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Tomen:A Plant monitoring and smart gardening system using IoT

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Abstract—***This paper automates plant monitoring and smart gardening using Iot in the Raspberry Pi platform. The main purpose of automation is to provide comfort to the people by reducing the manual work and to improve the overall performance of any system without the user interaction. The important parameters for the quality and productivity of plant growth are soil and air temperature, humidity, sunlight, soil moisture and pH. Information to the user about the plant health and growth may be provided to the user by continuously monitoring and recording these garden parameters. It provides a better understanding of how each parameter affects the growth of plants. All the sensors (Temperature, moisture, humidity, LDR, pH) used in this project interface with the Raspberry Pi controller. And this information about the garden can be directly monitored and controlled by the owner of the garden through his or her smart phone using IoT. A camera is provided in this system to monitor the garden through smart device. This smart gardening system will provide convenience and comfort to the user by sensing and controlling the parameters of the garden without their physical presence. Any android supported device can be used to install the smart gardening application. The software's used are PHP, CSS, HTML, Apache 2, Python, and SQL. The CSS and PHP software's are used to develop and design a web page. Apache 2 is used as a web server in Linux system. The Python environment provides the space for coding in Raspberry Pi. SQL is used in programming and designed for managing data held in a relational database management system. All data are stored in the database and can be retrieved at any time. This will help the user to understand the relation between the plant growth and the mentioned garden parameters.***

***IndexTerms*— Apache2, IoT, Python, Raspberry Pi.**

I. INTRODUCTION

IoT (Internet of Things) is often referred to as Internet of Objects, since IoT will transform anything-including ourselves. This bold statement is given by considering the impact of internet on education, business, communication, science and humanity, etc., [2]. Kelvin Ashton used the term IoT first in 1998, which now has more and more developed [1]. In all of human history the most powerful and important creation is the Internet. The integrated part of future internet is IoT. In the field of business, social process, information and communication, the things are expected to become active participants by using IoT. They need to be enabled in order to interact with the environment and communicate among themselves by transforming and exchanging the data and information sensed about the environment. It reacts automatically to the real world events and is influenced by the processes that create services and trigger actions with or without human intervention.

The proposed system is designed and implemented using a low cost credit card sized Raspberry Pi, Which is controlled through internet under the android environment. The application consists to develop programs that allow for communication between a remote user using a smart phone, web browser and raspberry Picard that communicate with one or more interface cards to control. Raspberry Pi is a great option if you just need to read simple analog signals, like a temperature or light sensor. The MCP3008 (Analog to Digital converter) connects to the Raspberry Pi using an SPI (Serial Peripheral Interface) serial connection. It is possible to use either the hardware SPI bus, or any four GPIO pins and Software SPI to talk to the MCP3008. Software SPI is even more flexible because it only works with specific pins.

Tomen (Tomato Garden), is a plant monitoring and smart gardening system using IoT with the help of a Raspberry Pi controller. This helps to solve plants thrive by tracking the environmental conditions and monitoring them. The application gives a timely alert to the user's Android phone by gathering and analyzing the data about the changing soil moisture condition, weather, and temperature with the help of garden sensors. This system also includes an application which runs on android device and Microsoft Windows computer which help to monitor the plant's condition of any part of the world like the user's workplace.

All the garden parameters like humidity, temperature, soil moisture, light intensity, pH are tracked by the system and this informations are uploaded in the database (Storage-SD card in Raspberry Pi).

Tomen continuously monitors the conditions of the garden and alerts the user to make the changes that require immediate action for the garden. The Tomen solenoid Water Valve automatically controls the water system that isbasedon existing data collected by the Garden Sensor and adopts the change in the plant‘s requirements. This will save water,lowers electricity bills, utility bills, and the user needs not worry about the thirstof the plants.

