IoT Applications in Livestock Sectors

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Introduction

The term "ICT" was first introduced by Stevenson in 1997. Nowadays, the umbrella term "Information and Communication Technologies" (ICT) refers to a broad spectrum of services, applications and technologies. These technologies employ diverse equipment and software and are frequently operating across telecommunications networks. The significance of ICTs doesn't primarily lie in the technology itself, but rather in their empowering role in facilitating access to knowledge, information, and communication —an aspect growing in importance within contemporary economic and social associations. The phrase ICT covers all the specialized terminology associated with information management and facilitating communication. This encompasses computer networks, hardware and software (computer programs). To simplify, ICT includes information technology, telecommunications, electronic media, and the various procedures involved in transmitting audio and video signals, along with all the functions for controlling and managing networks like cloud computing, e- Commerce and e-Governance etc. (Bhaskar *et al*., 2013)

Recent advances in ICT

5G Technology

5G, the fifth-generation technology standard for high-speed cellular networks, was globally implemented by cellular operators launching in 2019. The GSM Association (Global System for Mobile Communication) predicts that, over 1.7 billion people worldwide will be connected to 5G networks by 2025. This next generation wireless access technology which not only promises higher data capacity and speeds faster than 10 GB per second, but also possesses the capacity to connect billions of devices. The key feature is dramatically reduced latency of less than 1 millisecond (ms) from the present 50ms, along with a throughput up to 10 gigabytes per second speed and exponential increase in number of connections. A higher throughput implies higher network speed for consumers. This will enable applications that could not have been possible with longer response times. For example, In India, there are large numbers of people who are outside the normal reach of specialists by virtue of their remoteness. The low latency in 5G technology could even open doors for remote robotic surgeries.

Artificial Intelligence (AI)

The replication of human intelligence functions by machines, particularly computer systems, is known as artificial intelligence. Expert systems, natural language processing, speech recognition, and machine vision are some examples of specific AI applications. Kaplan and Haenlein define AI as “a system’s ability to correctly interpret external data, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation” (Kaplan and Haenlein 2019). Poole andMackworth (2010) define AI as “the field that studies the synthesis and analysis of computational agents that act intelligently” An agent is something (or someone) that acts. An agent is intelligent when:

1. Its actions are appropriate for its circumstances and its goals

2. It is flexible to changing environments and changing goals

3. It learns from experience, and

4. It makes appropriate choices given its perceptual and computational limitations

Blockchain Technology

Blockchain is a distributed, unchangeable database that makes it easier to monitor assets and record transactions in a corporate network. An asset might be tangible (a home, car, money, or piece of land) or intangible (patents, copyrights, branding, and intellectual property). On a blockchain network, practically anything of value may be recorded and sold, lowering risk and increasing efficiency for all parties. Information is essential to business. It is best if it is received quickly and is correct. Blockchain is the best technology for delivering such information because it offers real-time, shareable, and entirely transparent data that is kept on an immutable ledger and accessible exclusively to members of a permissioned network. Among other things, a blockchain network can monitor orders, payments, accounts, and production. Additionally, because everyone has access to the same version of the truth, you can see every aspect of a transaction from beginning to end, increasing your confidence and opening up new prospects.

Robotics

Robotics is a branch of engineering and computer science that involves the conception, design, manufacture and operation of robots. The objective of the robotics field is to create intelligent machines that can assist humans in a variety of ways. Robots are frequently utilized in fields like auto manufacturing, where basic repetitive activities must be completed, and in fields where work must be done under hazardous conditions for people. Robots may be endowed with the equivalent of human senses including vision, touch, and the capacity to perceive temperature. Artificial intelligence is used in many parts of robotics.

Green ICT

The design, manufacture, use, and disposal of computers, chips, other technology components, and peripherals in a way that limits their adverse effect on the environment, including reducing carbon emissions and the energy consumed by manufacturers, data centers, and end-users, is known as green ICT/ green computing (also known as green IT or sustainable IT). In addition to choosing raw materials with sustainable sourcing, minimizing electronic waste, and encouraging sustainability through the use of renewable resources are all included in green computing.

What do you mean by IOT?

