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A Cost-Efficient IoT-Enabled Alerting and Prediction System for Rural People: Survey

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Abstract-IoT is the main high end-technological evolutions of the day that assist the interconnection and communicationby speedup of a device to device, device to human and human to human. It uses smart devices that used in sensing, analyzing and predicting. Thisresearch paper proposes a cost-efficient IoT enabled system with sensing rain, alerting the user, analyzing data and predicting flood based on the measurements of the rain. It uses the rain parameters such as temperature, humidity, and raindrop with a specific location using Global Positioning System (GPS) module using Wi-Fi.The temperature and humidity parameters are sensed by the DHT22 sensor and the rain by Raindrop sensor. The sensor senses data from the environment and stores the senseddata to the local storage (computer's hard-disk) and alerts the users when the rain values exceed its threshold limit with its exact location using GPS module installed within Arduino and Wi-Fi module (ESP8266 Module). The Wi-Fi helps in connecting to the network. The alerting service is sent to the Mobile Phone by using a Global System for Mobile Communication (GSM) module technology with an interconnection of Arduino. The rainfall data from the sensors may be graphed and analyzed using MATLAB to clearly provide flood prediction. The damages due to floods are increasing due to changes in the weather across the globe. Such a localized alerting system would help the users be aware of depending disasters.

Keywords:
IoT, Rain Sensor, Arduino UNO R3, Flood Prediction,GSM, GPS

Introduction:

IoT is the current area that comes into use with a unique identifier and the ability to share the works of human beings locally or globally. Thus, IoT is named as magic human being coming. Peoples around the world are interconnected to each other with the development of the high Internet. The IoT facilitates this interconnection further to human-to-device, device-to-device, and human-to-human accordingly by[1]–[3].With the current day, IoT technology enabled devices in the world helps today's users to aware about the environmental conditions of weather station parameter like rain, wind-speed, temperature, and humidity.[1]– [8]. The end-devices (embedded sensors) collect and stores the data to the local storage that assist to analyze and process, to provide information like flood predictions. Users can use the information from the local storage to alert or directly when the measurements obtained are at the threshold limit in the form of SMS, Buzzer or E-mail peoples staying in rural areas like Livestock Raising, Pastoralism, Handcrafts, Forestry, Huntings, and Fishers by using SIM900 GSM

Module and Wi-Fi connected devices especially at night. When they are away from their place, they had no idea about the environmental parameters, whether it is raining or not. The rain can affect our daily life if we did not know the weather conditions accordingly in the local area.Also, thedata was saved in a form .csv file to be analyzed and visualized. Then, based on the results of analyzing, flood prediction was undertaken[3], [5]–[7]. The notification will be done automatically and timely as per the range of rain various with its specific location (Latitude and Longitude)[5]–[7]. The research paper is based on Arduino UNO R3 with the cost-efficient IoT-enabled sensors like raindrops module. Every code is written on the Arduino IDE and loaded to Arduino UNO R3 board through the serial interface port (COMxxx). As soon as the code is uploaded the board and starts automatically working[3], [5], [7]–[9]. Additionally, now a day most countries are affected by heavy rain. Due to this flooding happens on the significant damage to the economy, environment, infrastructure, life and property of people destroys crops and agricultural land too.These risk can be improved and solved by using an IoT application.The physical environment which comprises the environmental parameters is sensed by the environmental sensors.Mainly, all current rain readings can be seen from outdoors, at a glance and at any time, rain readings automatically record maximum and minimum values for a range of rain parameters through each day and keep track of total monthly and yearly, readings can be easily taken direct from the microcontroller, a data logger and PC can be readily linked to the system so that all system is automatically logged, i.e., comprehensive statistics can be automatically calculated, and is analyzed and visualized data is graphical displayed.

