFICIAL INTELLIGENCE

The term Artificial Intelligence (AI) is coined in a proposal for a 2-month, 10-man study of artificial intelligence submitted by John McCarthy, Marvin Minsky, Nathaniel Rochester, and Claude Shannon (AI Magazine, 2006). The workshop, which took place a year later, in July and August 1956, is

generally considered as the official birthdate of the new field (Gil, 2018). AI has become more popular today mainly because of increased data volumes, advanced algorithms, and improvements in computing power and storage. AI is the single most important technology being developed today to help in understanding and spot useful insights in raw observations. It is a transformational technology and the main driver of the fourth industrial revolution. AI involves empowering machines or programs with human-intelligence abilities such as learning and problem-solving, thereby allowing them to think like humans and mimic their actions. Figure 1 shows the many dimensions of AI. In the past, the implementation of AI has been centered around creating programs that explicitly tells a computer or machine what to do. However, with the concept of machine learning (ML), computers are rather learned automatically through experience.

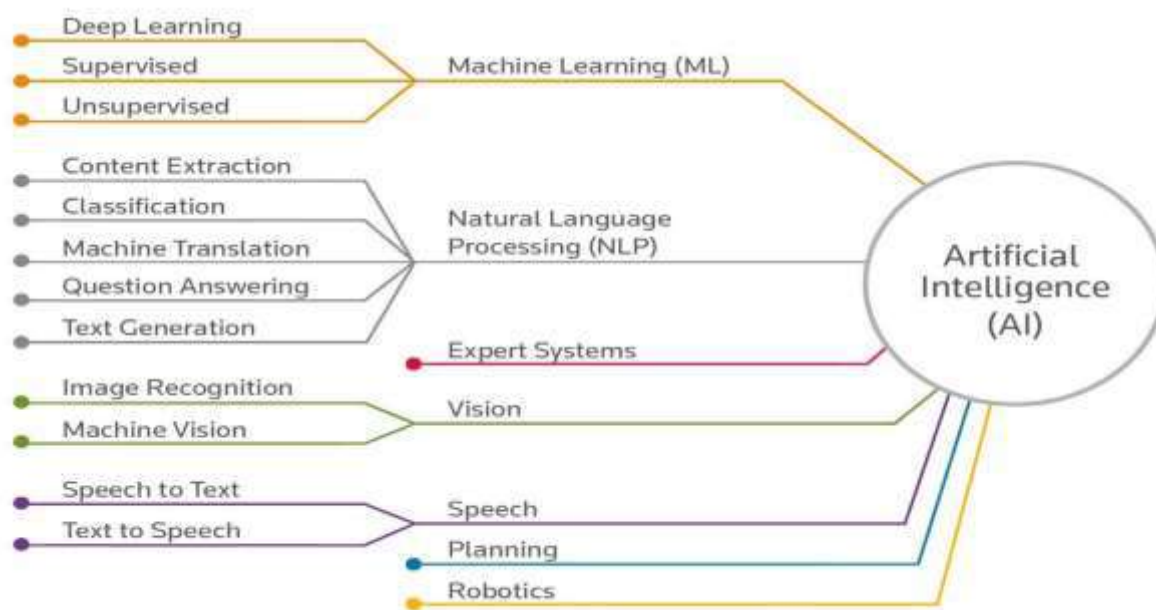


Figure 1: Artificial Intelligence and its dimensions

Source: Richardson (2018)

MACHINE LEARNING (PREDICTIVE ANALYTICS)

Machine learning (ML), a subset of AI provides machines or computers the ability to learn, build logic and make future inference by observing huge data; more like learning from experience. Major progress in AI such as the AlphaGo, AlphaFold, self-driving cars, object detection algorithms, several diagnostic algorithms used in the medical space, were made possible by the power of ML. Typically in ML, a model is trained to learn a problem using past data and is expected to make accurate predictions about future outcomes. Figure 2 summarizes the 3 paradigms of ML, which are the different approaches for building a model usually guided by the task at hand. Some of the tasks in ML are classification, regression, anomaly detection and objection detection. Generally, the performance of a model is measured by its ability to accurately predict a target giving a set of attributes.