An innovative paradigm change in the IT sector is the Internet of Things. The two terms "Internet" and "Things" were combined to form the phrase "Internet of Things," which is also commonly abbreviated as "IoT." Internet is the world’s largest computer network and that utilizes the standard Internet protocol suite Transmission Control Protocol/ Internet Protocols (TCP/IP) to provide services to its billions of users worldwide. It is a network of networks, and is dispersed over the entire world. It is a global system of interconnected computer networks that comprises of a vast network of electronic, wireless, and optical networking technologies that connects millions of private, public, academic, business, and government networks with a range of local to global reach. (Nunberg, G., 2012)

History of IoT

The introduction of the telegraph and its capacity to transfer information by coded signal over distance allowed for the connection of electrical equipment as early as the early 19th century, but the IoT's roots may be found in the late 1960s. At that time, a number of eminent academics started looking into how to connect computers and systems. The network built by the Advanced Research Projects Agency (ARPA) of the U.S. Defence Department, which served as a precursor to the Internet of today, was a prominent example of this effort. Businesses, governments, and individuals started looking at methods to connect personal computers (PCs) and other technologies to one another in the late 1970s. By the 1980s, local area networks (LANs) offered a practical and popular method of instantaneous communication and information sharing among a number of PCs. By the middle of the 1990s, the Internet had expanded such capabilities internationally, and academics and engineers had started looking into methods to improve connectivity between people and machines. In 1997, British technologist Kevin Ashton, cofounder of the Auto-ID Centre at MIT, started investigating radio-frequency identification (RFID), a technology framework that would allow physical objects to connect via microchips and wireless signals. It was in a speech in 1999 that Ashton first coined the term "the Internet of Things." Within a few years, a foundation for more reliable data collection, storage, processing, and sharing had been developed thanks to cellphones, cloud computing, improvements in processing speed, and enhanced software algorithms. At the same time, sophisticated sensors started to emerge that could track a person or a device using geolocation in addition to measuring mobility, temperature, moisture levels, wind direction, sound, light, pictures, vibrations, and many other factors. These advancements make it feasible to have real-time communication with both digital and actual items. It was feasible to link people and things in a nearly omnipresent fashion with the broad adoption of mobile devices like smartphones and tablets and the arrival of pervasive wireless communication. Smart traffic networks, networked storage tanks, and industrial robotics systems consequently became commonplace. Modern Internet of Things (IoT) applications utilise artificial intelligence to run very complex simulations, monitor agricultural animals and crops, and identify pollution in water sources. For instance, it is now able to monitor the whereabouts and health of animals and to remotely treat crops with the ideal amounts of water, fertiliser, and pesticides (Internet of Things, 2023)

Components of IoT

i. **Sensors:** A sensor is a device that detects and responds to some type of input (light, heat, motion, moisture, pressure or any number of other environmental phenomena) from the physical environment. The output is normally a signal that is transformed into a display that can be read by humans at the sensor location or that is electronically sent over a network to be read or put through more processing. The internet of things (IoT) is totally dependent on sensors. They make it feasible to develop an ecosystem for gathering information about a particular environment and processing it so that it may be monitored, managed, and controlled more effectively. IoT sensors are generally used in homes, out in the field, in automobiles, on airplanes, in industrial settings and in other environments. Sensors bridge the gap between the physical world and logical world, acting as the eyes and ears for a computing infrastructure that analyzes and acts upon the data collected from the sensors.

ii. **Connectivity:** “IoT connectivity”, usually means various methods in which we connect IoT devices, including applications, sensors, trackers, gateways and network routers. The term "IoT connectivity" typically used in the IoT sector to describe the various IoT network solutions that can support this form of connectivity, such as Wi-Fi, cellular, and Low-power Wide Area Network (LPWAN) systems etc. Therefore, we often divide these possibilities into three categories when deciding which IoT connectivity option is best for you or your company: bandwidth capacity (speed), coverage area, and power consumption. Before selecting a connectivity solution, it's crucial to know what your IoT requirements are because it might be challenging to locate an alternative for an IoT connection that prioritizes all three.

iii. **IoT Platforms:** An application or service that offers integrated tools and capabilities to link every component in an IoT ecosystem is known as an IoT platform. By offering services including device communication, device lifecycle management, data analytics, integration, and application enablement. The numerous moving pieces that go into making up your IoT system are coordinated by an IoT platform. Building IoT solutions that benefit the organisation, its end users and other stakeholders starts with an IoT platform. IoT platforms make it possible to keep visibility, security, and control over linked assets, allowing starting and scaling of IoT initiatives quickly, allowing to introduce customer-focused services and sustain competitiveness in a changing market environment.

