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Research Article

Smart IOT Cloud Based Livestock Monitoring System: A Survey

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Abstract: Animal husbandry plays a significant role in the world economy. The advancement in new technologies such as the Internet of Things (IoT) and Cloud Computing plays a vital role in governing the health of the livestock, tracking their live location and also smart feeding the cattle. The targeted survey was designed mainly to focus on precision livestock farming (PLF) techniques which helps to improve animal health, welfare, and farm efficiency. The evidence of the interest in, and significant presence of, PLF tools for the individual monitoring of livestock are provided in the survey. Here, in this study, we have discussed about the recent and updated research on the various livestock monitoring and management systems.

Keywords: Internet of Things (IoT), Cloud computing, livestock, animal health monitoring, location tracking, smart feeding, precision livestock farming

1.Introduction

Livestock are farm animals such as cattle and sheep that are raised in an agricultural setting. Livestock farming is simply the management and breeding of domestic, livestock or farm animals for the purpose of obtaining their meat and other products. Traditional method of farming involves manual inspection and visual observation. The main disadvantages of tradition livestock farming are the farmers areunaware when the cattle are infected by disease, it is difficult to monitor location of the cattle since do not stay at fixed location and the traditional process is moretime consuming and it is unreliable.

Livestock management, otherwise called livestock monitoring or precision livestock farming (PLF), uses IoT-enabled devices to track and monitor the health of livestock, most commonly cattle. PLF is referred to as the application of process engineering principles and techniques to livestock farming to automatically monitor, model and manage animal production. The primary goal of PLF is to make livestock farming more economically socially and environmentally sustainable and this can be obtained through the observation, interpretation of behaviors and, if possible, individual control of animals.

The Internet of Things, or IoT is the network of physical items that are embedded with sensors, software and other technologies. It is used for connecting and exchanging data with other devices and systems with the help of the Internet.

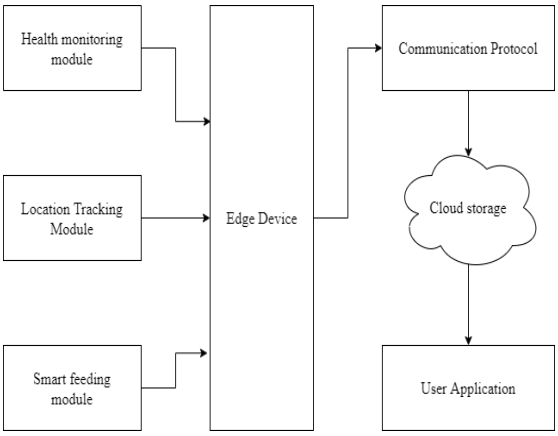
Cloud computing refers to storing and accessing the data over the internet. Cloud computing refers to running our workloads remotely on someone else's servers which is provided by commercial service providers over the internet.
Cloud IoT is the term evolved because of the convergence of cloud computing with the Internet of Things (IoT). Both of them complement each other by leveraging its services. The number of devices used in day-to-day life of the human as well as industries is growing rapidly because many services are automated. Animal livestock can leverage the power of cloud IoT services.

Animal health monitoring systems use sensor technologies to monitor various health parameters such as heart beat, body temperature, respiratory rate, rumination, blood pressure and physical gestures of the livestock. The location monitoring system uses several techniques such as GPRS, Wireless Sensor Networks (WSN) and RFID tags to track the live location of the cattle. The smart feeding system for the cattle is achieved by using ultrasonic sensor technology.

2. Recent Trends in Livestock Monitoring

The advancement in recent technologies provides different techniques to monitor and manage the livestock. The animal monitoring system include various features like monitoring the health level of livestock, tracking the live

location of the cattle and also includes smart feeding methodology to monitor the quantity and quality of the animal feed.



2.1 Livestock health monitoring system

Disease management is the main part of animal health monitoring. An animal can be easily affected by disease due to its environment conditions. Diseases are an abnormal condition of the animal where they are directly or indirectly affect the metabolism of the animal. The livestock health monitoring system provide various techniques to monitor heart rate, body temperature, respiratory rate, blood pressure and animal movements and gestures which can help farmers stay up- to-date with their cattle's health levels and also helps to detect various diseases in the beginning stage itself. Moreover, tracking these factors also contributes to a significant reduction in livestock feeding issues.