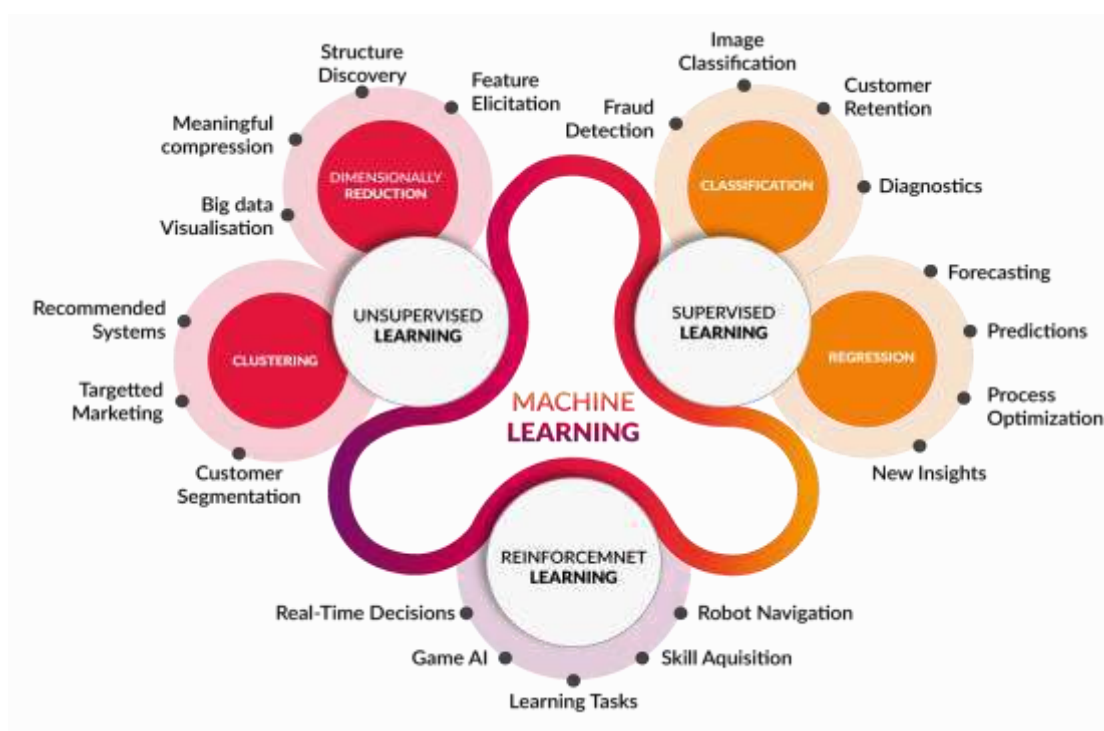


Figure 2: Machine Learning Paradigms

Source: <https://becominghuman.ai/a-simple-way-to-explain-how-machines-learn-7d9155ac8bed?gi=cfb56755fa63>

Supervised learning

In this approach, a model is guided through the learning process by training it with pairs of independent variables (features or attributes) and dependent variables (target or label). This is also termed *training by example*. The goal is that the model infers a function from labeled training data consisting of a set of training examples. For instance, a model that will have the capacity to check if an animal has a certain disease or not can be built based on past observations with corresponding ground truths.

Unsupervised learning

This approach operates like a discovery tunnel where an ML model is trained unguided. The model is allowed to discover and create patterns from the independent variables by itself. A typical application of this could be clustering of animals beyond the conventional taxonomy based on historically observed features. Unlike in supervised learning, the historical data provided for learning is not annotated; the model will learn to annotate each observation by grouping them into clusters. The clusters are then analyzed further to discover cluster-specific insights.

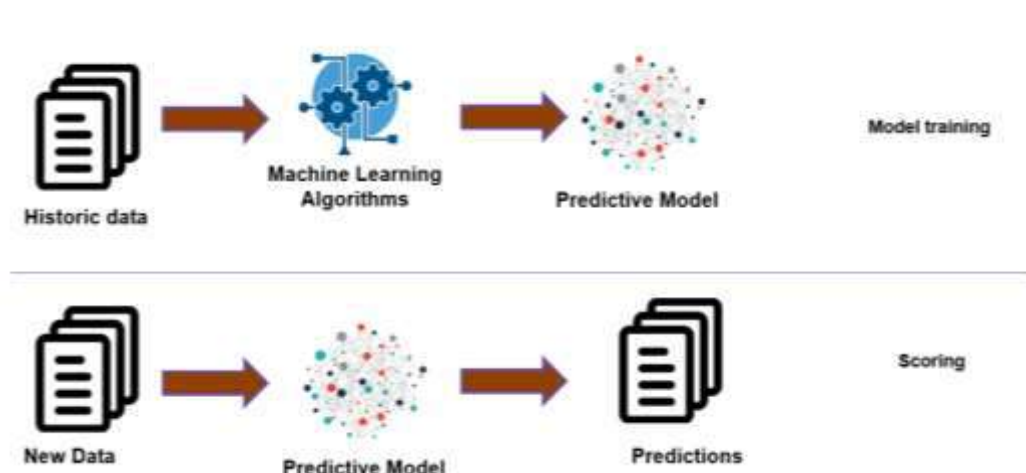


Fig 3: Typical Supervised-Unsupervised Learning Pipeline

Source: <https://in.pinterest.com/pin/632052128952335188/>

Reinforcement learning

In this approach, a ML model is trained using 3 concepts namely goal, penalty and reward. The model uses reward to reinforce a right move and penalty to punish a wrong move during the learning phase when trying to reach a specified goal. This usually involves learning with no prior experience or historical observations. For example, a farm robot could be trained to identify a stressed animal through visual inspection by making iterative guesses with real-time observed features.