iv. **Cloud Computing:** Cloud computing is an on-demand utilisation of computer resources housed in a distant data centre and controlled by a cloud services provider (or CSP), such as apps, servers (both physical and virtual), data storage, development tools, networking capabilities, and more. These materials are made available by the CSP for a monthly subscription fee or are billed based on usage. The three most popular kinds of cloud services are IaaS (Infrastructure-as-a-Service), PaaS (Platform-as-a-Service), and SaaS (Software-as-a-Service

v. **Edge Computing:** Edge computing enables distant devices to process data at the network's "edge" either on-board or on a local server. Additionally, only the most crucial data is transported to the central datacenter when processing of data is required, reducing latency. Without edge computing, the enormous amount of data that edge devices create would overload the majority of today's commercial networks, impairing all network functions. The price of IT might rise. Valuable equipment may suffer damage or just perform less well. Most crucially, the security of employees may be jeopardised in fields where sophisticated sensors are used to keep them safe.

vi. **Security:** IoT security, often known as internet of things security, is the area of technology dedicated to securing IoT networks and linked devices. In the Internet of Things (IoT), internet connectivity is added to a network of connected computers, mechanical and digital machinery, items, living things, and people. Every object has the capacity to autonomously transport data across a network and has a distinctive identity. However, allowing a device's internet connection exposes it to major risks if it isn't well safeguarded.

vii. **Data Analytics and Machine Learning:** The big data produced by IoT are not only enormous in terms of size and volume, but they are also incredibly precise as well as diverse with a range of data types and quality. It also stands out greatly for its speed in terms of production, processing, location dependence, and accessibility. Smartly analysing such data in order to gain insightful information is therefore a difficult challenge. For IoT to achieve its touted market potential and maximise its economic value, intelligent data analytics is a crucial precondition. IoT data issues may be handled using machine learning, which can be used efficiently because it requires little to no human involvement.

viii. **User Interfaces:** The means for interacting between a user and a computer system is known as a user interface, or UI.

ix. **Standardization and Protocols:** Standard protocols specify the procedures and formats for establishing and running IoT networks as well as the means by which data is transferred between them.

x. **Power Management:** It's crucial to think about how a device's behaviour will affect its energy budget at every stage of an IoT product's design. The energy budget's main elements are power generation, battery capacity, and energy consumption.

xi. **Regulatory and Compliance:** IoT security is acknowledged by governments all around the globe as a major concern. IoT compliance guidelines, meanwhile, are still being created globally. Solution providers must adhere to regulatory compliance norms set by each nation in order to market their goods.

xii. **Blockchain and Distributed Ledger Technology:** A blockchain is a network of computers (or nodes) that contains a distributed digital ledger of all transactions. Instead of holding all of their transactions on a single centralised server, distributed ledgers employ separate nodes to record, share, and synchronise transactions in each of their distinct electronic ledgers. Blockchain applications are made possible by a variety of technologies, including distributed networks, distributed encryption/decryption methods, and distributed ledger technology. One kind of DLT where transactions are recorded with an immutable cryptographic signature known as a hash is blockchain. Due of this, distributed ledgers are frequently referred to as blockchains.

xiii. **APIs and Integration:** An application programming interface (API) is a messenger that handles requests and makes sure that business systems operate without interruption. Data, programmes, and devices may communicate with each other thanks to APIs. It provides connection between programmes and devices and distributes data. API may also be referred to as an organization's web programming interface. Applications can connect with backend systems thanks to it. The establishment of an online sales channel for the business is made possible by an application programming interface. API makes it possible for apps to access services by adding codes. It strengthens functionality and significantly improves connection.

Application of IoT in Livestock Sector

The application of the Internet of Things (IoT) in the Agriculture and Livestock sector, often referred to as AgriTech or Smart Farming, has the potential to revolutionize the industry by improving efficiency, productivity, and sustainability. Here are some key applications of IoT in the A.H. sector:

Livestock Monitoring:

- Health Monitoring: IoT devices can be attached to animals to monitor their health in real-time. These devices can track vital signs, detect illnesses, and send alerts to farmers if any abnormalities are detected.
- Location Tracking: GPS-enabled IoT tags can help farmers keep track of the location and movement patterns of their livestock, aiding in management and security.
- Feed and Water Monitoring: IoT sensors can monitor feed and water consumption, ensuring that animals receive adequate nutrition and hydration.

Precision Livestock Farming:

- Environmental Sensors: IoT sensors can measure temperature, humidity, and air quality in livestock enclosures, helping to create optimal conditions for animal health and growth.
- Smart Feeding Systems: Automated feeding systems can use IoT data to adjust feed distribution based on the specific nutritional needs of each animal.

Crop Monitoring:

- Soil Health Monitoring: IoT sensors can collect data on soil moisture, nutrient levels, and pH, allowing farmers to make informed decisions about irrigation and fertilization.
- Weather Forecasting: IoT-connected weather stations provide real-time weather data, helping farmers make decisions about planting, harvesting, and protecting crops from adverse weather conditions.