Literature Review:

In this literature review, the author classifies the reviewed papers into three basic ideas. These are ideas are (1). IoT and its application areas, (2). Rain sensing and alerting system and (3). Flood prediction system. The first idea, whichis about the IoT and its application area[2], [10]–[12], [12], [13] described the definition of Internet of Things (IoT), the architecture of IoT, and application area of the IoT with their corresponding uses was proposed and implemented. IoT is the interconnection and communication of physical objects, sensors, controllers, actuators and Internet in the form of human-to-human, human-to-machine (things) and machine-to-machine. It has the features of smart, connected. The IoT architecture consists of three parts as the perception layer, the network (gateway) layer, and application layer[13]. The perception layers consists of sensors and actuators those which are very close to the users that collect data from the environment, the network (gateway) layer consists of the protocols Message Queuing Telemetry Transfer (MQTT), Constraint Application Protocol (CoAP), Hypertext Transfer Protocol (HTTP), ZigBee, Bluetooth Low Energy (BLE) and WiFi that helps as a middleware in IoT. They serve as an intermediate between the lower layer and the upper layers in the system. The application area used are Environmental Condition Monitoring in Smart Home Automation with a cheap and dynamic solution as per the environment and improved ways of using energy. In this application, there are three basic sensing units which were described as attributes of hot water, parameters of current and voltage measurement and values of environmental conditioning. The quality of service concerning the integration of ZigBee technology, reliability and throughput were taken into deep considerations. The web interface was created to display the information gathered. It is summarized in the following table 1 below.

Reference Number	Advantages	Methodology and Technology	Limitations
[2], [10], [11], [13]	Reduction in power consumption, remote utilization and controlling over routing of packets and ability to adapt to other WSN.	Sensors and ZigBee	Lack of IPv6 Connectivity.

Table 1. IoT and Its application

Another class of the research paperis about the rain sensing and alerting system. It was the system in which IoT was much interconnected with an intelligent system and machine learning. The articles discuss the detailed concepts about end-devices used for sensing, storing sensed data to IoT cloud services platforms (Open sources) or database servers, and notifying the user when threshold limit happens. It was used the fundamental environmental parameters like temperature, humidity, barometric pressure, light intensity, and rain value. These parameters were sensed by Temperature (LM35[14] and Humidity Sensor (DHT11), Pressure Sensor (BMP180[3]or (BMP085[14], light sensor (LDR) and Raindrop sensor or (Acoustic Sensor) or (WXT520[4] with an integration of Arduino UNO R3/ Nano or WeMos or which are the hardware end-devices[5], [7], [14], [15]. The rain was very an essential parameter for living things on earth. It came based on the mostly seasonal-wise. But, currently, with the development of technology and pollution of the weather conditions, the season of raining keeps changing. Depending on these the coverage of clouds on the sky greatly differ. The rain measurements were categorized as a clear sky, cloudy sky and rainy sky [4] that assist the user to take care of the weather conditions and the devices sense and notify the user. They also used Organic Light Emitting Diode (OLED)[6] and

Liquid Crystal Display (LCD)[1]devices to display information received from cloud database. The software used was Arduino IDE that helps in developing codes with the C syntax and loading to the Arduino before compiling. After it has been done successfully the loading process, the compilation was undertaken. The analysis and prediction of the sensed data were saved on the cloud service or in .csv file on the SD-card or database servers like MySQL. The IoT cloud platform used were IBM Bluemix, Wunderground, Xively and ThingSpeak [5], [7]in which data were uploaded into web server from the Arduino using Ethernet Shield W5100 or WiFi module. They used for retrieving data and visualize graphs, charts, and statistical information. This cloud platform generates their own API that makes intercommunication among the devices by [5], [7]. The other point regarding these ideas is, the notifications sent to the users in a form of SMS, E-mail, Buzzer or Tweet from the cloud to the users at the threshold limit[1], [5], [7], [14]. This can be done through a web browser [14] or Mobile app[5]. The notification was accomplished automatically and timely with respect to the full information. Based on that the users were in touch with the system and helps the analyzer to use the appropriate analysis software. It is summarized in the table 2 below.

Reference Number	Advantages	Methodology and IoT Technology	Limitations
[1]	Simple and reliable, low cost and low power consumption	Arduino Nano, Raspberry Pi, and ZigBee	Not Specified
[3]	Users are aware of the environment weather from their room, and easy to use.	Sensors, ESP8266 (Raspberry Pi), WiFi Module and NodeMCU (12E)	The enormous amounts of data collected are unmanageable.
[4]	More rain events detected	Ground based Microwave Radiometer (MWR3C) and WXT520 sensor	Rigorous statistical analysis of the reliability and inaccuracy due response time for brightness at beginning.
[5]	Cost efficient, easily accessible, and user friendly	Sensors, Arduino , ZigBee, Raspberry Pi, and WiFi	Not specified
[6]	Automatic collection of data, scalability, quick and easy, and cost-effective.	Arduino, WeMos D1, OLED, and GSM	Lack of fetching accurate weather data.
[7]	Low cost, high accuracy, and user friendly	Arduino and ZigBee	Lack of comprehensive monitoring due to cost constraint and inconvenience in some countries.
[8]	Provides easy access to information, and resource management.	Acoustic Sensor, WiFi, and Arduino	Disaster management and difficult to identify the types of sounds.
[14]	Scalability, performance, efficiency, low cost, and improved reliability	ATmega328 (Arduino UNO Board), Ethernet Shield W5100 and Sensors	Not specified

