Smart farming: IoT based smart sensors agriculture stick for live temperature and moisture monitoring using Arduino, cloud computing & solar technology

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Smart Farming: IoT Based Smart Sensors Agriculture Stick for Live Temprature and Moisture Monitoring using Arduino, Cloud Computing & Solar Technology

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ABSTRACT: Internet of Things (IoT) technology has brought revolution to each and every field of common man's life by making everything smart and intelligent. IoT refers to a network of things which make a self-configuring network. The development of Intelligent Smart Farming IoT based devices is day by day turning the face of agriculture production by not only enhancing it but also making it cost-effective and reducing wastage. The aim / objective of this paper is to propose a Novel Smart IoT based Agriculture Stick assisting farmers in getting Live Data (Temperature, Soil Moisture) for efficient environment monitoring which will enable them to do smart farming and increase their overall yield and quality of products. The Agriculture stick being proposed via this paper is integrated with Arduino Technology, Breadboard mixed with various sensors and live data feed can be obtained online from Thingsspeak.com. The product being proposed is tested on Live Agriculture Fields giving high accuracy over 98% in data feeds.

Keywords: Internet of Things (IoT), Agriculture, Agriculture IoT, Agriculture Precision, Arduino Mega 2560, DS18B20 Temperature Sensor, Smart Farming, Soil Moisture Sensor, Cloud Computing, Solar Technology, ESP8266, Thingspeak.com

1. INTRODUCTION

The next era of Smart Computing will be totally based on Internet of Things (IoT). Internet of Things (IoT), these days is playing a crucial role of transforming "Traditional Technology" from homes to offices to "Next Generation Everywhere Computing". "Internet of Things" (Weber,R.H, 2010) is gaining an important place in research across the nook and corner of this world especially in area of modern wireless communications. The term, Internet of Things (Suo et al, 2012) refers to uniquely identifiable objects, things and their respective virtual representations in Internet like structure which was proposed in year 1998. Internet of Things was discovered by “Kevin Ashton” (Weber, R.H, 2010) in 1999 with regard to supply chain management. These days, the strength and adaptability of IoT has been changed and nowadays it is being used even by normal user. From the point of normal user, IoT (Ashton, 2009) has laid the foundation of development of various products like smart living, e-health services, automation and even smart education. And from commercial point of view, IoT these days is being used in business management, manufacturing, intelligent transportation and even agriculture.

One of main areas where IoT based research is going on and new products are launching on everyday basis to make the activities smarter and efficient towards better production is “Agriculture”. Agriculture sector is regarded as the more crucial sector globally for ensuring food security. Talking of India farmers, which are right now in huge trouble and are at disadvantageous position in terms of farm size, technology, trade, government policies, climate conditions etc. No doubt, ICT based techniques have solved some problems but are not well enough for efficient and assured production. Recently, ICT has migrated to IoT which is also known as “Ubiquitous computing” (Patil et al, 2012). Agricultural production requires lots of activities like soil and plant monitoring, environmental monitoring like moisture and temperature, transportation, supply chain management, infrastructure management, control systems management, animal monitoring, pest control etc.

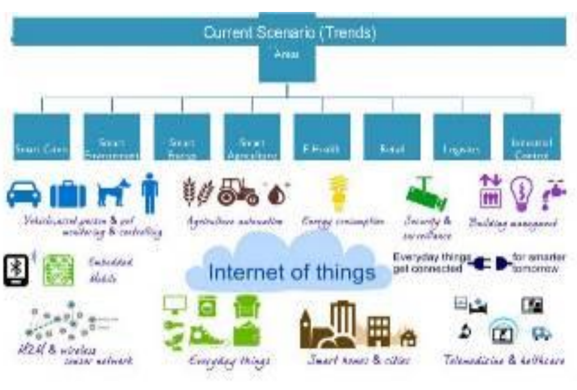

Figure 1. Current Scenario of IoT

IoT based agricultural convergence technology (Lee et al, 2013) creates high value in terms of quality and increased production and also reduces burden on farmers in ample manner. In addition to Agricultural IoT, the future of agriculture is “Precision Agriculture” which is expected to grow at $3.7 billion by 2018. With data generated from GPS and Smart Sensors on agricultural field and integration of smart farming equipment along with Big Data analytics, farmers would be able to improve crop yields and make effective use of water and in turn wastage of any sort would be reduced to a remarkable level.