Pest and Disease Management:

- Smart Traps: IoT-enabled traps can detect the presence of pests and notify farmers when intervention is needed.
- Remote Surveillance: Cameras and sensors can be deployed in crop fields to monitor for signs of disease or pest infestations.

Supply Chain Optimization:

- Cold Chain Monitoring: IoT devices can monitor temperature and humidity in storage and transportation facilities, ensuring the quality and safety of agricultural products, including meat and dairy.

- Inventory Management: Smart sensors can track the quantity and condition of agricultural products in storage, reducing waste and spoilage.

Farm Equipment Management:

- Predictive Maintenance: IoT sensors on farm equipment can monitor usage and performance, predicting when maintenance is needed to prevent breakdowns and reduce downtime.

- Autonomous Farming: IoT-enabled tractors and machinery can be programmed to operate autonomously, improving efficiency and reducing labor costs.

Data Analytics and Decision Support:

- Data Collection and Analysis: IoT generates vast amounts of data, which can be analyzed to gain insights into crop and livestock behavior, helping farmers make data-driven decisions.

- Farm Management Software: IoT data can be integrated into farm management software platforms to provide a comprehensive view of farm operations.

Water Management:

- Irrigation Control: IoT-based irrigation systems can be controlled remotely and adjusted based on soil moisture levels and weather conditions, conserving water resources.
- By leveraging IoT technology in the Agriculture and Animal Husbandry sector, farmers can increase productivity, reduce operational costs, improve sustainability, and enhance the overall quality of agricultural products.

Advantages of IoT

The Internet of Things (IoT) offers numerous advantages across various industries and applications. Here are some of the key benefits of IoT:

Efficiency and Productivity:

- IoT devices can automate tasks, reducing the need for manual intervention and saving time.

- Real-time monitoring and data collection enable more efficient resource allocation and decision-making.

Cost Savings:

- IoT can lead to cost reductions through predictive maintenance, energy savings, and optimized resource usage.

- Remote monitoring and control can reduce labor and operational expenses.

Improved Safety:

- IoT sensors and devices can enhance safety by monitoring potentially hazardous environments and sending alerts in case of anomalies.
- Wearable IoT devices can monitor the health and safety of workers in industries like construction and mining.

Data-driven Insights:

- IoT generates vast amounts of data that can be analyzed to gain valuable insights into processes, customer behavior, and operational efficiency.
- Data analytics can lead to better decision-making and competitive advantages.

Environmental Sustainability:

- IoT can help reduce energy consumption through smart building systems, smart grids, and efficient transportation management.
- Precision agriculture powered by IoT can optimize resource usage and reduce environmental impact.

Enhanced Customer Experience:

- IoT enables businesses to offer personalized and convenient services to customers, such as smart home automation, personalized marketing, and predictive maintenance for products.
- Real-time feedback and customization options can improve customer satisfaction.

Supply Chain Optimization:

- IoT sensors and tracking devices can provide real-time visibility into the supply chain, improving inventory management and reducing delays.
- Predictive analytics can help prevent supply chain disruptions.

Healthcare and Wellness:

- IoT devices like wearables and remote monitoring tools enable continuous health tracking and early detection of health issues.
- Telemedicine and remote patient monitoring improve access to healthcare services.

Smart Cities:

- IoT can make cities more efficient and livable by optimizing traffic management, reducing energy consumption, and improving public services.
- Smart city solutions enhance safety and reduce congestion.

Asset Tracking and Management:

- IoT enables businesses to track and manage their assets in real time, reducing theft and loss.
- It provides insights into asset utilization and maintenance needs.

Predictive Maintenance:

- IoT sensors can monitor the condition of machinery and equipment, predicting when maintenance is required to prevent costly breakdowns.
- This reduces downtime and maintenance costs.

Remote Control and Automation:

- IoT allows for remote control and automation of devices and systems, enhancing convenience and operational control.
- Home automation, industrial automation, and smart grids are examples of this capability.

Global Connectivity:

IoT devices can be connected and managed remotely from anywhere with internet access, enabling worldwide monitoring and control.

Innovation and New Business Models:

- IoT fosters innovation by creating opportunities for new products and services.
- It enables subscription-based models, data monetization, and new revenue streams.

Competitive Advantage:

Organizations that adopt IoT early can gain a competitive edge by improving efficiency, customer service, and innovation.

While IoT offers numerous advantages, it also comes with challenges related to security, privacy, data management, and interoperability. Addressing these challenges is essential for realizing the full potential of IoT while ensuring its responsible and secure deployment.