Table 2. Rain sensing and alerting system

The third idea is the analysis and predictions of the system. These systems are the combinations of machine learning algorithms or data mining algorithms and intelligent system approach. It is all about analyzing, visualizing and predicting data using algorithms applicable for IoT. The article was written by [9]analysis the three IoT-based wireless sensors for environmental monitoring which are (1). UDP-based WiFi communication, (2). HTTP-based WiFi communication, and (3). Bluetooth Smart. The criteria of analysis are based on energy autonomy, ease of use, solution complexity and Internet connectivity. For all the hardware used for an experiment was the same which was ZigBee. Also, for better data gathering and service sharing collaborative IoT was essential. Collaborative-IoT provides for gathering heterogeneous data sources by different researchers and applying SenSquare to make an improved architecture of IoT. The SenSquare was used to reduce the gap among data fusion[16]. Additionally, the article of[15]proposed the correlation among the environmental parameters on the Online Smart Weather Station System on the bases of statistical measures. This correlation started from data generation, data processing, storage and management, data representation and Analysis. The analysis of data mining algorithms such as SVM, KNN, LDA, NB, C4.5, C5.0, ANN and DPANN. The fundamental analysis criteria are classification accuracy and an elapsed time on the same dataset in the form of confusion matrix[17]. Thus, the results of the better algorithms are obtained as C4.5 is 97.15%, C5.0 is 96.61%, and ANN is 96.19% average accuracy and the execution time 7.70 second for C4.5 and 7.21 for 7.21 seconds for C5.0. The rest algorithms have less than these algorithms considering three datasets. The methods and models of ANN used for flood predictions proposed using Mean Square Error (MSE) and Regression (R) by[18].The article proposed by [7] depends on the data captured on April, 2014 and got the correlation factor of temperature, humidity, pressure, and wind-rose as 0.96, 0.98 %RH), 0.88, and 0.98, respectively. The data sensed was analyzed by using MATLAB [5], [15]. Therefore, the sensor

measurements gather environmental parameters from the physical environment and upload the data to the clouds or any storage for the analysis and visualization using the built-in algorithms in the cloud or explicitly using analysis tools that use the .csv file to display the result. Table 3 below summarizes the details of each paper.

Reference Number	Advantages	Methodology and IoT Technology	Limitations
[9]	Low cost, scalability, variable network topologies, and lower maintenance	WiFi, ZigBee, and ESP8266	Huge energy consumption;
[15]	Accessibility, reduce maintenance cost and reduce human labor.	ZigBee	Not specified
[16]	Price reduction for the devices, provide unique interpretability and improved accuracy.	Mobile Crowd Sensing, and 10-fold cross validation	Lack of data reliability (availability and correctness).

Table 3. Analysis sensed data and flood prediction system

The Proposed System:

This proposed system is the system which extends, modify and solves the observed problems in the rural areas. This system mainly focused on the rain and its causes, flood for the rural people. Becausemore than half of the population of every country is living in rural areas working on different jobs.Since their jobs are not connected the technology, they are not aware of the environmental conditions. This system helps them to have information about it with the help cost-efficient IoT enableddevices and technologies. It is pointed out as follows:

- Sensing rain from the environment by using a raindrop sensor with the integration of the Arduino UNO R3. The raindrop sensor collects data and stores local storageon the computer.The sensed data was saved in the form of the.csv file to help in analyzing and visualization in the flood prediction.
- Alerting the user timely in the form of either SMS, E-mail or Buzzer. The sensor differentiates the rain in an environment as "Not Raining", "Raining" and "Heavy Rain". If the heavy rain continues for long hours or days, it also alerts the user to take care of flooding to be going to happen. Because floods have a lot social impact on communities and individuals. This alerting aware the rural people from a loss of human life, damage to property, destruction of crops, loss of livestock, and deterioration of health conditions owing to waterborne diseases.
- Specifying the location of the sensed rain using GPS module. This helps in identifying the latitude and longitude of specific alerted place[5]Also, the time which the rain was rained.
- Analyzing the data and predicting flood. This helps the rural people such as Livestock Raising, Pastoralism, Forestry, Handcrafts, and others to take care of the flood[1], [4], [15]–[17]. These analysis and visualization will in the form of charts and graphs to clearly understandable using MATLAB2016b with the help ANN algorithms.