The work proposed in (K., S. 2018), Cloud IoT- based LMS(Livestock monitoring System) has the following three features such as a wearable collar for monitoring and recording the animal health parameters using IoT sensors, identification of livestock using a unique identifier(UID) and display of the details via wireless by QR code reading and processing. The animal physiological parameters such as body temperature, heart beat rate, physical gestures like sitting, standing, eating, heartbeat and environmental parameters such as air temperature and relative humidity are detected using developed animal monitoring devices. The sensors used in this system includes the DHT11 sensor for sensing temperature and humidity level in environment, the MLX90614 is a Infrared contactless temperature sensor to detect the cattle's body temperature, the KG011 is a heartbeat pulse sensor that monitors the cattle's heartbeat per minute and the 3 axisaccelerometer sensor is used finding thephysical gestures of the animal. Thissystem uses arduino UNO for processing and Bluetooth module HC-05 and Wi-fimodule ESP8266 for communication. The data collected from the sensors are storedin cloud. This system also has a web basedanimal husbandry for better interaction with the farmers, veterinary doctors andveterinary hospitals.

The work in (Y. P. Pratama 2019) has three components in a collar device that reads the heart rate, body temperature and movement in cattle, management of local servers by building the base station and the health conditions can be visualized and analyzed by using web application. The data collected from sensors are stored and classified using machine learning to produce health classification outputs like normal, less normal and abnormal conditions. This method uses Wemos D1 mini as a microcontroller, MLX90615 as a body temperature sensor, MAX30100 as a heart beat sensor, GY-25 as a accelerometer and gyroscope sensor, TP4056 as charging module and Baterai 18650 as resource. Here the system uses seven layer IoT model such as a)device and physical controller layer which include all the sensors and microcontroller module, b)connectivity layer which uses 4g/3g or wifi module to connect the devices and physical controller layer to the edge computing layer, c)edge computing layer that may have MQTT broker in which the received data is received by all other sub system. d)data accumulation layer where the data is stored to the cloud, e)data abstraction layer which has MQTT broker or node.js to reduce the delivery time of the data, f)application layer which consist machine learning, visualization, predication and IoT cloud platform dashboard, and

f)Collaboration andprocesses website which provides feedback about the cattle's health level andbehavior.

A system for continuously monitoring the animal health by calculating critical parameters that affect the animal's health like heart rate, rumination and body temperature is proposed in (Kumari2018). Here the core controller which is used in this system was Raspberry Pi 3, it uses Wifi module for communication. The sensors used in this system are DS18B20 sensor for detecting body temperature, pulse sensor detecting heartbeat and the accelerometer ADXL335 is used for developing the rumination sensor. Here the system uses Analog to Digital Converter (ADC: MCP 3008) since Raspberry pi does not support analog sensors. The sensed data by IoT devices can be accessed from anywhere by using a cloud database. This system uses ThinkSpeak which is open source IoT cloud. Thus it allows the farmers to access the data using mobile via android application and it also uses email so that the farmers can get access to the data easily.

The work proposed in (Shinde) aims in using sensor technology to automatic measurements of various health factors like Temperature, Heartbeat and movements of cattle. This sensor is mounted on the cattle body. Here LM35 is used to detect the temperature, Stethoscope is used to detect the Heartbeat and electronic accelerometer is used to detect the each and every movement of the cattle. Using wireless technology sensors are accessed to collect data for early detection of disease and to reduce the difficulty to take care of them and to monitor the health of cattle. This is developed using IOT .Sensor is connected to the Arduino UNO (Controller)and signals from Controller is sent to the healthmonitoring app using Wifi module.

The idea submitted in (Swain, 2017) propose Health monitoring system using Arduino to detect the parameters like heart rate, temperature, rumination and body humidity of the cattle. Arduino is used for interface purpose and Xbee for wireless communication. Different types of sensors such as DHT11 will sense the temperature and humidity of a cattle, kg011 which senses the heart rate and three axis gyro- accelerometer is used for sensing the rumination of a cattle. Lab view is used to analyze the heart rate using arduino module and is used to display the result. To receive and send the data between Xbee's software is used XCTU. Cattle health monitoring system provides accurate health parameters which are helpful to monitoring the health condition and detecting any change health problems and behavior of cattle. So, it can be a very effective device for the farmers to analyze the every problem by themselves without being dependent on the veterinarians.

The work implemented in (P. Khatate, 2018) focuses on a Wearable smart health monitoring system is developed using IOT. wearable animal health monitoring system used by the owner at home and the data is conveyed to the veterinary doctor for primary treatment. It consists of parameters like temperature, pulse rate and respiratory rate. Sensors such as DS18B20 is used for detecting Temperature, flex sensor for Respiratory rate, Oscillometric method for Blood Pressure are integrated to the arduino UNO and output is displayed on LCD.

