

Internet of Things Based Smart Agriculture and Applications

T.Venkat Narayana Rao¹, Harshini Upender², Ayitham Divya³ and M Jyothi Priya⁴
Professor¹, Student^{2,3,4}, Department of C.S.E
Sreenidhi Institute of Science of Technology
Yamnapet, Hyderabad, TS, India.

Abstract: Introduction of internet of things brought many changes in different fields like medical, transportation etc. Advancement of this technology has become one of the major advantages to live a happy and smart life. And due to the recent climatic conditions which are rapidly changing, it has become difficult for the farmer to use the regular practice. Mainly agriculture includes farming and cattle management, this paper discuss about few applications that result in effective farming and efficient cattle management. This paper gives a brief idea to the reader about hardware components that can be implemented in agricultural practices. The main intention of this paper is to convert traditional agriculture to smart agriculture by implementing various applications like smart irrigation system, livestock monitoring system, smart greenhouses and agricultural drones. In all, the applications discussed in this paper include the information collected by these systems are sent as alerts or Short Messaging Services (SMS) to the farmers. It also narrates, why we need smart agriculture and what are different applications to be implemented in one's farm.

Keywords: *Internet of Things(IoT), Smart agriculture, Unmanned Aerial Vehicle(UAV), Sensors, Irrigation, Livestock, Drones, Greenhouses.*

1. Introduction

Agriculture plays an important role in the process of economic development of a country. India ranks 2nd in the world in agricultural production. About 17% of India's GDP (Gross Domestic Product) is bestowed by agriculture. Approximately 65% of labor livelihood depends on agriculture in India. Nearly 60% of water used in irrigation goes in vain due to lack of proper usage. Even though agriculture provides food which is a necessity in everyone's life, no one of our generation are coming forward to opt agriculture as their occupation as it involves lot of physical work, stress due to improper production and their hard work is not paid off. To overcome these problems the agriculture industry must embrace IoT. With growing technology around us, applying technology like IoT in farming will result in great outcomes. Smart agriculture based on IoT will result in less wastage of water, high production, less manpower and most importantly it saves time. IoT is equipped enough to influence the world we live in. So, what is smart agriculture? It is an application that uses modern technologies like IoT to increase the quality and quantity of the production to sustain the growing population.

The area of land for agriculture has been decreasing over the years due to numerous reasons that include population, soil erosion, etc. Without imposing any additional burden on the environment, adapting IoT in the agriculture will be an optimal solution for meeting the needs of growing population and increasing crop productivity. Smart agriculture is an agriculture management concept that uses modern technologies in order to increase the quality and quantity of agricultural products. In this century, farmers have access to GPS, IoT and other technologies. Adapting the strategies accordingly farmers can increase the effectiveness of pesticides and fertilizers, use required amounts of water and therefore increase crop productivity. Similarly the farmers can monitor individual animals and manage their nutrition, thereby preventing diseases in animals and enhancing cattle health.

2. Applications of IoT in Agriculture

IoT based smart agriculture is highly efficient than manual or traditional methods. It gives rise to many applications like agricultural drones, livestock monitoring, organic farming, smart irrigation, smart green houses etc.

A) **Smart irrigation system:** As everyone know the traditional method of irrigation is to go to farm time to time, check water level and give water supply to farm and also to face some unexpected weather changes which may sometimes ruin complete farm. Smart irrigation is the single solution for all these problems because with the help of this technology farmer can have a smart life and control all the problems sitting at his place and going to his farm occasionally. In this method the farming is controlled by a smart phone which is provided with a mobile application which automatically displays temperature, humidity and ground water level so that he can on or off motor from his home as shown in figure 1 and figure 2, with the help of temperature and humidity one can predict the weather conditions and take care of his farm. If there is no smart phone with the farmer there will be a message sent to the farmer to on or off the motor based on the water conditions.

Hardware Tools required are:

1. Moisture sensor
2. Ultrasonic sensor
3. DHT11 sensor
4. Node MCU
5. Relay switch
6. Motor
7. Android device
8. Breadboard
9. Male and female jumper wires.

Table I:Sensor descriptions.

SENSOR NAME	DESCRIPTION
1)Moisture Sensor	To measure volumetric content of water in soil
2)Ultrasonic sensor	Measures distance based on sending ultrasonic signals
3)DHT11 Sensor	To measure humidity and temperature
4)Node MCU	NodeMCU is an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module

The entire coding is done in Arduino and it is dumped in node MCU which is the backbone of the project. The data is stored in the cloud and it shows the variance of the atmosphere in the form of graphs.

i)Architecture

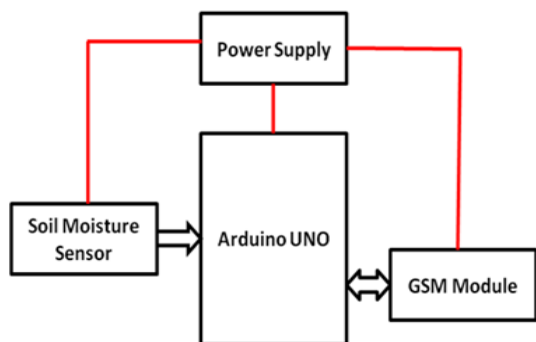


Figure 1:Architecture of smart irrigation system.

ii)Final output : The implementation kit is presented in figure 2 and the out can be on the display a live data.



