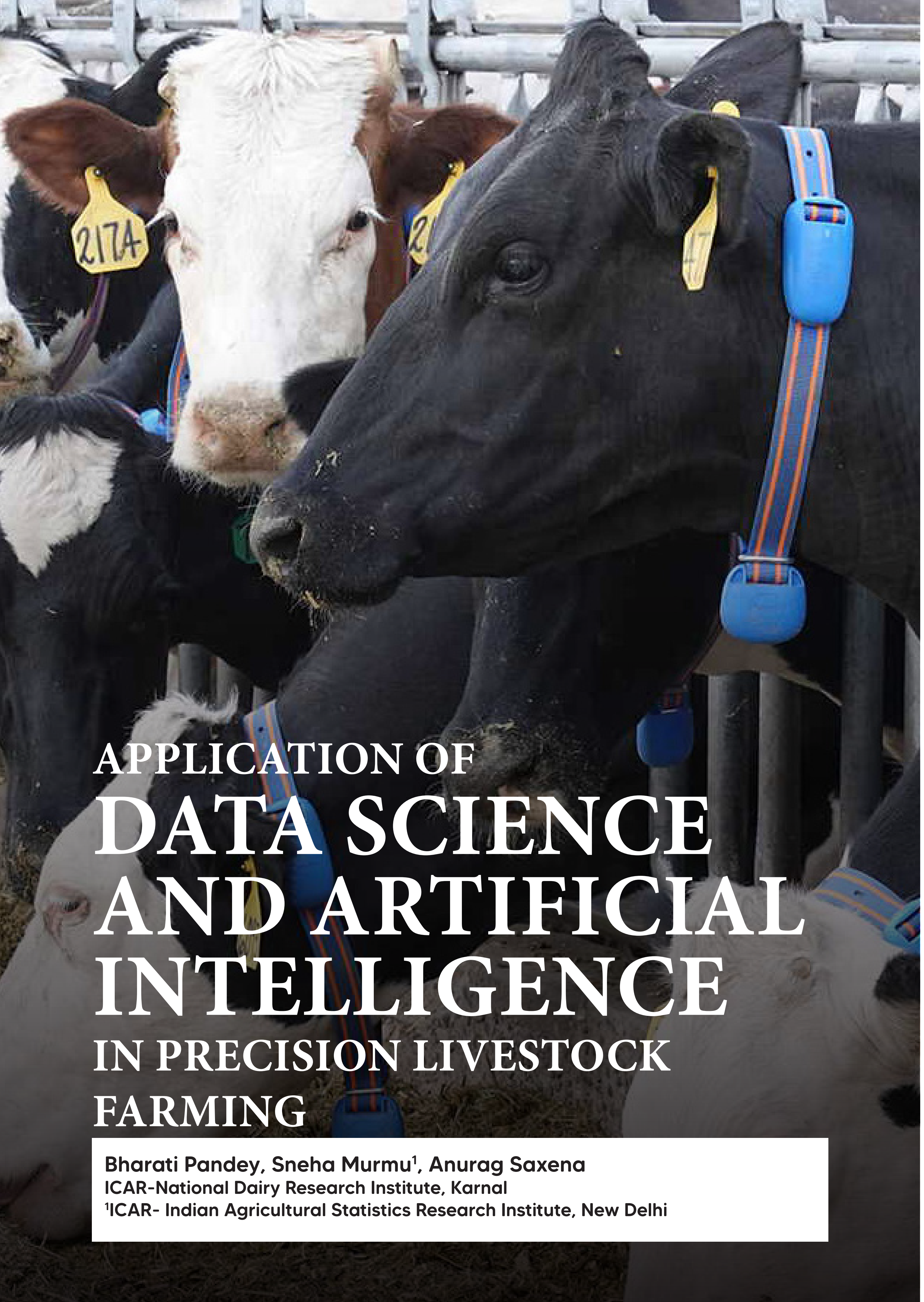

APPLICATION OF DATA SCIENCE AND ARTIFICIAL INTELLIGENCE IN PRECISION LIVESTOCK FARMING

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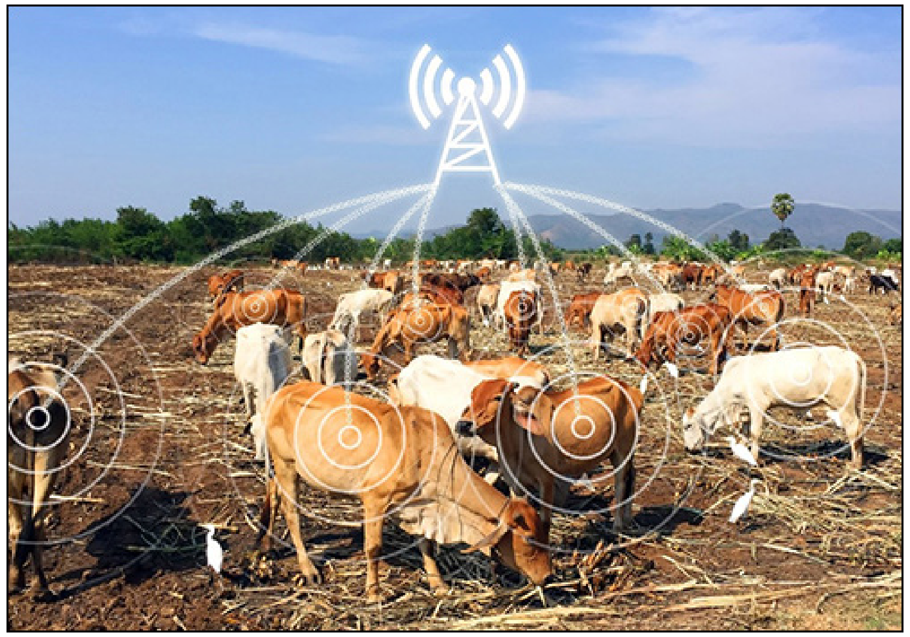
Research on animal farming has significantly increased in recent years, with particular attention paid to sensor technology, data processing, transmission, and the use of AI models like machine learning (ML), deep learning (DL), and artificial neural networks (ANN). Identifying animals, identifying behaviours, tracking diseases, and maintaining environmental control are just a few of the difficulties faced by animal farming industry. By utilizing sensors, analyzing data, and leveraging AI models, researchers aim to improve animal farming practices.

The application of AI technology in intensive animal farming has shown to be extremely advantageous since it enhances smart farming techniques, which eventually increase animal health, welfare, and economic outcome. Modern animal farming requires the use of cutting-edge technology like big data, AI, and ML. Big data offers scalability and accessibility by enabling the storing and administration of massive amounts of data on remote computers.

At numerous points in the agricultural process, from data gathering to decision-making, AI technologies have been used. AI-enabled wearables, cameras, and sensors make it easier to monitor critical metrics, record animal behavioural patterns, and gather data automatically. Farmers may examine this real-time data using AI algorithms to spot anomalies, spot symptoms of disease or discomfort, and take immediate action. This proactive approach improves animal welfare and minimizes the economic impact of diseases.

APPLICATION OF BIG DATA AND AI IN PRECISION LIVESTOCK

Technologies for precision livestock husbandry are essential for supporting AI-based monitoring of animal welfare and health. These technologies include a wide range of topics, including sound analysis, tracking animal movement, eating behaviour, and water intake, and radio frequency identification (RFID) devices. By combining these technologies, AI systems can analyse the information gathered and offer detailed insights into the health and behaviour of animals.



AI and facial recognition technology have shown great potential in various fields, including healthcare and animal farming. When applied to the early disease prediction in cattle, AI-based facial recognition systems can offer significant benefits. Early disease detection in cattle is crucial for prompt intervention and effective treatment, ultimately improving animal health and minimizing economic losses for farmers. Traditional methods of disease detection often rely on manual observations, which can be time-consuming and subjective. AI-based facial