An integrated architecture in (Saravanan, K., 2017) proposes an animal husbandry livestock management system with an objective to monitor the animal's health, heat stress and also it recognizes the right time for artificial insemination. The system is designed to help the farmers by providing better monitoring and taking care of the cattle by using the real time data. The sensor used here is the Infrared thermometer sensor that detects the body temperature of the animal. The processing is done by an arduino atmega 328p module and the wireless communication technologies used here are smart bluetooth and ESP8266 wifi module. The users who are present within a short distance can receive the animal's health information via bluetooth enable devices. Arduino atmega 328p board is programmed using the arduino software and putty is used to configure the wifi module. The data from the temperature sensor is used to detect temperature related disease, to predict the heat stress of the animal and classify it as normal, low stress, mild stress and danger stress and also used to find the right time for artificial insemination. This system uses an Internet of Things (IoT) based analysis software, ThinkSpeak to store the data collected from the sensor by connecting it to the network via wifi.

A Zigbee animal health monitoring system (Kumar, A., 2015) is developed for monitoring the parameters such as

rumination, body temperature, and heart rate with surrounding temperature and humidity.

The developed system can also analyze the stress level corresponding to thermal humidity index (THI).DHT11 is used to detect the humidity, thermistor (TTC05102) is used to detect temperature, polar equine T56H to detect heart rate and ADXL335 accelerometer to detect rumination. The microcontrollers used in the implementation of the sensor module are Zigbee device and PIC18F4550

.According to the IEEE1451.1 standard the graphical user interface (GUI) is implemented in LabVIEW 9.0. GUI sensesall parameters. The real time monitoring ofphysiological and behavioral parameters present on the GUI PC. The device is very helpful for farmers and inexpensive health care of livestock.

The table 1 given below depicts the comparison of various animal health monitoring system.

Table 1: Comparison of various animal health monitoring system

Reference	Parameters detected	Sensors used	Microcontroller used	Communication protocol used
Cloud IOT based novel livestock monitoring and identificationsystem using UID (K., S.2018)	Body temperature, Heart beat rate, Physical gesture and Environmental parameters	MLX90614, KG011, 3d accelerometer, DHT11	Arduino UNO	HC-05 Bluetooth ESP8266 Wifi
Designing ofa Smart Collar for Dairy CowBehavior Monitoring with Application Monitoring in Microservicesand Internet of Things-Based Systems (Y. P. Pratama2019)	Body temperature, Heart beat and Movements in cattle	MLX90615, MAX30100, GY-25	Wemos D1 mini	Wifi
Developmentof IoT BasedSmart Animal Health Monitoring System Using Raspberry Pi (Kumari,2018)	Heart rate, Rumination and Body temperature	Heart beat sensor, ADXL335 accelerometer, DS18B20	Raspberry Pi 3	Wifi
IoT-Based CattleHealth Monitoring System (Shinde,)	Temperature, Heart beat, Movements	Temperature sensor,LM35 Heartbeat, stethoscope Movements, electronic accelerometer	Arduino UNO	ESP8266 Wifi
Cattle health monitoring system using Arduino And LabVIEW for early detection of diseases (Swain,2017)	Temperature, Heart rate, Rumination	Temperature sensor,DHT11 Heart rate,kg011 Rumination,three-axis-gyro-accelerometer	Arduino	Xbee(wireless communication protocol)

Wearable Smart Health Monitoring System For Animals (P. Khatate,2018)	Temperature, Respiratory rate, Blood pressure, Heart rate	Temperature sensor,DS18B20 Respiratory sensor,Flex sensor Blood pressure,Oscillometric method Heart rate,ECG	Arduino UNO	Wifi
An Integrated Animal Husbandry Livestock Management System (Saravanan, K.,2017)	Body temperature and Heat Stress	Infrared thermometer sensor	Arduino atmega 328p	smart bluetooth and ESP8266 wifi
A Zigbee- Based Animal Health monitoring System (Kumar, A.,2015)	rumination, body temperature, heart-rate, temperature, humidity	Humidity,DHT11 temperature, thermistor (TTC05102) Heart rate, polar equine T56H Rumination,ADXL335 accelerometer	PIC18F4550 and XBee-PRO S2	Zigbee

2.2 Livestock location tracking system Tracking the location of the grazing animals plays a major role in monitoring the livestock. It is very difficult for the farmers to manually inspect and monitor the livestock. Fencing and visual tracking of cattle requires a considerable cost and it is a time consuming process and it involves farmers' physical intervention to keep an eye to stop them from crossing beyond the access points. Livestock location tracking can also be used in places where the farmers face animal theft problems. More importantly this tracking of livestock is very useful when thelivestock have to separate themselves fromthe herd, especially when they are ill or in heat.

