Application of IoT Based Smart Farming in Sustainable Production and Improvement of Animal Genetic Resources

R. Rajendran[1(✉)], A. K. Thiruvenkadan[1], and M. R. Kishore[2]

[1] Department of Animal Genetics and Breeding, Veterinary College and Research Institute, Tamil Nadu Veterinary and Animal Sciences University, Theni 625602, Tamil Nadu, India
drrajjam@gmail.com

[2] Chief Technology Officer, Rearly Tech Private Limited, Madurai, Tamil Nadu, India

Abstract. Internet of Things (IoT) is a collective network of real-world objects with sensors and connectivity. Lot of data is obtained through the sensor and networks to analyse the behaviour of the subject involved. Smart farming involves monitoring and managing of animal farms using modern ICT and data tools to increase production efficiency. With increasing population and the food requirement, optimised and sustainable production has become the need of hour. From Farm management, field handling to research scenarios, IoT plays various roles in enhancing the outcome of intended production. Areas like animal identification, animal health, vital monitoring, whereabout tracking, disease intelligence, production quality and quantity monitoring have scope for improvement using IoT. The data generated gives visibility and perspectives that are not so clear or new paradigms may emerge in production efficiency. The data defined approach improves production and management efficiency by enabling quick and easy decisions in farm control and management. These are a big leap from conventional farming and they bring certainty and predictability to farming whose future will be technology driven. Being in the early stages of the digital transformation in animal husbandry, there is still a long way to go in the path demanding collaboration from various domain stakeholders like animal sciences and information technology for holistic and sustainable improvement.

Keywords: Animal Science · Internet of Things · Smart Farming · Sustainable

1 Introduction

The Internet of Things (IoT) is a collective network of real-world objects named as "things" that are enabled with sensors, technology, and connectivity with the goal of exchanging information such as their internal status with other external "things", systems and cloud on a network like the internet. As of today, a lot of common gadgets and devices, cars, industrial and agricultural machines, home appliances are rapidly getting IoT enabled to transmit data and offer useful and interactive experiences to the users. The advent of IoT and related technologies into agriculture and animal husbandry has

E. Widodo et al. (Eds.): ICESAI 2022, ABSR 28, pp. 18–24, 2023.
https://doi.org/10.2991/978-94-6463-116-6_4

brought in a new paradigm called smart farming. It involves monitoring and managing farms using modern electronics ICT tools helps to increase the production efficiency by improving the quantity and quality of the produce with optimum use of resources and human involvement. This in turn helps to reduce the impact of production on the environment.

Due to various factors including technological advancements and increase in life expectancy, the UN projects that the world human population will reach ~10 billion by 2050. FAO says this increase needs to be fed by a 70 percent increase in food production to achieve food security. Even to address the problem of world hunger to attain SDG2 by 2030, the world needs to ensure nutrient rich, sufficient, balanced diet for the poor and vulnerable sections. Around 30 percent of the world energy consumption and 22 percent of green house gas emissions is by food production. These challenges demand not only increase in production, but do them in a sustainable manner. Moving from the industrial era into intelligence-based Industry 4.0 phenomena is essential in the context. Smart farming of animals for necessary protein and dairy requirements plays a major role in production increase with the disposal of all technologies available today in a responsible way. This helps in quantitative and qualitative increase in production by enabling quick and easy decisions in farm control and management.

2 Materials and Methods

2.1 Smart Farming Cycle

The smart farming generally involves a cycle of following activities (Fig. 1).

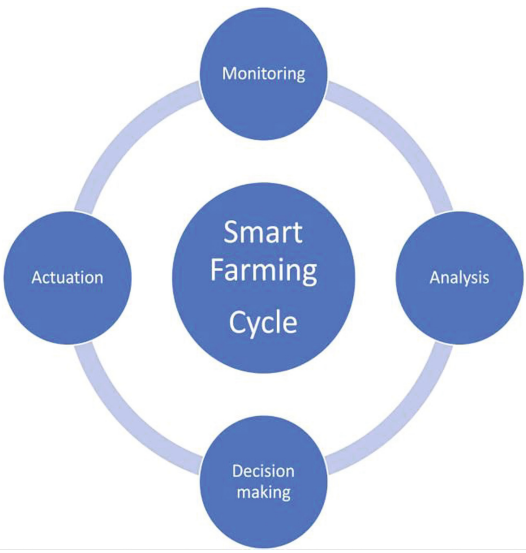

Fig. 1. Smart farming cycle

2.1.1 Monitoring and Data Collection

Sensors obtain live data from animals and environment. A high volume of data is generated and stored relating to weather, animal health, milk or meat quality, disease prevalence etc., at high precision. The data usually gets pushed to cloud and thus readily accessible everywhere. Even if animals are affected by the similar symptoms from decade ago, it can help find solutions faster than before, preventing losses.

