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Role of ICT in developing Smart Agriculture Systems: Digital India Initiatives

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Abstract— Information and Communication Technology [ICT] with Digital India initiative aims at bringing major revolutionary changes in rural India with focus on developing "Smart Systems". The Government of India under ministry of Information Technology has launched numerous schemes to promote use of IT in rural area and especially in agriculture sector. Even after regular efforts, the problems are still persisting, due to non availability of regular resources like: power, environmental resources and trained manpower. In agricultural sector farmers suffers due to electricity and irregular weather conditions. This reduces the overall crop production and affects the economy & development of country. The major problems can be classified as: over / under irrigation of crops, non-availability of electric power to operate the water pumps as and when required. The research work presented in the paper is an attempt to design an application to provide solution to farmers and ease the hectic life style. The solution designed is an android based application, with support of "native" language. The presented work is based on Mobile system to fascinate the farmers for operation of day-to-day activities like: motor pump operation, decision making based on weather information, data and message sharing related with crucial activities involved in farming. The system operates irrespective of global location of farmer and equipments.

Keywords— *ICT, Agriculture, Smart Systems, mobile ecosystem*

I. INTRODUCTION

In the current era of digitization, the role of ICT is not limited to development of modern system for betterment of life style, but it has made its footprint in development of systems for rural population. The domains like healthcare, agriculture, transportation etc., are now focussing on design and implementation of systems for modernization of rural area life.

In order to support industry, Government is also taking step forward and providing necessary subsidies in application design, which in all promoting ICT in modernization operations at rural area of country. The tools like farmer portal, m-kisan portal are introduced by Government to simplify the ICT use for farmers **[http://agriculture.gov.in/].** To make fast development and reach common village farmer the budget of agriculture sector has been increased by 80%.

Government of India has developed "Soil Health Card" portal to assist farmers with ICT. The portal is capable of suggesting the type of fertilizer like: organic, biological to be used. The recommendations are provided to aim to promote organic farming. [http://soilhealth.dac.gov.in/#]. The above discussion clarifies the need of single window framework, which helps in catering various needs of farmers with mobile ecosystem.

The presented research work covers following section: existing system and related work, proposed system, hardware requirements, novel features of proposed system, utilities of proposed system, screen shots, results and discussion, future work and references.

II. RELATED WORK

J. Dhivya et.al, studied the soil parameters and designed sensor based system to real time monitor the soil parameters. The parameters measured are: temperature, moisture and light. The PIC controller is used as sensor interface to send the data to mobile devices, which is received using Bluetooth technology. The system has reduced the process of soil testing to decide suitability for crop production. As the system is Bluetooth based, the data generated by sensor is only available to farmer when PIC controller and mobile Bluetooth communicate with each other and as the range is Bluetooth is low, the communication channel establishment is main restriction of the system. [1]

In the research work carried out by [3], automatic irrigation system is designed based on soil condition. The automation is implemented using 8051 microcontroller. The moisture sensors are used to sense the soil moisture content and provide input signal to op-amp, which compares the input value with set parameters and decides whether to switch on/off the motor. A LCD display device is used to display the soil moisture content, which should be located in closed distance to 8051 microcontroller circuit. This is the major restriction of system.

Rathore L.S [2], developed a smart weather forecasting system. The system designed was capable of predicting weather conditions using metrological information. The tool designed is capable of reducing negative impact of weather conditions on crop by recommendation mechanism. The system operates in English language and is fixed rule based system. The system restricts addition or customization of prediction rules at user interface level.

In the research work presented by Ronel Smith, the ICT technology is used in modernization of agriculture process and handling agro-waste for environmental protection. The paper describes, the modernization process, which improves the crop yield and allows farmers to decide crop selling strategy based on supply-demand analysis. Similarly the application presented in research work also allows farmers to determine suitable process of recycling agro-waste produced during crop production. The system is web-based and operated using desktop interface.