recognition systems provide a non-invasive and automated approach to monitor cattle health continuously. For instance, Identifying and separating sick cattle from the herd quickly can save thousands of dollars in medical treatment each year. Using MyAnIML's technology, ranchers can identify, separate and treat cattle 2-3 days before symptoms arise. MyAnIML's predictive health dataset leverages subtle changes in cow muzzles to detect cattle illnesses 2-3 days before they present symptoms. Therefore, AI and ML help cattle producers more effectively manage their Herd Health.

The health and well-being of cow have a substantial influence on milk output. But maintaining the best possible cattle health often necessitates constant, round-the-clock observation of each animal, which drives up labour expenses by at least 30%. The world's first dairy farmer's assistant, Intelligent Dairy Assistant (Ida), was created by researchers to address this issue. Ida uses artificial intelligence (AI) to learn and understand cow behaviour and to give farmers useful operational insights. Ida turns field data collection into actionable information that aids farmers in making decisions on a daily basis by combining cutting-edge sensor technology, machine learning algorithms, and cloud computing. Ida goes above and beyond previous cow movement trackers that only provide mobility data to a central gathering location by performing intelligent pattern analysis. Ida can recognise and examine trends in cow behaviour, such as eating, resting, strolling, and drinking, by utilising AI. Then, any deviations or irregularities that would suggest possible health problems or decreased productivity are identified by comparing these behaviour patterns to established norms and algorithms. Ida equips farmers to act quickly by giving them real-time alerts and useful information, enhancing animal health and production.

Maintaining a vigilant watch over herd is crucial for ensuring optimal performance. Individual monitoring enables early heat cycle detection, illness diagnosis, and quick response for any other problems. However, it has become more difficult for farmers to set aside adequate time for attentive observation due to the growth in herd numbers and labour demands in recent decades. This problem is intended to be solved by U-motion®, a Cattle Behaviour Monitoring System powered by Artificial Intelligence (AI) (http://desamis.co.jp/en/). Cattle actions and behaviours, such as feeding, drinking, ruminating, moving, standing, and laying down, are continually recorded and observed by U-motion®. The application of AI technology enables this round-the-clock surveillance. The system may detect trends, deviations, and abnormalities in the behaviours of particular cows or the herd as a whole by reviewing the collected data.