II. INTERNET OF THINGS

IoT helps people and things to be connected anytime, anyplace, with anyone, ideally using any network and any service. Automation is another important application of IoT technologies. It helps to monitor and control the garden environment by using different types of sensors and actuators that control lights, temperature, and humidity, moisture, soil pH. Smart phones, internet, televisions, sensors and actuators are connected to the internet where the devices are intelligently linked together which enables them a new form of communication. This happens amongst people and themselves with the help of IoT [3].

The significant development of IoTs over the last couple of years has created a new dimension to the world of information and communication technologies. The IoTs technology can be used for creating new concepts and wide development space for smart homes in order to provide intelligence, comfort and improved quality of life.

The rising number of internet enabled devices which can network and communicate with web enabled gadgets and with each other are already under way, the Internet of Things describes this revolution. Everything like objects, vehicles, environments, furnishing, and clothing will have more and more information associated with them. It also has the ability to become an integral part of the Internet, produce more valuable information, network, communicate, sense, etc.,.. All these states are referred by the Internet of Things (IoT).

Materializing of IoT is possible by the development of sensors, actuators, mobile phones, and internet, RFID tags which help to cooperate and interact each other. By this the service would be better and can access from anywhere and anytime. Thus to produce seamless communication and service, thenIoT will connect all the objects around us like electrical, electronic, non-electrical, etc.

IoT helps to link the object of the virtual world with the real world, so that the connectivity is enabled anytime for anything at any place. Iot will create a new world where all the living beings, physical objects, environment, real life data and virtual data will interact with each other at the same time and same place.

The path of development and improvement of the Internet has been on a steady path, but it hasn't changed abruptly. From the APPANET era, it does the same thing. Today the standardization of Internet is an IP but in the earlier days there was several communication protocols like Token Ring, AppleTalk, and IP (Internet protocol).

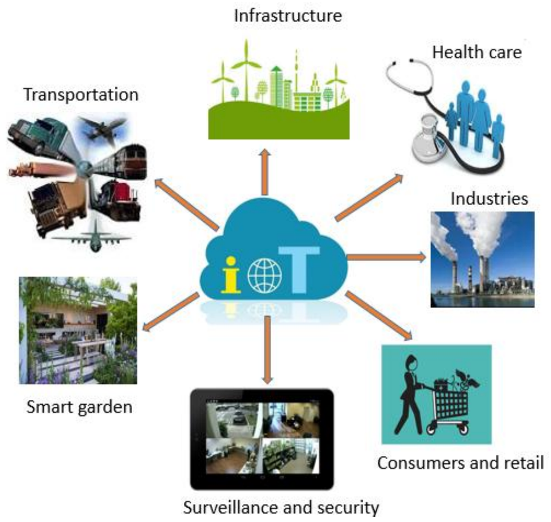

Fig.1 Applications of IoT

III.CLOUD COMPUTING

Cloud computing is a model for on demand network, enabling convenient access to the computing resources like application, service, networks, communication, servers, storage that can be rapidly released and provisioned with minimal effort or service interaction. The existence of different perceptions in cloud computing is that the cloud computing is not a new technology like other technical terms but rather it has a new operations model. All these are brought together as a set to run the business in a different way with existing technologies. Most of the technologies are used by cloud computing, such as utility-based pricing, virtualization, demanding, etc., is not new.

The cloud computing will help to leverage these existing technologies, so as to meet the economic requirements as well as technological requirements of future's demand in information technology [4]. It is also focused on maximization of shared resources effectively. Cloud computing provides storage and on demand service to the clients. The access to these resources is provided through the internet. It also comes in handy when sudden requirement of these resources is needed.

The paradigm of Internet of Things is based on self-configuring nodes and intelligence that are interconnected in the global network infrastructure. One of the most disruptive technologies is represented by IoT like pervasive computing scenarios and enabling ubiquitous. It is generally characterized by small things problems with limited storage and processing capacity and real world problems like issues regarding security, privacy, reliability, performance [5]. In terms ofstorage and processing power it has virtually unlimited capabilities. It is a matured technology. The IoT and the cloud are the twocomplementary technologies, which is merged together. It is expected to disrupt the future internet and to disrupt current [20].