2.1.2 Analysis

The data is passed on to a software layer locally or on the cloud to analyse and identify any deficiencies or needs. This layer usually on the cloud integrates and uses every type of data available with respect to farms to enable broader and deeper levels of analysis.

2.1.3 Decision Making

The decision-making layer in the software, usually an algorithm or an artificial intelligence module defines the actions required to be taken by the farm owner and/or by the devices or machines. All forms of past and current data after analysis provide actionable insights into optimum feed, water, and medicinal requirements for the animals. The platform also alerts wherever discrepancies are identified.

2.1.4 Actuation

The decided actions are actuated at the farm by the owner and the cycle continues.

2.2 Smart Farming Requirements

Smart farming involves a bringing in a suite of technology tools and methods (Fig. 2) applied in tandem with animal sciences to solve farm level problems. These involve

Sensors: Electronics to collect various environmental, animal vitals and production data
Processing systems: Pre-process the collected data to feed into further actions
Software: Piece of computer code that analyses the data locally passes on to external systems
Communication: Media like the wired and wireless interfaces to push the data to cloud and other systems
Location intelligence: Consider real-time localised farm or field environmental factors that affect animal health and production which are necessary to provide suitable advisory
Analytics: Technologies like big data, Machine learning and computer vision are involved to analyse the collected data and come up with actionable insights

Areas of Application
Smart farming techniques can be employed in sustainable production and also in improvement of Animal Genetic Resources in many ways at both farm and field level use

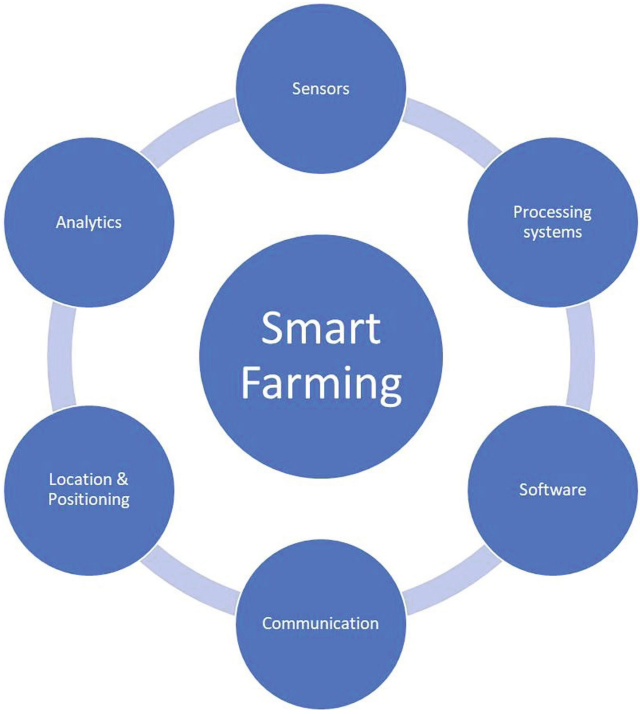

Fig. 2. Smart farming technology tools and methods

cases. Some of the applications like identification, physiological monitoring of animals are common to both.

Animal Identification and Traceability

Unique Animal identification is the cornerstone measure to build other applications. This can be achieved using the electronic IDs (EIDs) like the classic RFID and computer vision techniques with machine learnt classification on unique body patterns. Measures like identifying cattle with the muzzle print are being experimented in the industry. Identification helps not just monitoring the animal in question but also be utilised traceability use cases like food traceability in farm to fork market connect and field progeny testing (FPT) programme.

Monitoring the Physiology of Animals

The physical physiological data of animals are recorded on the electronic register in the form of a mobile app. The vital body parameters like weight, temperature, heart rate, breathe rate, stress levels, heat & pregnancy detection can be monitored using vital and environmental sensors available and integrated to the farm management system for data collection, analysis and advisory over cloud. These parameters in turn will give direction

to the manager to attend the abnormal animals at the earliest. Here animal welfare is ensured which otherwise be ignored by human beings.

Farm Level
Studying the Animal Behaviour: Using vision analytics on camera streams fused with accelerometer data to monitor the movement and behaviour of individual animal against expected behaviour from historical data. This is useful in identifying animals suffering with laminitis, choking, Traumatic Reticulo Pericarditis (TRP), etc., and is also useful to detect the hyperactive estrus and diseased lazy animals.