So, seeing the current scenario of agriculture which is surrounded by tons of issues, it is utmost requirement to have IoT based Smart Farming. In order to implement smart farming in real world, IoT based products are required to be developed and implemented at regular intervals and also at a very fast pace.

The objective of this research paper is to propose IoT Based Smart Stick which will enable farmers to have live data of soil moisture, environment temperature at very low cost so that live monitoring can be done.

The structure of the paper is as follows: Section II will cover over of Overview of IoT Technology & Agriculture- Concept & Definition, IoT Enabling Technologies, IoT Applications in Agriculture, Benefits of IoT in Agriculture and Present and Future Scenario of IoT in Agriculture. Section III elaborates “Novel Proposed IoT Based Smart Farming Agricultural Stick- Overview, Components- Sensors and Modules, Circuit Diagrams and Working. Section IV will highlight live demonstration of IoT Based Smart Stick and live data results. Section V will cover conclusion and future scope.

2. IOT TECHNOLOGY & AGRICULTURE

2.1 *Internet of Things- Concept & Definition*

Internet of Things (IoT) (Atzori et al 2010) (Nayyar, 2016) consists of two words- Internet and Things. The term “Things” in IoT refers to various IoT devices having unique identities and have capabilities to perform remote sensing, actuating and live monitoring of certain sorts of data. IoT devices are also enabled to have live exchange of data with other connected devices and applications either directly or indirectly, or collect data from other devices and process the data and send the data to various servers. The other term “Internet” is defined as Global Communication network connecting trillions of computers across the planet enabling sharing of information.

As forecasted by various researchers, 50 Billion devices based on IoT would be connected all across the planet by year 2020. The Internet of Things (IoT) has been defined as (Smith, 2012):

A Dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual “Things” have identities, physical attributes, and virtual personalities and use intelligent interfaces and are seamlessly integrated into the information network, often communicate data associated with users and their environments”.

An ideal IoT device consists of various interfaces for making connectivity to other devices which can either be wired or wireless.

Any IoT based device consists of following components:

- I/O interface for Sensors.
- Interface for connecting to Internet.
- Interface for Memory and Storage.
- Interface for Audio/Video.

IoT devices can be of various forms like wearable sensors, smart watches, IoT smart home monitoring, IoT intelligent transport systems, IoT smart health devices etc.

2.2 IoT Enabling Technologies

Internet of Things has a strong backbone of various enabling technologies- Wireless Sensor Networks, Cloud Computing, Big Data, Embedded Systems, Security Protocols and Architectures, Protocols enabling communication, web services, Internet and Search Engines.

Wireless Sensor Network (WSN): It consists of various sensors/nodes which are integrated together to monitor various sorts of data.

Cloud Computing: Cloud Computing also known as on-demand computing is a type of Internet based computing which provides shared processing resources and data to computers and other devices on demand. It can be in various forms like IaaS, PaaS, SaaS, DaaS etc.

Big Data Analytics: Big data analytics is the process of examining large data sets containing various forms of data types—i.e. Big Data – to uncover hidden patterns, unknown correlations, market trends, customer preferences and other useful business information.

Communication Protocols: They form the backbone of IoT systems to enable connectivity and coupling to applications and these protocols facilitate exchange of data over the network as these protocols enable data exchange formats, data encoding and addressing.

Embedded Systems: It is a sort of computer system which consists of both hardware and software to perform specific tasks. It includes microprocessor/microcontroller, RAM/ROM, networking components, I/O units and storage devices.