IV.RELATED WORK

A similar research work was done in a tomato greenhouse on the south of Italy by Mancuso et all [19]. The air temperature, relative humidity and soil temperature are measured using Sensicast devise with wireless sensor network. Web-based plant monitoring application has also been developed. The Greenhouse user can read the measurements over the Internet. If some measurable variable changes rapidly, then an alarm will be sent to the owner's mobile phone by SMS or GPRS. In one minute interval the bridge node gathers data from other sensor nodes and transmit the measurements of temperature and relative humidity.

Smart plant monitoring, research was done by Teemu Ahonen et al [21]. He did the research in the Martens Greenhouse Research center in Narpio town in Western Finland. Four environmental key variables in greenhouse control were measured by integrating three commercial sensors with Sensinode's sensor.

Advance research work was done by Tong Ke et al [22] with the inspection of Ambient Intelligent systems. They made the farming easier by integration of the ambient intelligent system with the plant monitoring system. They used Net Gadgeteer which probably handles the plant monitoring system. It works along with cloud based server and mobile based device (Android /Ios devices) which helps the user to control the status of the plant which is being monitored by hardware devices.

Real time Monitoring and Control System from Green House Based on 802.15.4 Wireless Sensor Network by Jayapal Baviskar et all designed Wireless Sensor Network based systems [15]. Various greenhouse parameters such as light intensity, temperature, humidity, soil moisture level can be monitored in real time. The parameters are displayed on the LCD at San system. The parameters are successfully transmitted to the PCN system along with the use of 802.15.4 (Reliable wireless communication).

Various appliances using GUI based application and actuator nodes can also be controlled remotely. The sensed parameters of SAN system are transmitted towards PCN and plotting real time graph was the primary aim. The most important consideration in this system is, it was implemented using readily available sensors, where other systems use accurate and sophisticated sensors.

In greenhouse monitoring system the low cost, low power wireless ZigBee technology is applied in the greenhouse monitoring system. To the room equipment this system realizes the remote intelligent control through the Internet [16]. By using wireless sensor network instead of the traditional wired network, it improves the operational efficiency and system application flexibility. This proves that the system can send the environmental data reliably and control the instruction sent.

This system reduces the manpower cost and also helps the farming by scientific and rational planting of crops. So it has a certain value to popularize. The software of this method is designed by LabVIEW. Since it is a virtual instrument platform developed by NI Company. It adopts powerful graphic language instead of procedural code.

Nitrogen is the most important nutrition in the characterization of soil [23]. Many spectrometers are available in the market for accurate spectrophotometric analysis of soil samples. Making an inexpensive device specific for this purpose is the primary design constraint which costs around 800 USD. A feasible method for implementation in real time, in field monitoring scenarios is near infrared spectroscopy. A discrete wavelength approach is found to yield good results instead of assessing a wide range of wavelength.

A cost effective TN estimation device has been developed by using a thermopile detector 940 nm, 1050nm, 1100nm, 1200nm, 1300nm and 1550nm. Calibration can be done by partial least square method. This device can be reliably used for on field soil monitoring as calibration R2 of 0.867 and validation R2 of 0.812 was achieved.

A smart Agriculture System (AgriSys) that can analyze an environment and intervene to maintain its adequacy [24]. The system has an easy-to-upgrade bank of inference rules to control the agricultural environment. AgriSys mainly looks at inputs, such as, temperature, humidity, and pH. In addition, the system deals with desert-specific challenges, such as, dust, infertile sandy soil, constant wind, very low humidity, and the extreme variations in diurnal and seasonal temperatures.

The system provides increased productivity, enhanced safety, instant interventions, and an advanced lifestyle. The system is ubiquitous as it enables distant access. AgriSys is an addition to the current state-of-art Internet-of-things. Future work includes incorporating additional sensors and outputs at an increased level of smart interventions by the system.

Bluetooth communication is used for communicating sensor data to a nearby mobile phone [12]. The mobile application BT Terminal was used at the mobile phone end for receiving data from the device. In the graphic shown, a USB power supply is being used to power the microcontrollerboard. However, during actual field testing, a DC supply comprised of two AAA cells was used.