Maintaining of Animal Shed Environment
Farm weather can affect the physiology of animals directly. Ambient sensors monitor the parameters like housing temperature, relative humidity, wind flow to operate heater, cooler, air flow controller in a feedback loop and alert the farm management system.

Milking of Animal
Automatic milk parlour in dairying can be coupled with sensors in the milking container and can be a connected weighing and sensor fitted container itself which transmits milk quantity and quality data from farm/field over cloud to the processing centres for each animal after milking.

On-spot Milk Composition Analyser
On-spot dip test coupled with sensors where the composition of milk is instantly measured and recorded in front of individual producer. The connected milk analyser can give the on-spot results to both the producers and procurers on milk quality, composition and adulterants to bring in transparency in the value chain.

Hatchery Management
Gas sensors like ammonia monitors with ambient sensors help in effective hatching. Automatic feed dispensers for caged layers can be used for monitoring and control feed patterns.

Field Level
Field based flocks along with their owners once identified can be registered on spot and their location GIS mapped with mobile apps provided for field operators. Detailed socio- demographic data can be collected from the flock owner on the app and breed characteristics of animals can be fed into the app automatically by taking photo of animal in the flock. The photos can be processed and analysed for various physiological parameters like body measurements, weight, age, breed information, disease prevalence and history etc. Each animal can be assigned a unique ID with EID tags and stored in the data base.

1. Weight monitoring done through internet connected weighing scales that are used to track animal weights in periodic intervals and information is automatically transferred.

2. Selection of animals can be made based on the records collected and stored on the cloud over time.
3. Health control measures and advisories to the flocks (prophylactic and veterinary) are provided to filed owners through scheduled guiding information and necessary alerts for deworming, vaccination alerts, weather change, etc.
4. Essential guidelines, technical inputs and market information can be provided on the app about profitable sale options.

Technology

Low cost, low power sensors - Wide variety of sensors are available in the market today what can plug and play based on the parameters that need to be monitored. These sensors are interfaced to microcontrollers that form the edge node and act as data source node. Connectivity - Protocols like Bluetooth Low-Energy, Long Range Wide Area Network (LORAWAN), LTE, 5G can be used to connect the wireless node and push data to the cloud through hubs. Computing infrastructure - Public cloud platforms like the Amazon Web Services (AWS), Azure and Google Cloud platform (GCP) can be used to scale computing workloads on the cloud on demand and pay as per usage without expensive capital IT investments.

Machine learning & analytics

Animal behaviour and prediction based Machine learning and deep learning models developed with vast amounts of data that is collected.

The emergence of related technologies like Big Data analytics and Machine learning pushes the limits of IoT. The analytics realized from them feedback into the IoT and vice versa.

Benefits of Smart Farming

1. Optimization of processes enables increased livestock production.
2. Robust and easy identification of animals for breeding.
3. Continuous quality analysis of the produce increases subsequent production quality.
4. Automation of monitoring activities reduces the use of human resources and thus cost in a skill short labour market.
5. Early infection and lameness detection in the livestock enables improved animal welfare and health
6. Easily accessible and robust farm management possible on universal interface PCs, tablets & Mobiles
7. Tailor made farm level package of practices
8. Weather and location based advisory
9. Actionable insights and Detailed reports can be obtained in fingertips

3 Conclusions

Smart farming with IoT focuses on applying digitally collected data and combining them from different data sources to form a bigger picture and manage all farm activities.

It is a big leap from conventional farming as it brings certainty and predictability to farming which is the future of Livestock management. Technologies like bots and sensors deployed in operations can collect data that can be processed to provide never before seen operational insights from various integrated sources to yield the best performance, feed schedules, disease outbreaks and market intelligence. We are still in early days of deep technology intervention into the veterinary and animal husbandry sector and there is a long way to go in this path demanding collaboration from various domain stakeholders.

Bibliography

1. Akhigbe, B.I., Munir, K., Akinade, O., Akanbi, L. and Oyedele, L.O. IoT technologies for livestock management: A review of present status, opportunities and future trends. Big Data Cogn. Comput., 5, 10. https://doi.org/10.3390/bdcc5010010 (2021).
2. Dineva, K. and Atanasova, T. Design of scalable IoT architecture based on AWS for smart livestock. Animals, 11: 2697 (2021
3. Gherghe, D. IoT application to sustainable animal Production. Annals of the University of Oradea, Fascicle: Ecotoxicology, Animal Husbandry and Food Science and Technology, Vol. XVI/A. (2017
4. Wankhede, K., Pathakala, M. Use of IoT in animal husbandry. IOSR journal of Computer Engineering. 40–44 (2018).