III. METHODOLOGY

The system designed and presented in the paper can be operated using desktop as well as mobile interface. The main components of the system are:

a) Hardware component
b) Software component

Fig.1

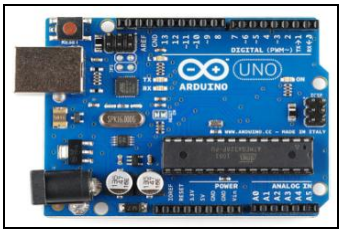


Fig.2

The hardware designed uses

- Arduionuno board
- GSM SIM900A module
- Soil moisture sensors
- Temperature and humidity sensor
- Relay circuit
- SMPS [AC-DC Convertor]
- Transmitter and Receiver
- SD Card

The components are interconnected with each other and final circuit is design as compact system board.
Brief Description of hardware components

Arduion Uno Board: Arduino is an open-source platform with complete hardware and software configuration at user control. The board is capable of interacting with sensor and other data acquisition devices, which helps in building control systems. Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins of which 6 can be used as PWM outputs, 6 Analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. A simple USB interface is provided to connect the board with processing unit.

Advantages

- Low cost
- Multiple platform usability
- Simple, clear programming environment
- Open source software
- Open source hardware
- Scalable.

GSM SIM900A module:GSM (Global System for Mobile communication) is a digitalized, TDMA [Time division multiple access] based mobile telephony system. GSM is widely used for three digital wireless telephony technologies (TDMA,GSM, and CDMA).GSM digitizes and compresses datafor transmission. It operates at either the 900 MHz or 1800 MHz frequency band. [4]

Features of GSM SIM900A:

- Quad-Band 850/ 900/ 1800/ 1900 MHz
- Dual-Band 900/ 1900 MHz
- GPRS multi-slot class 10/8GPRS mobile station class
- Compliant to GSM phase 2/2+Class 4 (2 W @850/ 900 MHz)
- Class 1 (1 W @ 1800/1900MHz)
- Control via AT commands (GSM 07.07 ,07.05 and SIMCOM enhanced AT Commands)
- Low power consumption: 1.5mA(sleep mode)
- Operation temperature: -40°C to +85°C

Sensors: A sensor is capable of sensing the input, capturing it and transmitting to data acquisition system. In the presented research work temperature, humidity and moisture sensors are used.

DHT11:It is Low-cost digital temperature and humidity sensor. Two components of the sensor are: capacitive humidity sensor and temperature measurement thermostat. The data capture and transmission frequency can be set to minimum 2 seconds.

Soil moisture sensor has two probe pins, inserted in soil to measure moisture by measuring conductivity or resistance value in soil. If resistance is high the moisture is low or vice versa. The sensor operates on low current and voltage. The 10 bit ADC attached to sensor converts analog input to digital form [range 0-1023]

In the presented research work and model designed, other standard components like: transmitter, receiver, SMPS, relay circuit, SD Card module etc., are used.

Software components in system:
a) User interface on mobile
b) Database
c) Control system
d) Interface for hardware and software
e) Native language support
f) Individual user action report
g) Crop weather requirement database
h) Login password interface

The total design is cost effective, as it is based on open source like Android studio, Firebase as database support and SQLite as static database, Hindi/Marathi wordnet and Google language support for multiple languages.

The mobile app is designed as application, which can be uploaded to Google play store under general purpose license agreement. The mobile app is not only installable on smart phone but also can be installed on touch button mobile phones.

The administration module is designed to process the data received from various users. This module is interfaced on flash magic terminal and displays the SD card data.

Flow Chart for software components:
Login component:
This component is used to allow user to login into application. The userid and password are generated at the time of first login. The user can interact with application in native language. The application user will enter the native language and then after all the operations are carried out in native language.

Using the location entered by user, the longitude and latitude values are generated. The Google geo-positioning service is used for conversion. The crop yield dataset provided by Government of India, Ministry of Agriculture is used in the application.

Remote water pump access:
The user can control the water motor pump On/Off feature remotely from any location.
The module provides two basic features:
a) Checking the electricity status at farm location from current location.
b) If electricity is available: managing on/off motor operations.