2.3 IoT Applications in Agriculture

With the adoption of IoT in various areas like Industry, Homes and even Cities, huge potential is seen to make everything Intelligent and Smart. Even the Agricultural sector is also adopting IoT technology these days and this in turn has led to the development of “*AGRICULTURAL Internet of Things (IoT)”*

Table 1. Various projects and applications are integrated in Agricultural fields leading to efficient management and controlling of various activities

Application Name	Description
Crop Water Management	In order to perform agriculture activities in efficient manner, adequate water is essential. Agriculture IoT is integrated with Web Map Service (WMS) and Sensor Observation Service (SOS) to ensure proper water management for irrigation and in turn reduces water wastage.
Precision Agriculture	High accuracy is required in terms of weather information which reduces the chances of crop damage. Agriculture IoT ensures timely delivery of real time data in terms of weather forecasting, quality of soil, cost of labor and much more to farmers.
Integrated Pest Management or Control (IPM/C)	Agriculture IoT systems assures farmers with accurate environmental data via proper live data monitoring of temperature, moisture, plant growth and level of pests so that proper care can be taken during production.
Food Production & Safety	Agriculture IoT system accurately monitors various parameters like warehouse temperature, shipping transportation management system and also integrates cloud based recording systems.
Other Projects Implemented Till Date	1. The Phenonet Project by Open IoT 2. CLAAS Equipment 3. Precisionhawk's UAV Sensor Platform 4. Cleangrow's Carbon Nanotube Probe 5. Temputech's Wireless Sensor Monitoring.

2.4 Benefits of IoT in Agriculture

The following are the benefits of IoT in Agriculture:

1. IoT enables easy collection and management of tons of data collected from sensors and with integration of cloud computing services like Agriculture fields maps, cloud storage etc., data can be accessed live from anywhere and everywhere enabling live monitoring and end to end connectivity among all the parties concerned.
2. IoT is regarded as key component for Smart Farming as with accurate sensors and smart equipment's, farmers can increase the food production by 70% till year 2050 as depicted by experts.
3. With IoT productions costs can be reduced to a remarkable level which will in turn increase profitability and sustainability.
4. With IoT, efficiency level would be increased in terms of usage of Soil, Water, Fertilizers, Pesticides etc.
5. With IoT, various factors would also lead to the protection of environment.

2.5 *IoT and Agriculture Current Scenario and Future Forecasts*

Table 2. shows the growth of IoT based adoption in Agriculture sector from Year 2000-2016 and Forecasts of year 2035-2050.

Year	Data Analysis
2000	525 Million Farms connected to IoT
2016	540 Million Farms till Date are connected to IoT
2035	780 Million Farms would be connected to IoT

2050	2 Billion Farms are likely to be connected to IoT

3. NOVEL PROPOSED IOT BASED SMART AGRICULTURE STICK

In today's era of IoT, lots of new research in terms of Smart IoT based product's development is being carried out to facilitate Smart Farming in terms of Crop Management, Pest Management, Agriculture Precision, Agriculture Fields Monitoring via Sensors and even Drones.

In this section, Smart IoT based Agricultural stick being developed for live monitoring of Temperature, Moisture using Arduino, Cloud Computing and Solar Technology is discussed.

3.1 *Definition- Smart Agriculture IoT Stick*

Smart Farming Based Agriculture IoT Stick is regarded as IoT gadget focusing on Live Monitoring of Environmental data in terms of Temperature, Moisture and other types depending on the sensors integrated with it. Agricultural IoT stick provides the concept of "Plug & Sense" in which farmers can directly implement smart farming by as such putting the stick on the field and getting Live Data feeds on various devices like Smart Phones, Tablets etc. and the data generated via sensors can be easily shared and viewed by agriculture consultants anywhere remotely via Cloud Computing technology integration. IoT stick also enables analysis of various sorts of data via Big Data Analytics from time to time.

3.2 Components

In this section, various components i.e. Modules and Sensors being used for Smart IoT Agricultural Stick development is discussed:

3.2.1 *Modules*

3.2.1.1 *Arduino Mega 2560*

Arduino Mega 2560 is designed for developing Arduino based robots and doing 3D printing technology based research.