A standby mode which is inbuilt in STM32 firmware was used to improve the power efficiency of the device [24]. Soil pH, moisture and temperature measurement with Iot based system has been presented in this system. Senor designs have been successfully implemented for pH, moisture and temperature and also tested for proper working. Bluetooth isbeing used for communication with a farmer's smart phone. The whole system has been developed on STM32. For networking 6LoWPAN is integrated for further preceding. In order to upload sensor data to the cloud a website is created.

V.ARCHITECTURE OF PROPOSED SYSTEM

Here we are designing plant monitoring and smart gardening system using Iot with the help of a controller Raspberry Pi. All the parameters of the garden like temperature, humidity, moisture, light intensity are controlled with the help of sensors like humidity sensor, moisture sensor, LDR, temperature sensor is interfaced with the Raspberry Pi board. And this information about the garden can be directly monitored and controlled by the owner of the garden through his or her mobile phone using Iot. The proposed system is generally for the people who love gardening but are busy in their jobs or day- to- day lives. It is not possible for the people to maintain garden regularly. This will cause improper growth of the plants. This system helps to solve those worries. Thus, by installation of this application on theowner's smart phone the user can forget about watering the plants on a regular basis. This proposed system takes care of this tedious job. Moreover, this system also tracks humidity, soil and air temperature, pH, light intensity. It then uploads this information to cloud through the database. Humidity is the presence of water in the air. The presence of water vapor also influences various physical, chemical and biological processes. Humidity measurement determines the amount of water vapor present in the gas. It is the mixture of pure gas such as nitrogen and argon.

Soil moisture sensor measures the volumetric water current in the soil. Soil moisture sensor measures the volumetric water content indirectly by using some other property of the soil, such as electrical resistance, dielectric constant, or interaction with neutrons, for the moisture content as a proxy. The relation between the soil moisture and measured property must be checkedand it may also vary depending on environmental factors such as soil type, temperature and electrical conductivity. This sensor is used to detect the moisture of the soil and inform the user through this mobile application. Tomen application continuously monitors the moisture content and will alert the user to take required action. It also automatically controls this existing water system with the data collected from the garden sensors.

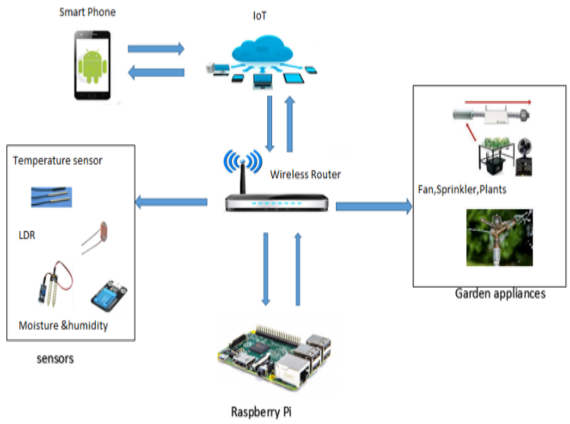

Fig.2. Architecture of the proposed system

The systemhelps to save water, the utility bills, also the thirst of the plant is also fulfilled. The application can also be used by the user to control the water valve manually. Thus the user can water the plants from anywhere and pour his/her love on the plants [19]. This system water valve is simply attached to a hose, making a simplest watering system ever. Based on the sensor reading it will allow turn on or off and gives the plant a precise amount of water they need. This system is also made to display different charts based on the sensor reading and graph is plotted to check the plant growth. The open source cloud database is used by this stem to reduce the cost of the issues of storing large amount of data. All the data are gathered by the sensor and the value is refreshed for every 2 minutes. All the sensor data are stored and sent to the mobile application and also to windows application. Also the watering of the plants is also checked regularly which can be done manually or automatically. It integrates Android, windows, Raspberry Pi, Iot to work in tandem to achieve the system goals. It also gives an enjoyable experience to the user. A very low implementation cost is enough for this system and assures to be successful compared to other kickstarter projects in which there is an issue of high cost. All the platforms used in this project are of open source and free to use. The primary aim of the project is to reduce the implementation cost compared to another system. The application builds on this system receive the data from humidity, moisture, LDR, temperature sensor. All these data can be viewed in the database using numerical values, charts and graphs. It displays the real time data. The refresh gap is 2 minutes. The front end application and the cloud are 2-way connected to retrieve the data as well as give command to the Raspberry Pi hardware to water the plants in the garden.