Architecture of the Proposed System:

This architecture contains the main components of the system such as hardware devices used, IoT technology, users, and their communication interfaces. Also, it shows clearly the components that connected to each other accordingly. The input taken from onedevice was processed and produce output onanother device and given for the next device as input to produce another result as per necessarily. In such way, it will be easily understandable by everyone. The architectural system is shown as figure 1 below.

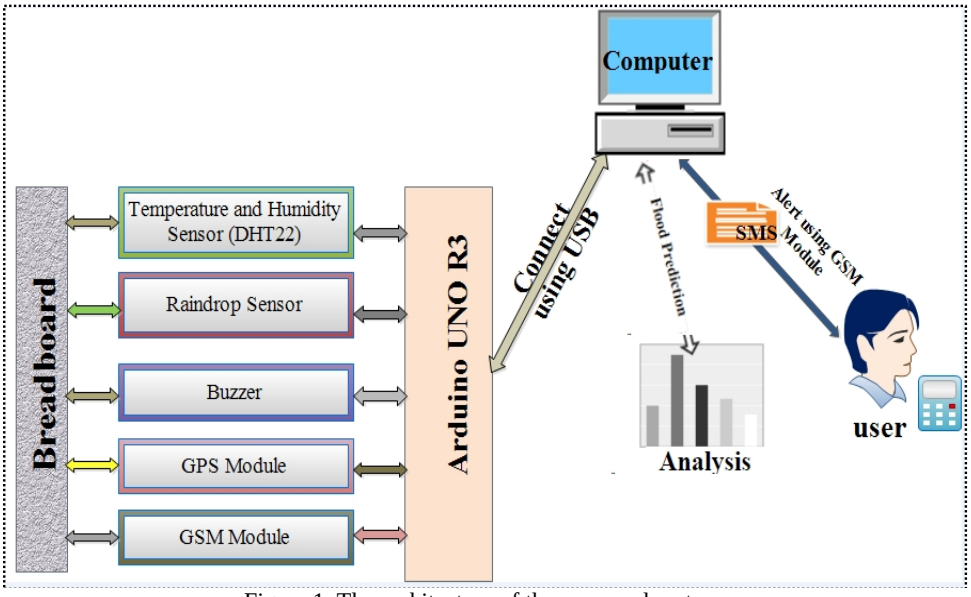

Figure 1. The architecture of the proposed system

Layered Architecture of the Proposed System

This layered architecture describes the main idea of the IoT. The system basically depends on the three-layer architecture. The three layers, namely, the perception, network, and application layers. The perception layer is the physical layer that has sensors for sensing and gathering information about the environment and help to identify physical parameters in the environment.The network layer is responsible for connecting to other smart things, and network devices and used for transmitting and processing sensor data.The application layer is responsible for delivering application specific services to the end-user about the environmental parameters in the form of SMS, E-mail or buzzer. It is shown figure 2 below.

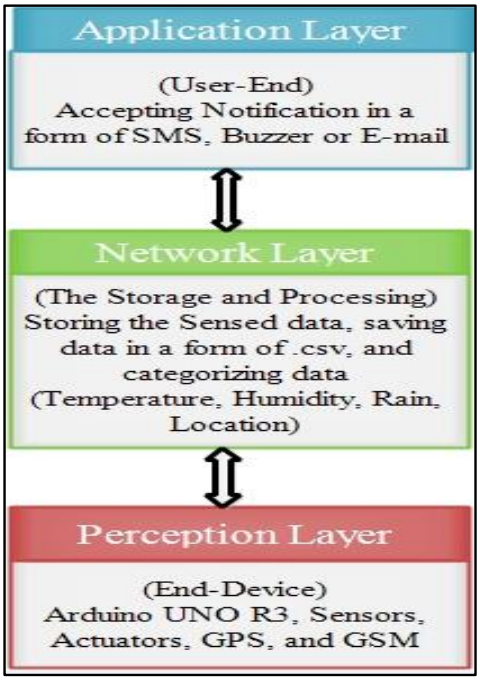

Figure 2 - Layered architecture of the proposed system

The Flowchart of the Proposed System:

This flowchart describes the flow of data in the system. It is show in figure 3 below.