Following steps are involved:

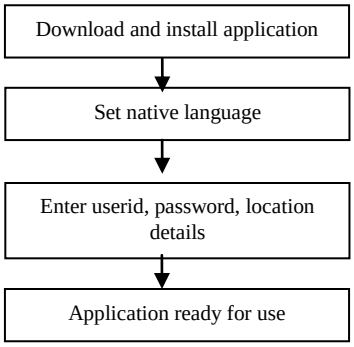
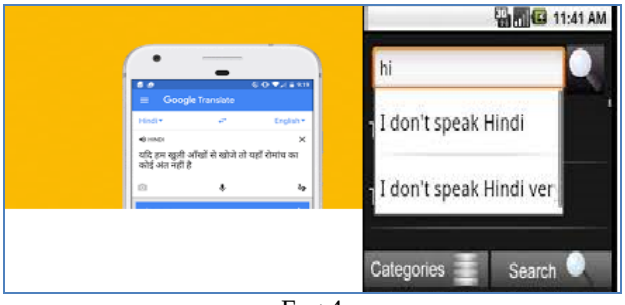


Fig.3

Use of Google Translator API:[5]
The translator allow to user interaction in native language. Once the language option is selected, the user will be allowed to interact with the application in selected language. The language based keyboard as well speech interface is provided to user. The application works with more precision if input is provided using keyboard. The mobile interface is user friendly and has inbuilt generalized questions present in Hindi and Marathi language. The farmer can select one of the questions from the set and submit as query or otherwise can construct new question. The question submitted by farmer is parsed and POS tags are generated. The tags used to understand the contents and query component of question. The contents and query component are mapped to answer. The static answers are available for major types of questions expected from farmer size.



Fog.4

Remote access to water pumps:

The user can control the water motor pump On/Off feature remotely from any location.

The module provides two basic features:

a) Checking the electricity status at farm location from current location.
b) If electricity is available: managing on/off motor operations.
c)

Following steps are involved:

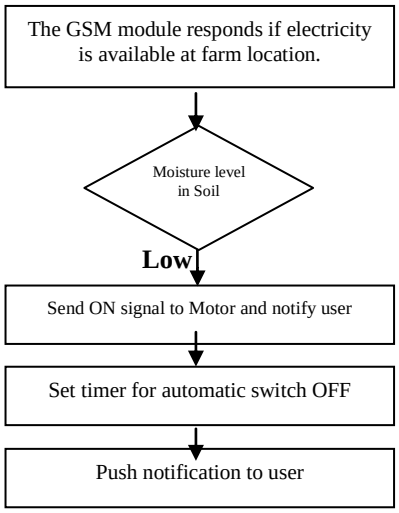


Fig.5

Sensor and Arduino module:

The input to SA module is crop and season details. The user enters the details at interface in native language. The message is received at GSM, which is submitted to Arduino interface.

The Arduino access the SD card data to check the moisture requirement for the respective crop based on season data entered by user. The Arduino also access the sensor data to check the soil moisture content.

If the moisture content is less than the requirement, the humidity and temperature sensor information is checked. This helps in deciding the possibility of rainfall. If rainfall is predicted, the wait timer is set to specific value. This allows in holding the transmission of motor ON signal. If rain fall is not predicted, motor ON signal is generated, with push notification to user. This module helps in conservation of water, if it is not required. The prediction is performed based on humidity and temperature value, if not found correct in specific period of time, again the motor ON signal is generated to set the supply of water in the farm. The waiting time period is fixed, and is based on value of humidity and temperature along with history data. In some situation, farmer may decide to water the farm, can do by simply transferring the ON signal to motor via mobile app. The signal is transmitted as SMS, which is received by GSM installed at motor site.

Parsing of "on" and "off" signal to operate motor is carried out by "JSON" parser. This parser converts the signal into a "bit". This bit acts as a trigger signal to operate the motor. The interface with execution mode is shown in the figure below.