Technical Specifications: Arduino Mega 2560 is based on ATmega2560. Consists of 54 digital Input/ Output pins, 16 analog inputs, 4 UART (Universal Asynchronous Receiver and Transmitter). Can simply connect to PC via USB port.

Figure 2. Arduino Mega 2560

3.2.1.2 ESP 8266

ESP8266 Wi-Fi Module is SOC with TCP/IP protocol stack integrated which facilitates any microcontroller to access Wi-Fi network. ESP8266 module is cost effective module and supports APSD for VOIP Applications and Bluetooth co-existence interfaces.

Technical Specifications: 802.11b/g/n; Wi-Fi Direct, 1MB Flash Memory, SDIO 1.1/2.0, SPI, UART, Standby Power Consumption of <1.0mW.

Figure 3. ESP8266 Wi-Fi Module

3.2.1.3 BreadBoard BB400

BreadBoard-400 is a solderless breadboard with 400 connection tie points i.e. 400 Wire insertion points. BB400 has a 300 tie-point IC-circuit area plus four 25-tie point power rails. Housing is made of White ABS plastic, with a printed numbers and letters of rows and columns.

Technical Specifications: 36 Volts, 2Amps, 400 tie points, 50000 insertions.

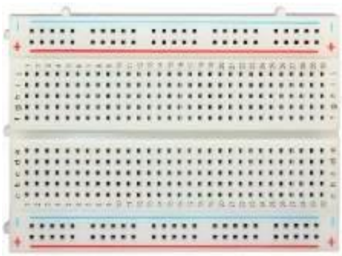

Figure 4. Breadboard

3.2.1.4 BreadBoard Power Supply
Power Module designed for MB102 breadboard.
Technical Specifications: Compatible to 5v or 3.3v, Output Voltage: 5v and 3.3v, Max output current: <700mA; Suitable for Arduino, AVR, PIC, ARM

Figure 5. BreadBoard Power Supply

3.2.1.5 Solar Plate
6 Watts High-performance solar panel utilizes highly efficient crystalline solar cells to increase light absorption and improve efficiency.
Technical Specifications: 0.53mA; Voltage: 11.2v

Figure 6. 6 Watts Solar Panel

3..2.1.6 Battery
Li-Ion 11.2V battery is made of 3 A-Grade 18650 cylindrical cells with PCB and poly switch for full protection. It is Light weight and has high energy density.
Technical Specifications: 2200mAh; 11.2V.

Figure 7. 11.2 Volts Battery

3.2.1 *Sensors*

3.2.2.1 Temperature Sensor-DS18B20
The DS18B20 temperature sensor provides 9-bit to 12-bit Celsius temperature measurements and has alarm function with non-volatile user-programmable upper and lower trigger points. The DS18B20 has 64-bit serial code which allows multiple DS18B20s to function on same 1-wire bus.
Technical Specifications: Unique 1-Wire Interface; Measures Temperature from -55^{o}C TO +125^{O}C; Coverts temperature to 12-bit digital word in 750ms.

Figure 8. DS18B20 Waterproof Temperature Sensor

3.2.2.2 Soil Moisture Sensor
Soil Moisture Sensor is used for measuring the moisture in soil and similar materials. The sensor has two large exposed pads which functions as probes for the sensor, together acting as a variable resistor. The moisture level of the soil is detected by this sensor. When the water level is low in the soil, the analog voltage will be low and this analog voltage keeps increasing as the conductivity between the electrodes in the soil changes. This sensor can be used for watering a flower plant or any other plants requires automation.

Technical Specification: 3.3V to 5V; Analog Output; VCC external 3.3 V to 5V.