Figure 2:Implementation of smart irrigation system.

B) Livestock monitoring system

Currently agriculture along with farming consists livestock management, fishing etc. Due to the increase in demand of the dairy products in recent times, dairy production companies are moving towards profits. This led for a greater demand in technologies through which we can achieve livestock monitoring. As some dairy production companies contain huge number of livestock ,it is hard to check the condition of cattle continuously for the owners/farmers. The idea of this system is to monitor the health of each cattle time to time and take necessary action by giving proper treatment to the sick cattle .In this application we use sensors which measures the conditions of cattle such as body temperature, heartbeat as shown in table I [1][2].The data collected is reported to the farmer timely. This application decreases the

costs of monitoring health of each animal and saves lot of labor work. This livestock monitoring application uses IoT sensors that are compact.

Architecture:

The architecture consists of three parts as shown in figure 3 .

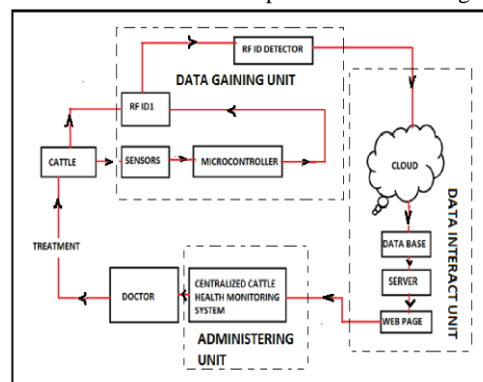


Fig 3: Architecture of Livestock monitoring system

Basically this application is divided into three domains :

- i) Sensor Technology
- ii) Communication
- iii)Wireless Sensor Networks Technology (WSNs)

i) Sensor Technology

Livestock monitoring system measures conditions of cattle like heart rate,temperature etc by using sensors like body temperature sensor ,heart beat sensor and piezo electric sensor as shown in table II [2].

Table II: Sensors details

Sensor Name	Description	Image
Body temperature sensor	These sensors are used to sense the body temperature of the cattle. The body temperature sensor used is LM35.	
Heart beat sensor	This sensor will detect heartbeat, stress as well as animal's anxiety. The heartbeat sensor generally used is a stethoscope.	
Piezo electric sensor	This sensor will detect heartbeat, stress as well as animal's anxiety. The heartbeat sensor generally used is a stethoscope.	

ii) Communication

This application sends the cattle's data regarding its health to the doctor phone using ESP8266 WIFI which sends signals using technology of IoT as shown in figure 5. Through that data, doctor and farmer will get to know about cattle condition. Signals from the sensors are transformed by AT89C51 controller as shown in figure 4 to a ESP8266 Wifi unit which are used for communication and monitoring the condition of a animal[2] .

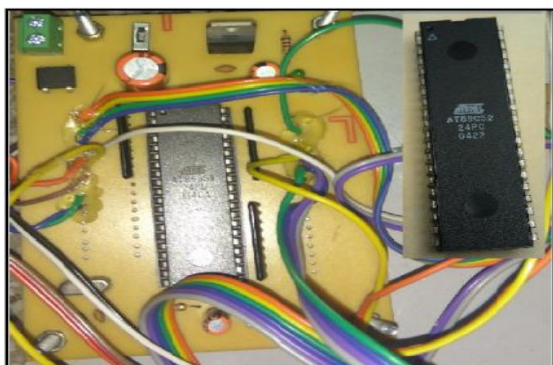


Figure 4: AT89C51 Controller & Its Circuitry.

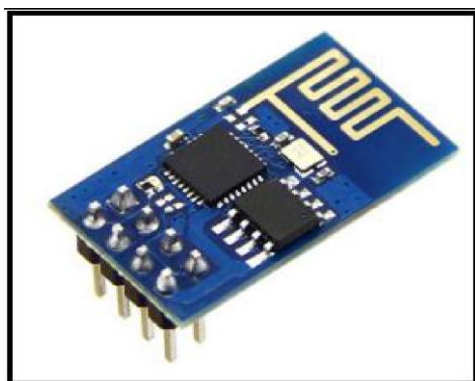


Figure 5: ESP89C66 WIFI Module.

iii) Wireless Sensor Network Technology (WSN):

Monitoring the health of the cattle by using the sensor technology is the objective of livestock monitoring system. Wireless sensor network is the collection of wireless body monitoring sensors which are used for checking the condition of a cattle. This data is accessed by using a website or mobile application as shown in figure 6[4].