Enhancing artificial insemination (AI) success rates in dairy production is essential for maximising profitability. High conception rates are largely dependent on the timing of insemination, which works best when it takes place 8 to 12 hours following the onset of estrus. Accurately detecting cow estrus is one of the biggest hurdles in AI. Current estrus detection techniques are labor-intensive, not always accurate, and call for knowledgeable and experienced workers. Missed opportunities for insemination might result in financial losses for dairy producers if estrus is not detected in time or is misdiagnosed. The BOVINOSE is a significant initiative focused on developing an electronic nose designed to detect estrus in dairy cows. The primary goal is to develop a device that can precisely determine the best time for artificial insemination by identifying sex pheromones emitted by cows solely during estrus. The working prototype comprises of a probe, an array of sensors, and self-learning software for estrus prediction. The sensor array is in charge of detecting and analysing the chemical composition of these samples.

The accurate monitoring of feeding behavior, including rumination and eating patterns, is crucial for assessing the health, growth conditions, and early detection of diseases in cattle. Cattle behavioural data is gathered using a Noseband pressure sensor. The researchers developed a method that involved analysing local data variation, extracting frequency-domain features via Fast Fourier Transform (FFT), and then using the Extreme Gradient Boosting Algorithm (XGB) to categorise these extracted features into rumination and eating behaviours to address the challenge of accurately identifying feeding behaviour in cattle using data from a noseband pressure sensor.

The ability to accurately identify individual animals is crucial for implementing precision management practices. In order to identify individual cattle using photos of their muzzles, 59 deep learning models' performance and viability were evaluated. The findings showed promise for obtaining high accuracy and processing speed. As a way to improve precision livestock farming methods, automatic individual cow identification using video data has attracted a lot of interest. Researchers have created a unified deep learning architecture technique to accurately and effectively identify individual cattle from video data. The deep learning architecture combines multiple components, including Convolutional Neural Networks (CNNs), Long Short-Term Memory (LSTM) networks, and self-attention mechanisms. These components work together to extract spatio-temporal features from the video data, enabling reliable identification of individual cattle.

Forecasting the occurrence of disease based on meteorological and geographical data using ML approaches. A condition known as lumpy skin disease (LSD) is now growing quickly among cattle and water buffalo. It is an infectious, eruptive, and occasionally fatal illness characterized by skin nodules. It is feasible to obtain excellent accuracy in forecasting the presence of lumpy skin disease virus (LSDV) infection in unseen test data by using machine learning techniques and adding climatic and geographical factors as predictive variables. An example of such accomplishment is the use of an Artificial Neural Network (ANN) algorithm, which produced a 97% accuracy score.

COMPONENTS REQUIRED TO DEVELOP AI-DRIVEN SENSOR IN CATTLE

The creation of an AI-driven sensor system for cattle requires a number of elements. The following elements combine to gather data, process it with AI algorithms, and deliver useful information for managing cattle. The following are the crucial elements:

1. **Sensor Nodes:** Sensor nodes are tiny electronic gadgets with a variety of sensors that may gather information about various behaviour and health characteristics of cattle. As examples of these sensors, we may mention gyroscopes, accelerometers, temperature sensors, humidity sensors, heart rate monitors, and GPS modules. In order to collect data in real-time, the sensor nodes are fastened to the cattle.
2. **Data Acquisition System:** A data acquisition system is responsible for collecting data from the sensor nodes. It typically includes hardware components such as microcontrollers or microprocessors that can communicate with the sensor nodes and gather the data they collect. The data acquisition system ensures reliable and continuous data transmission from the sensors.
3. **Wireless Communication:** Wireless communication is essential for transmitting the collected data from the sensor nodes to a central processing unit or cloud-based platform. This can be achieved using wireless technologies such as Wi-Fi, Bluetooth, Zigbee, or LoRaWAN. The choice of wireless communication depends on factors such as the range, power consumption, and data transfer rate required for the application
4. **Data Storage:** The obtained data must be saved in order to be processed and analysed further. This can be accomplished by local storage within the sensor nodes or through data transmission to a cloud-based storage system. Cloud storage provides scalability and accessibility, making it possible to easily retrieve and analyse data from various sensor nodes.
5. **Artificial Intelligence Algorithms:** AI algorithms are critical for analysing data and generating relevant insights. Deep learning and other machine learning (ML) methods aid in tasks such as activity recognition, behaviour detection, disease diagnosis, and prediction. Based on the patterns they identify, these algorithms can offer predictions or classifications.
6. **Data Processing and Analytics:** To extract usable information, the acquired data is processed and analysed using AI algorithms. This includes pre-processing raw data, extracting features, and applying AI models to tasks like as anomaly detection, health monitoring, and behaviour prediction. Data analytics approaches are used to gather insights and make educated livestock management decisions.
7. **User Interface and Visualisation:** The AI system should give farmers or veterinarians with a user-friendly interface for accessing and interpreting the acquired data and insights. Web-based dashboards, mobile applications, and other graphical user interfaces that provide information in a clear and actionable manner are examples of this.