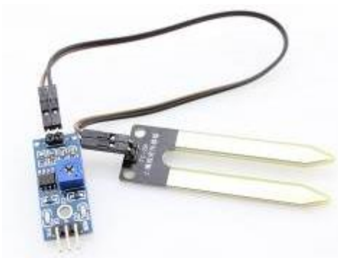

Figure 9. Soil Moisture Sensor

3.2.3 Circuit Description

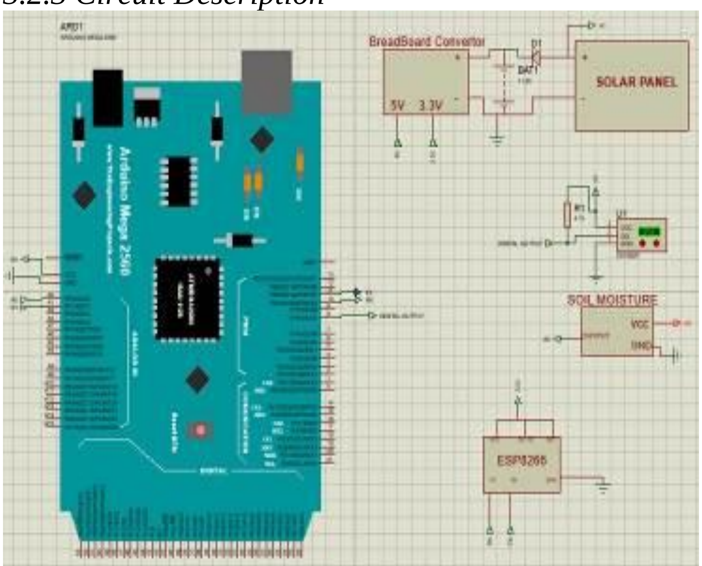

Figure 10. Circuit of "Novel Smart Agriculture IoT Stick for Monitoring Temperature and Soil Moisture"- Designed in Proteus Software

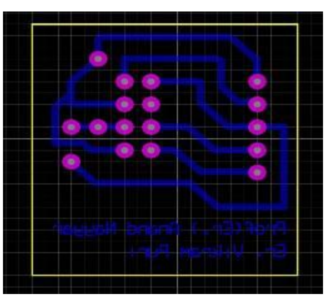

Figure 11. PCB Design for ESP8266.

Description:

IoT based Smart Agriculture Stick incorporates Arduino Mega 2560 unit that provides base for live monitoring of temperature and soil moisture and sends the data to the cloud via ESP8266 Wi-Fi module. In this IoT product, 3 values are measured: Environmental Temperature, Soil Moisture and Solar Panel Voltage powering the entire system. DS18B20 Temperature Sensor is relatively accurate digital temperature sensor and uses MAXIM's 1-wire bus protocol for transmitting as well as receiving data in bytes and supports parasite power mode.

The following formula shows to calculate the Temperature:

$$\text{Temperature} = ((\text{HighByte} << 8) + \text{LowByte}) * 0.0625$$

Soil Moisture Sensor works on the resistance changing principle. It has two large pads as probes for the Soil Moisture sensing and also acts as a variable resistor. When water level is low in soil, conductivity is less between the pads and resistance is higher. When water level is high in soil, conductivity is high between the pads and resistance is low and provides higher signal out. ESP8266 is low-cost Serial to Wi-Fi module and easily interfaces with Arduino Mega 2560. ESP8266 is based on AT Commands and fully supports TCP/UDP stack. Arduino is configured as Digital DC Voltmeter to measure the solar voltage. Arduino Mega 2560 is basically measures up to 5V through the analog pins. One diode is used between the solar panel and battery for protection of solar from back current provided by the battery.

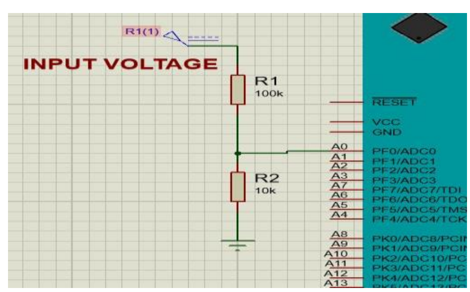

Figure 12. Implementation of Voltage Divider

R1 = 100 K
R2 = 10 K

$$VOUT = VIN * (R2 / (R1+R2))$$

4. LIVE IMPLEMENATION AND REAL TIME DATA ANALYSIS AND MONITORING

In this section, the overall working of the system is being discussed.