VI.SYSTEM DESIGN FLOW FOR WATER VALVE

The following flowchart explains how the watering system is controlled by this proposed project.

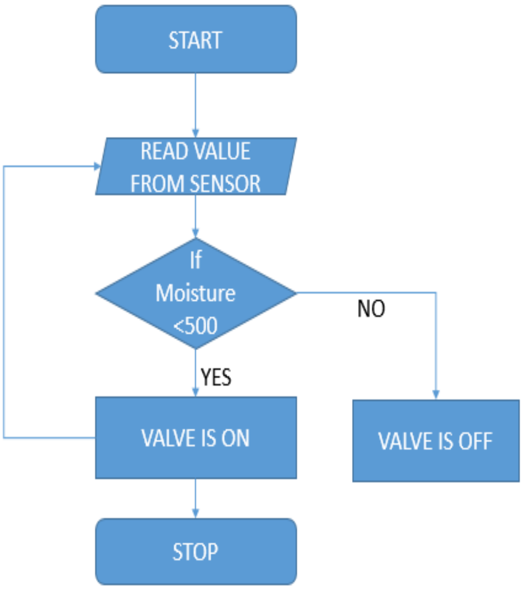

Fig.3. System design flow for the watering system.

VII.EXPERIMENTAL RESULTS

The results generated are given below and visualized using charts. The charts show the moisture, temperature and humidity levels of a houseplant outside a room. Different types of charts are generated by the system used to monitor the plant details such as Line chart, Column chart, Bar chart and Spline chart. These results were generated after the successful implementation and deployment of the system. While analyzing the graph closely, one would identify the sudden rise in moisture levels at a very high rate just before the last few readings. The system was pre-programmed to react when the moisture levels reach below a certain level. In this scenario, it was considered that a moisture level of 500 points is low which means that the system should trigger some action when the readings are low. Here, the system automatically pours out water from the *TOMEN* Water Valve in a way that the moisture readings are high again which is clearly displayed in the graph

VIII.FUTURE ASPECTS

In future aspects we can develop a robot which compares the color of the leaf with an already saved picture of the leaf using digital image processing technique to identify whether the plant is in good condition or if there is any other nutritional deficiency. This can be further developed by making the robot to take care of the whole garden without the presence of humans.Digital Image processing technique to identify the plant's health. Further can be developed for smart agriculture, where robots may be used for harvesting yield and manure.