COMPONENT OF ANIMAL PRODUCTION THAT CAN BE SUPPORTED BY ARTIFICIAL INTELLIGENCE

It is estimated that farmers need to increase production by 70% over the next 50 years to meet the growing global demands of meat and animal products (Rojas-Downing *et al.*, 2017). Since land and other natural resources are limited, to meet this growing demand we will need to find more efficient ways of growing more animals per hectare. This also means that manual processes of animal farming may no longer be sufficient. It also means that we need to find ways and systems that help us achieve greater gains in animal farming (Neethirajan, 2020). Today, technologies such as computers, sensors, cloud computing, machine learning (ML) and artificial intelligence (AI) are already transforming several industries. They create greater gains and efficiencies (Wolfert *et al.*, 2017). This is why we need to explore how these advanced technologies can help in achieving greater efficiencies and gains in animal farming.

Advanced technologies now provide us an opportunity to explore how complex systems such as biological systems work. It can help us extract meaningful information from data and increase our ability to understand complex animal systems (Ellis *et al.*, 2020). They can help us compile experimental data and derive meaningful parameters, for example, deriving fractional rates of rumen degradation (France *et al.*, 2020) or clear-cut rates of mammary cell proliferation (Dijkstra *et al.*, 1997).

Machine learning (ML) approach leverages on past data to predict future events. Miller *et al.* (2019) used 3D imaging technology and machine learning to automate the process of selecting cattle for slaughter at the correct specification, so improving the efficiency and profitability of beef enterprises through marketing of animals at the optimal time. Rudenko *et al.* (2020) proposed method for measuring cattle using neural network image processing algorithms that will allows modern farmers to quickly and accurately measure the weight of animal, as well as recognize its breed, saving time and reducing effort without compromising the habitat and disturbing livestock growth. The system can be widely used in the management of modern farming. Pawar and Panchal (2019) stated that AI has multiple applications like monitoring the activities of the dairy-cows, boosting the milk

production and farm productivity, detection of mastitis in dairy-cows, detecting the dairy farm odours and developing the smart cow houses powered by image analysis. Iyiola-Tunji *et al.* (2021) explored the potentials of ML in forecasting climatic conditions for proper planning in livestock production. The extent to which AI can be deployed in animal production is endless.

ARTIFICIAL NEURAL NETWORK AND NEURO-FUZZY AS APPLICABLE IN ANIMAL SCIENCE

Artificial neural networks (ANNs) and neuro-fuzzy are two important component of AI that had been deployed into establishing biological patterns which can enhance management and productivity of farm animals. Frankenfield (2020) described ANN as the piece of computing system that was designed to simulate the way the human brain analyzes and processes information. It was stated as the foundation of artificial intelligence (AI) and it is capable of solving problems that would normally prove impossible or difficult for human or statistical standards. The author further stated that ANNs have self-learning capabilities that enable them to produce better results as more data becomes available.

Neuro-fuzzy uses what is called fuzzy logic in its operations. Cintula *et al.* (2017) explained the fuzzy logic as arising by assigning degrees of truth to propositions. The standard set of truth values (degrees) is $[0,1]$, where 0 represents “totally false”, 1 represents “totally true”, and the other numbers refer to partial truth, that is, intermediate degrees of truth. The classification of variables into fuzzy sets from 0 to 1 has recently found its way into agricultural research (Kim and Cho, 1997; Ribeiro *et al.*, 1998). Applications have included development of decision-support systems for analyzing test-day milk yield data (Lacroix *et al.*, 1998). Detection of mastitis and estrus from automated milking systems (De Mol and Woldt, 2001), and definition of contemporary groups for the purpose of genetic evaluation (Rekaya *et al.*, 1999).

CONCLUSION

The applications of AI, ML, ANNs and neuro-fuzzy in data analysis, dairy production, growth performance and animal breeding and genetics are inexhaustive. These new tools are capable of transforming animal agriculture to meet the expectation of demands on this important sub-sector of agriculture. Nigerian Animal Scientists and livestock farmers are encouraged to start looking at incorporation of AI in their researches and management of livestock.

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