The following diagram shows the Animated View of the Smart IoT Based Agriculture Stick being proposed for Agriculture Temperature and Moisture Monitoring.

Figure 13. Overall System Working of “Smart IoT Based Agriculture Stick”

The Following Diagram shows the complete details of the system being developed by us: “Smart IoT Agriculture Stick Monitoring- Temperature and Moisture”.

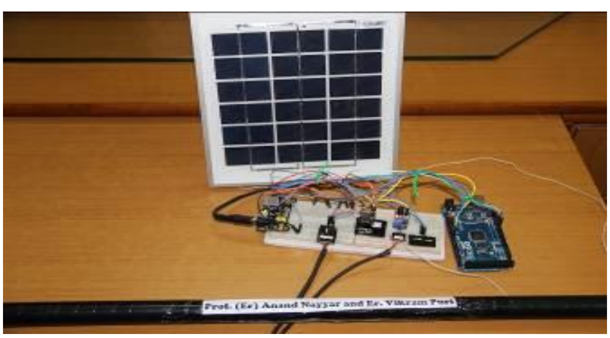

Figure 14. Complete Agriculture IoT Stick Monitoring Temperature and Humidity

Figure 15. Soil Moisture Sensor and Temperature Sensor Mounted on IoT Agriculture Stick.

Figure 16. Stick Mounted with Sensors in Flowerpot giving Live Data of Temperature and Moisture.

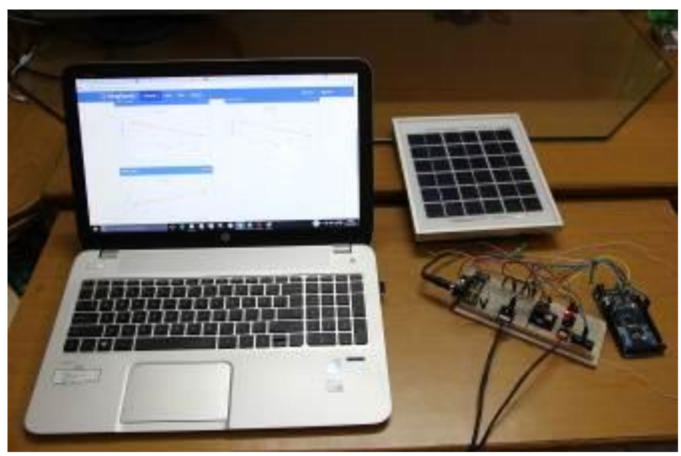

Figure 17. Complete system with Arduino Board, BreadBoard and Laptop giving results using ThingSpeak.com website

Figure 18. Live Data of Soil Moisture with Date and Time from Thingspeak.com

Figure 19. Live Data of Temperature with Date and Time from Thingspeak.com

Figure 20. Live Data of Solar Power Plates powering the entire Agriculture IoT Stick.

5. CONCLUSION

In this Research Paper, a Novel Smart Farming Enabled: IoT Based Agriculture Stick for Live Monitoring of Temperature and Soil Moisture has been proposed using Arduino, Cloud Computing and Solar Technology. The stick has high efficiency and accuracy in fetching the live data of temperature and soil moisture. The Agriculture stick being proposed via this paper will assist farmers in increasing the agriculture yield and take efficient care of food production as the stick will always provide helping hand to farmers for getting accurate live feed of environmental temperature and soil moisture with more than 99% accurate results.

6..FUTURE SCOPE

Future work would be focused more on increasing sensors on this stick to fetch more data especially with regard to Pest Control and by also integrating GPS module in this IoT Stick to enhance this Agriculture IoT Technology to full-fledged Agriculture Precision ready product.

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