The novel method proposed in (Juan Ignacio Huircán, 2010) uses Wireless Sensor Network (WSN) for livestock monitoring in grazing fields. This method does not require any additional hardware since it uses LQI (Link Quality Indication) for distance estimation and instead of usual RSSI(Received Signal Strength Indication), the RVI(Radiometric Vector Iteration) algorithm was implemented and modified to work with LQI measurements. The Zigbee wireless sensor network consists of three types of devices: coordinators, routers and an end device. The network coordinator implemented with JN5139-Z01-M02 device. Then by connecting through UART it interfaces to the PC in which the data is collected and the localization algorithm is applied. Four JN5139-Z01-M02 devices were used as routers and they were used as anchors in localization algorithms. One JN5139-Z01- M00 end node which is referred to as a "sensor node", is mobile and its location is determined. This model mainly focuses on reducing the cost, weight and lowering the power consumed by the system.

The idea implemented in (Maphane, 2017) provides a livestock monitoring and identification system by developing an electronic control circuit using Wireless Sensor Network (WSN) and GSM. The circuit models in this system are simulated by using a software called Proteus 8. The proteus 8 software is used for simulation as it has the ability to render third party libraries like Arduino Microcontroller (MCU), XBee module, XBee shield, GPS receiver and SIM900 GSM/GPRS shield. An Arduino microcontroller is used as the controller for this work. GPS is used for finding the location of the cattle and The XBee is used for sending and receiving wireless messages. Here the XBee shield is used for successfully interfacing Arduino MCU to the XBee module.

The work submitted (Ilyas, 2020) aims an enhanced Livestock monitoring and geofencing system that creates virtual geographical safe boundaries for the animals. This system helps the farmers by providing the safe zone for the cattle to graze and also notifies the farmer when the livestock crosses the boundaries of the safe zone. This system uses ultrasonic sensors which are installed at the geographical safe zone boundaries to calculate the safe- distance threshold. The livestock are equipped with navigation sensors like GPS to find the location of the animal through satellite. In case if the animal is outside the safe zone the system locates the exact location of the cattle by finding its current location coordinates by communicating with the satellite.

The system explained in (Anu, V. M., 2015) is a Radio Frequency identification (RFID) based techniques in precision

livestock management has made data management and retrieval extremely efficient and offers some advantages like decrease in recording errors, automation of farm implements, reduction in labor costs, overall productivity optimization and cost-prohibitive to farmers. RFID can be used to monitor and track livestock accurately and it is integrated with cloud which enables continuous tracing of livestock location and also grazing patterns. The Active RFID technology is deployed to identify livestock and also shows the current location of the livestock. A RFID tag is attached in the ear of an animal and is used to give an unique ID for individual animals. Radio frequency facilitates an automatic identification process for transmitting data from RFID tags to RFID reader using radio-frequency electromagnetic fields. RFID Bluetooth- based card reader consists of RFID reader module, microcontroller processing module and wireless communication module. Using wireless communication, module location of livestock is transferred from RFID tags to RFID reader and then to microcontroller processing unit and data is transferred simultaneously to the smartphone of the farmer and cloud storage. A smart card designed for the farmer it consists of an embedded computer chip comprising a microprocessor with memory to store and query. It improves security and privacy of animal information. Smart cards contain full details of the owner like name, date of birth, contact number, unique ID and animal detail.

Paper	RFID	WSN	GSM	GPS	LQI & RVI	GPRS
ZigBee-based wireless sensor network localization for cattle monitoring in grazing fields **(**Juan Ignacio Huircán,2010)		✓			✓	
Development of Electronic Control Circuits for WSN: Towards a Livestock Tracking and Identification System **(**Maphane2017)		✓	✓	✓		
Smart Farming: An Enhanced Pursuit of Sustainable Remote Livestock Tracking and Geofencing Using IoT and GPRS Ilyas,2020				✓		✓
Animal Identification And Data Management Using RFID Technology **(**Anu, V. M.,2015)	✓			✓		

2.3 Smart Feeding

Feeding the livestock plays an important role in farming. The cattle should be fed with nutritious and good quality food to prevent it from various food borne diseases. Feeding the cattle at a regular interval time with proper nutrient and quality feed will improve the cattle's health level and behavior. Silos and hopper storage are medium to large structures mostly used by farmers to store the grains for feeding the cattle and also to protect the grains from insects, rodents, birds, etc . Smart feeding techniques includes using IoT technology for monitoring the volume of the grain present inside the silos, proper management of grain to avoid wastage due to surplus stocks and refilling of the stock in silos to prevent out of stock danger and also monitoring the temperature and humidity inside the silos to ensure the grain quality.