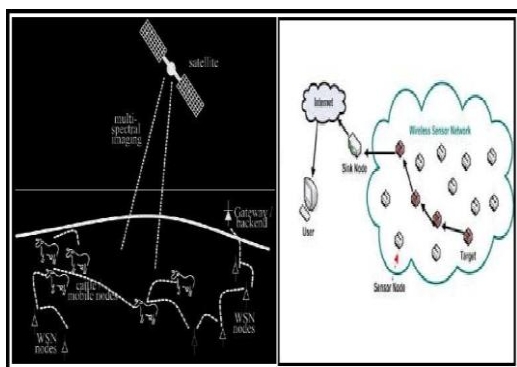


Figure 6: Typical Wireless Sensor Networks (WSNs) Architecture.

In this application the doctor or the farmer can monitor the health of the cattle by using website or mobile app that can be accessed anywhere. Layout of the android app is as shown in figure 7.

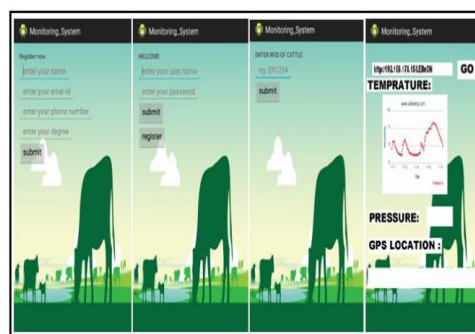


Figure 7: Layout of Android App.

C) Smart greenhouses

Greenhouses are structural buildings with roof and walls, which are built with different materials like glass, plastic etc. This provide the best environment to grow plants for optimal productions. Greenhouses will play a major role in agriculture and horticulture sectors. Greenhouses consist of hardware to control the environmental parameters like temperature, light etc. Automatic control of environmental conditions within greenhouse allows any type of plant to be grown throughout the year .Smart greenhouses reduces lot of physical effort to be put by the labor and also reduces errors made by them. It also decreases the cost of maintaining a greenhouse[3].

Smart greenhouses will automatically monitor and control the environmental parameters that govern the plant growth which increases the production. The sensors in the smart greenhouses continuously monitor and control the conditions in greenhouse to make sure that the environment remains at pre-set conditions (temperature, light, moisture and humidity levels). It will help farmer by increasing efficiency in plant growth, saving water, and reducing the environmental impacts on plant’s production. This system controls and monitors the greenhouse by IoT sensors using arduino[4]. By using smart greenhouses the farmer can know about the climatic conditions of the plants which are grown in a greenhouse through a mobile application and even from distant places the farmer can control the greenhouse . This application allows farmers to take correct decisions through the information provided by the system obtained by using sensors.

The important components used in smart greenhouses are show in table III [4]:

Table III: Components of smart greenhouses.

Component	Description
Arduino UNO	Arduino UNO is a microcontroller board based on the ATmega328P. The Arduino includes a serial monitor which allows textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted through the USB to serial chip and USB connection to the computer.
Soil moisture sensor	The soil moisture sensor is used to determine the volumetric content of water in the soil. It consists of two copper leads which act as the sensor probes.
Light Sensor	The light sensor is a device that converts the light energy into an electrical signal output.
Humidity Sensor (DHT11)	Humidity sensor is used for sensing the water vapour in the air.
Temperature Sensor (LM35)	The LM35 is an IC temperature sensor, whose output voltage is proportional to the Celsius temperature. It can be operated at -55° to +120°C.

The basic architecture of smart greenhouses system is shown in the figure 8[4].

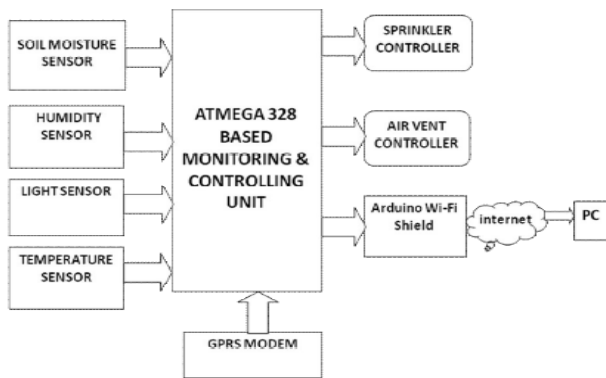


Figure 8: Architecture of smart greenhouses.