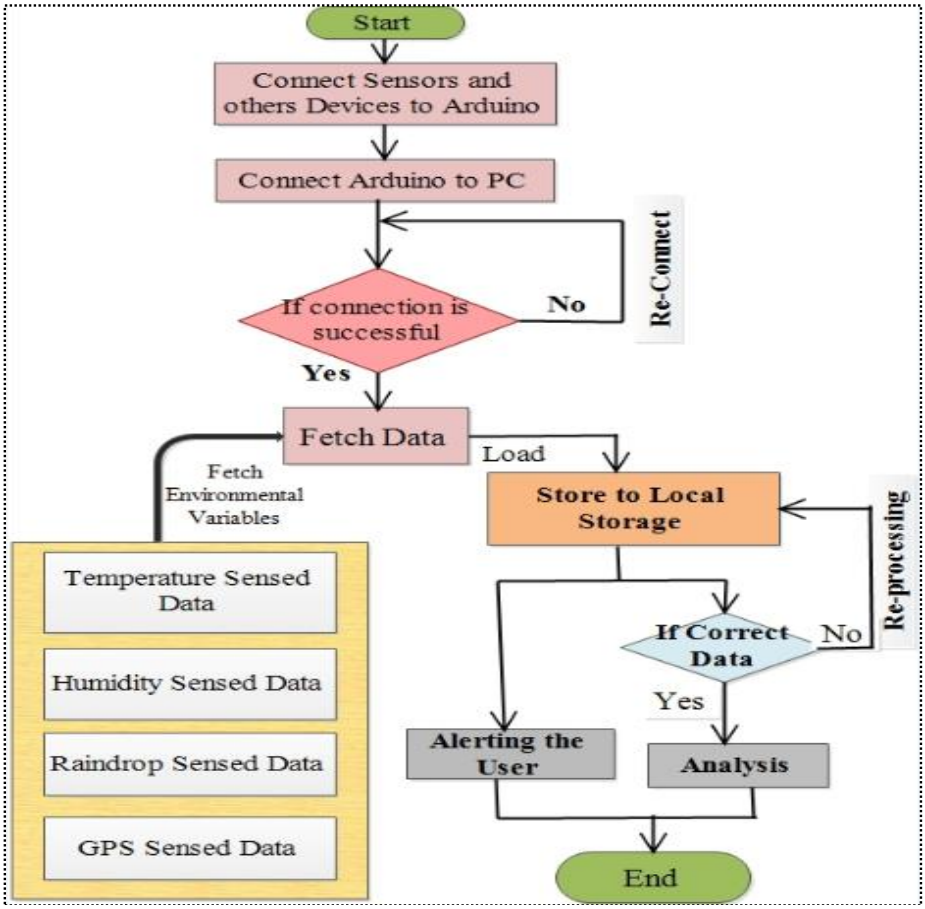

Figure 3- The flowchart of the proposed system

Conclusions and Future Works:

Know a day the IoT helps in simplifying the work of human being by directly connecting and communicating end-devices in a manageable way using smart connected technologies with an interconnection of Arduino. It extends the capability of environmental monitoring with the help of cost-efficient IoT enabled devices which are applicable and function in the local environment using raindrop sensor, temperature and humidity sensor, Wi-Fi, GPS module and for location identification. The saved file in the .csv file assists in analysis and predictions of the system and helps other developers. In every implementation of this system helps to aware the user within the environment he/she is living. It also, every rural people to follow their environment in that the rain values happens. This awareness of the rain values helps them to aware the flood that affects them. These help in reducing the costs of devices and easily using applications. The proposed cost-efficient IoT-based can be modified to incorporate many features. The Author can add rain forecasting, wind-direction, wind-speed, storm, tsunami and cloudbursts locally at a time.Also, extending the coverage area using the IoT technology LoRaWLAN is important.

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