The work implemented in provides a smart feeding in farming by using IoT devices in silos. This system addresses the problem in measuring the quantity or volume of the grain stored inside the vertical silos. This smart feeding system consists of GH-311 RT ultrasonic sensor, HS-645MG servo motor, DHT 11 temperature and humidity sensor,

wall adapter, ESP-8266 Wi-fi module and arduino UNOmicrocontroller. The distance between thegrain and the top of the silos can be measured by using the ultrasonic sensor. The servo motor is attached with the ultrasonic sensor so that it can cover three different angles. The temperature andhumidity inside the silos at different instances of time can be measured by using the temperature and humidity sensor. This system uses Arduino UNO as the microcontroller unit and the ESP-8266 wifi module is used to connect microcontroller to wifi network so that it transfers the data collected from the sensors to the server via Wi-fi.

The system explained is a control and monitoring system for livestock feeding time via smartphone. This system proposes a smart feeder which reduces the cost, time and the manpower. The system mainly focuses on controlling and monitoring thelivestock feeding time using smartphone application. Using the system the feed can be efficiently distributed among cattle and the wastage of feed can also be reduced. The smartphone application can be used for monitoring the quantity of food in the hopper storage, controlling the time to feed the cattle, calculate the amount of feed in thefood container and also to sense the presence of cattle near the feed. The smart feeder system consists of a hardware part which contains the ultrasonic sensor, servo motor, load cell and Arduino WeMos D1R2 and the software part which contain the Blynk app. The Blynk is used to control the IoT sensors remotely through the internet. The ultrasonic sensor is mounted to the hopper storage and the food container. The ultrasonic sensor in hopper storage is used tomonitor the level of feed in the hopper and the ultrasonic sensor in the food container is used to sense presence of livestock near the food container. The load cell helps the user to identify whether the cattle has eaten by calculating weight of the feed left in the container. By using the smartphone application the user can set the time to open the hopper storage to drop the feed on the food container. The system uses Arduino WeMos as a microcontroller which has the added advantage of inbuilt WiFi.

The work proposed is a MultiAgent System(MAS) for Smart Silos to Optimize Food and Water Consumption on Livestock Holdings. The Multi-Agent Systems(MASs) are computerized entities which consist of interactive agents with an ability to perform operation and achieve the goals with minimal or none human supervision. This system monitors, calculates, transmit data and notify the farmer of the volume of the feed in silos by using a Multi-Agent System.The system also refills the silos timely by using IoT devices. It uses SONAR technology(XL-MaxSonar-WRL MB7066)to measure the level of grain in the silos. The quality of the grain inside the silos can be sensed by using temperature and humidity sensor (SHT20 I2C). The SONAR and the sensor are mounted to the top cover of the silos. The system uses lolin v3 nodeMCU as the microcontroller. The calculations are performed once the obtained data is transmitted to the cloud. Depending upon the preference of the user, the system can be configured to take measurements periodically or instantaneously.

3. Findings

Based on the literature survey we have discussed in this paper, there are many animal health and location monitoring techniques for preventing and managing the cattle and various smart feeding techniques to address the livestock feeding problems. These systems still have some major disadvantages like more power consumption, complex structure and interface, high cost of installation and maintenance which make is not reliable for farmers to adapt these smart systems. These smart systems also need more sustentation when installing in large farms.

4. Conclusion

Animal health monitoring and location tracking are of great concern in precision livestock management. In this paper we have the studies submitted in various papers which focuses on preventing the cattle from various health issues, provides various livestock location tracking and smart feeding methods. We have also discussed the comparison in various techniques for health and location monitoring of livestock. The smart livestock monitoring system can be enhanced by making it more accurate, energy and power efficient and less cost consuming. The system can improve the power consumption using solar power to operate when the cattle were grazing in the field and can use batteries in absence of sunlight. The cattle which are affected by disease are detected by health monitoring and it can be treated by feeding the medicine along with the grain through the smart feeder. The system can also be made more accurate and efficient by using proper sensors.

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