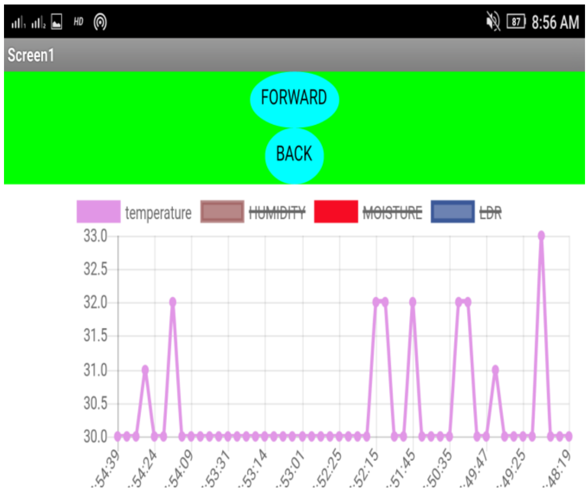

Fig.4. Graph for Temperature

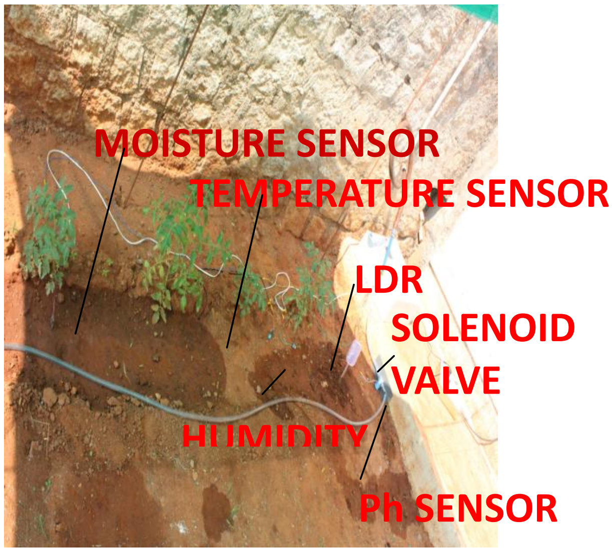

Fig.5. Hardware Setup

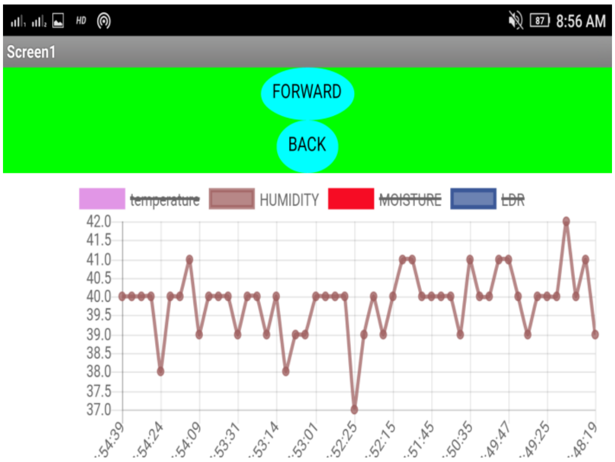

Fig.6. Graph for Humidity

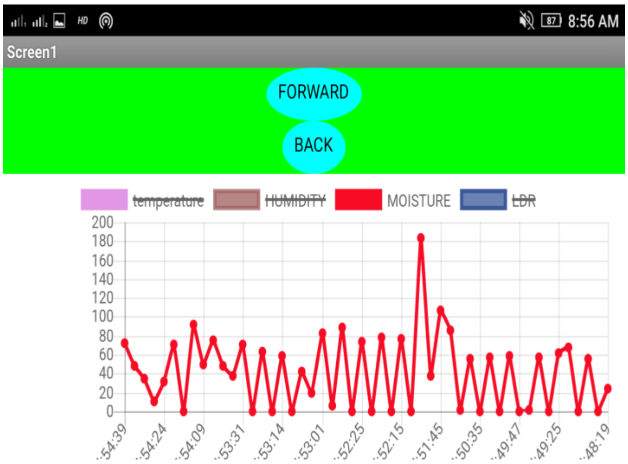

Fig.7. Graph for Moisture

Fig.8. Graph for LDR

IX.SUMMARY AND CONCLUSION

Tomen –plant monitoring and smart gardening system using IoT with the help of a Raspberry Pi controller helps to ease the most tedious job of gardening for plant lovers who are in a time of rush. This system monitors various garden parameters and inform the user about the details of garden through their smart phone. It also helps to solve many issues occurring in the existing plant watering and gardening system. It helps to save water and utility bills. Plant monitoring and smart gardening using IoT with the help of the Raspberry Pi controller will bring more convenience and comfort to people's lives for taking care of their garden. Any Android supported device can be used to install the smart gardening system. The user can control and monitor the environment of the garden using the android application. The controller in this system (Raspberry Pi) provides an economic and efficient platform to implement the plant monitoring and smart gardening system using IOT [16]. The main advantage of the smart gardening system is that the user can monitor the garden using the internet from far distances during leisure time or whenever necessary.

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