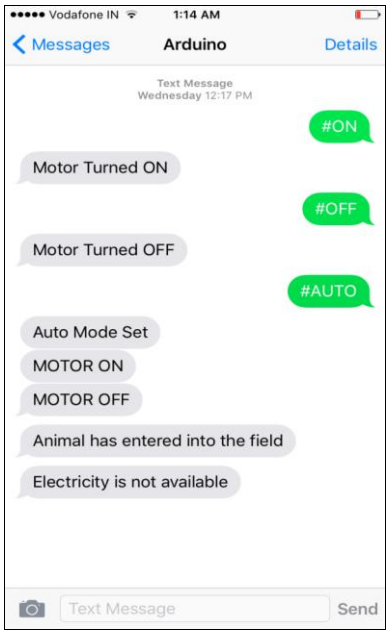


Fig.6

The following figure demonstrates the interface receiving message from Ardunio device and transmitted to farmer mobile phone.

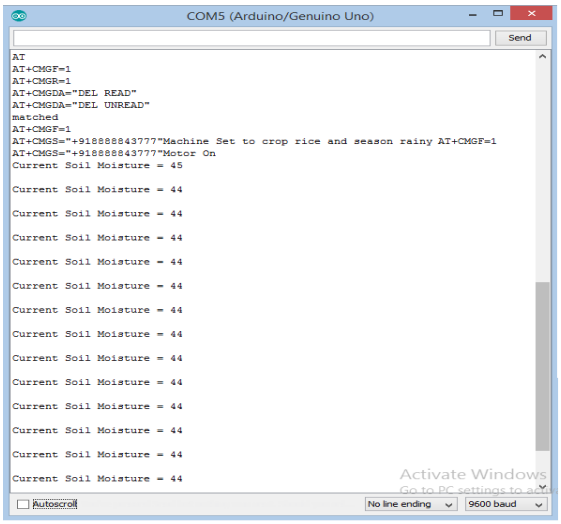


Fig.7

Data analytics model:

This model is specifically designed to perform analytics on the queries executed by the system. The model uses data storage and permit query based on NOSQL model. The data store includes tables to store the farmer interaction with water pump motor. The structure of table is

Time	Status	Electricity	Duration	Crop
11.00am	ON	Yes	1.30	Wheat
10.00am	ON	No		
9.00am	ON	Yes	1.00	Wheat
3.00pm	ON	No		
4.00pm	ON	Yes	1.00	Wheat
5.00pm	OFF	Yes		

Table.1

Above table can be used to perform analytics like: during 10.00am to11.00am on most of weekdays the electric power supply is not available. Similarly for "wheat" crop, in general the farmer uses water pump for one hour interval. The knowledge store designed can be used to educate new farmers. For example: if new farmer submit query like: *For how much duration water should be supplied in farm for wheat crop*, then the above table duration column will provide the answer.

The other structures are like

Month	Day	Moisture level	Temp	Motor Action
July	20	60	34	OFF
July	30	30	40	ON
Aug	10	50	31	OFF
Aug	11	60	30	OFF

Table.2

Above table can be used to perform analytics like: during most of time in the month of August, moisture level is good and water supply is not needed.

The temperature and humidity table is as:

Month	Day	Humidity	Temp	Outcome
July	20	60	34	Rain
July	30	30	40	No rain
Aug	09	70	34	Rain
Aug	10	78	30	Rain

Table.3

The above table can be used to perform analytic like: at what level of humidity and temperature, rainfall may occur. This helps the new farmers to understand the possibility of rainfall at specific level of humidity and temperature.

In order to improve the crop productivity, the weather forecast system API can be integrated with the system. This will allow the farmer to understand and predict the weather conditions at current time zone and also future predictions. The question-answer based module can be also integrated with system, in which fixed set of question – answers can be designed for QA information system.

Conclusion and Future Scope:

The system is designed with objective to allow farmers to make use of "Smart" devices and improve the crop productivity. The system also performs certain analytics to help new farmers with simple queries. The system supports native language interface.

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