D) Agricultural Drones

People working for agriculture and especially farmers are considered to be healthier and have lower mortality and morbidity rates than the non farming population. On the other hand, farming related tasks and farming itself involves serious hazard to the health and well being of farmers. Farmers are exposed to a vast range of occupational hazards, such as exposure to viruses, inorganic dust, sunlight, pesticides and other chemicals. All these are possible risk factors that lead to adverse health issues for farmers like pesticide poisoning, neurological dysfunction, cardiovascular diseases, and respiratory diseases. To overcome this adversity, the technology of agricultural drone should be adopted by the farmers [5].

Unmanned Aerial Vehicle : An agriculture drone is an Unmanned Aerial Vehicle that is applied in farming in order to increase the crop production. The UAVs are controlled remotely by a person(farmer in this regard) for various purposes like sprinkling pesticides and crop monitoring etc. The variety of sensors used in UAV and an additional feature of digital picturing will give a richer view of fields to a farmer. Here we are going to stress on sprinkling pesticides using agricultural drones[5]. Table IV depicts the hardware components used with UAV's.

UAV Architecture:

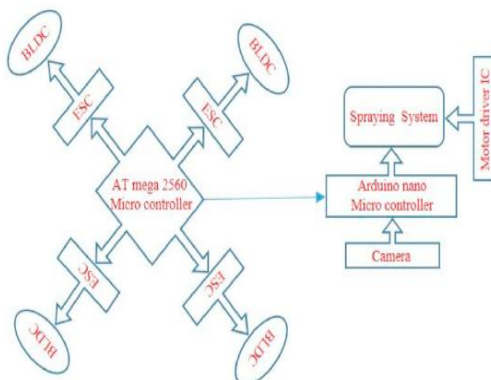


Figure 9: Block diagram of a UAV model.

Table IV: Description of the components.

Components	Purpose
Accelerometer	For measure the acceleration
Gyro	For rotational motion
Magnetometer	To measure magnetic field
WSN	Sensing environmental conditions
IMU	Measures angular rate and forces
GPS	Provides geo location of an object
Camera	To record visual images
Multispectral Camera	Images at specific frequencies
Hyper spectral camera	Images at narrow spectral bands
Thermal Camera	To record low light imaginary
Video Camera	Electronic motion of objects
Laser scanner 2D	Captures shape of the object
Telemetry	To get live data from UAV
Altimeter	To measure altitude
Air Pressure Sensor	Measurement of gases or liquids
BLDC	To motion control
ESC	Regulates the speed of BLDC
Microsoft Kinect	To motion sensing
Barometer	For atmospheric pressures
Solar	Energy source
PWM controller	For pulsing signal
Digital Temperature	Temperature detectors
Humidity indicator	Measures moisture in air
Water sensitive paper	For assessing spray coverage
Filter papers	To separate fine substances
Anemometer	To Measure Speed of wind

Sprinkling system:

This system is used for sprinkling pesticides/fertilizers over a large area of land/farm. Generally, a sprinkling system is attached to the lower region of the UAV to sprinkle the supplements towards downstream as shown in the figure 9. The sprinkling system consists of two models, one is the controller another is the sprinkling system itself. The sprinkling system consists a tank that has the supplements in it, and a nozzle connected to the tank for spraying purpose. A motor driver integrated circuit is used for pressurizing the pump in order to allow the pesticide to flow through the nozzle as per requirement as shown in the figure 9.

6.Conclusion

By discussing the possible applications of smart agriculture using IoT , this paper is portray easier and simpler ways of overcoming the challenges being faced in the agriculture. The paper focus on hardware components used in various applications that acknowledges the user about them and their uses. The IoT based smart agriculture provides many efficient ways not only in farming but also in livestock management which makes farmer's job easier. The Smart Agriculture includes, spraying pesticides using agricultural drones that minimizes the hazardous health issues caused by manual pesticide spraying. In livestock monitoring system the farmer is in check of his animal's health and is alerted if there is any sign of illness and allows him to take necessary actions. Other applications discussed are Smart greenhouses which involve automatic monitoring and controlling of climatic parameters that directly or indirectly govern the plant growth and hence increases their production and conserve water. Here , a mobile application substitutes the man's effort of going to farm just by clicking a button. The IoT based Smart Agriculture reduces the cost of labor , fertilizers, electricity ,etc and most importantly saves lot of time and hardwork. With the help of this technology the crop production is increased eventually giving profits to the farmers. In India each and every farmer should be aware of the importance of Smart Agriculture and should

implement it to increase the sustainability in their productions. The demand for growing population can be met successfully if the farmers implement agricultural IoT applications in a successful manner. As agriculture is considered to be most healthful, most noble employment of man, this paper is trying to bring technology via IoT into agriculture making it effortless and fruitful.

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