Disadvantages of IoT

While the Internet of Things (IoT) offers many advantages, it also comes with several disadvantages and challenges that need to be considered:

Security Concerns:

- IoT devices are often vulnerable to cyberattacks due to limited built-in security features and weak or default passwords.
- A compromised IoT device can lead to data breaches, privacy violations, and potentially dangerous situations.

Privacy Issues:

- IoT devices collect vast amounts of data, including personal information and behavioral patterns, raising concerns about data privacy and surveillance.
- Unauthorized data access or sharing can result in privacy breaches.

Complexity and Interoperability:

- IoT ecosystems often consist of devices from various manufacturers, and ensuring interoperability and seamless communication between devices can be challenging.
- Compatibility issues may arise as standards and protocols evolve.

Reliability and Stability:

- IoT devices and networks can experience downtime, connectivity issues, or software bugs that affect their reliability.
- Dependence on IoT for critical applications like healthcare or transportation raises concerns about system stability.

Data Overload:

- The massive amount of data generated by IoT devices can overwhelm organizations, making it difficult to manage, analyze, and derive actionable insights from the data.
- Handling and storing such large volumes of data can be costly.

Cost of Implementation:

- Deploying IoT infrastructure, including sensors, connectivity, and data analytics, can be expensive, especially for smaller businesses and industries with limited budgets.
- Maintenance and ongoing operational costs add to the financial burden.

Energy Consumption:

- Some IoT devices require frequent data transmission and processing, which can lead to increased energy consumption.
- This is a concern for battery-powered devices and sustainability goals.

Lack of Standardization:

- The lack of universal IoT standards can lead to fragmentation and hinder widespread adoption.
- It can also result in compatibility issues between devices and platforms.

Scalability Challenges:

Scaling up IoT deployments can be complex and costly, as it involves adding more devices, sensors, and infrastructure while maintaining data consistency and reliability.

Ethical Considerations:

- IoT raises ethical dilemmas, especially in areas like AI-driven decision-making, autonomous vehicles, and surveillance technologies.
- Balancing technological progress with ethical principles and societal values is a challenge.

Regulatory and Legal Issues:

- IoT devices often operate across national borders, making it difficult to establish consistent regulatory frameworks.
- Compliance with privacy and data protection laws, such as GDPR, can be complex.

Lack of Skills and Expertise:

Organizations may struggle to find and train personnel with the necessary skills to manage IoT systems, analyze data, and address security vulnerabilities.

Environmental Impact:

The production, use, and disposal of IoT devices can contribute to electronic waste (e-waste) and environmental concerns if not managed responsibly.

Overreliance on Technology:

Dependence on IoT for critical functions can create vulnerabilities, as system failures or cyberattacks can disrupt essential services and processes.

To mitigate these disadvantages and challenges, organizations and individuals must prioritize security, privacy, and responsible IoT deployment. Establishing clear regulations and standards, investing in cybersecurity measures, and promoting ethical and sustainable IoT practices are essential steps in maximizing the benefits of IoT while minimizing its drawbacks.

Summary

Modern livestock management has been transformed by Internet of Things (IoT) technologies that increase efficiency, animal welfare, and agricultural output. IoT sensors are increasingly often utilised to track the behaviour and health of cattle. These sensors can monitor an animal's vital signs, spot ailments early, and make sure they get the care they need. Farmers may better manage and safeguard their livestock by using GPS-enabled devices to track their whereabouts and avoid theft or loss. IoT also makes feeding and drinking systems more efficient, ensuring that animals get the proper nutrition and amounts of water. IoT environmental sensors are used in precision livestock farming to measure variables like temperature, humidity, and air quality to create circumstances that are best for animal development and welfare. This data-driven strategy increases productivity while using less resources. Additionally, IoT supports the management of pests and diseases with smart traps and remote surveillance systems, minimizing the impact of outbreaks on livestock. IoT, however, also comes with considerable difficulties. Since IoT devices are vulnerable to hacker attacks and data breaches, security issues are of the utmost importance. Due to the vast data gathering and potential surveillance, privacy problems develop, posing moral and legal issues. Problems with complexity, interoperability, and scalability prevent widespread adoption and smooth integration. Organisations may be burdened by data overload and administrative expenses, while energy usage raises questions about sustainability. Complexity is increased by regulatory, ethical, and environmental issues. Organisations must put security, privacy, and responsible deployment first in order to reap the benefits of IoT. Investments in cybersecurity, skill development, and ethical practises are essential, while standards and laws need to be developed. To maximise the benefits of IoT while minimising its downsides, it is crucial to strike a balance between technical development and ethical values and sustainable practises.

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