PROJECT GRANT REPORT

RDU1403113

Title

Farmer Digital Expert Assistance Systems

Project Members

Assoc. Prof. Ir. Dr. Fahmi Bin Samsuri

Dr. Vigneswaran Narayanamurthy

Dr. Balu Ranganathan

LIST OF PATENTS, PUBLICATIONS AND CONFERENCES BASED ON THIS RESEARCH

PATENTS

1. System And Device For Providing Real Time Agricultural Data
   (Patent Filed Number: PI 2015001588A)

ARTICLES AND CONFERENCES

1. Vigneswaran Narayanamurthy, Fahmi Samsuri 2016. "Perspectives of a Farmer Digital Expert Assistant System" **Engineering, Technology & Applied Science Research** Volume-06, No. 2, 2016, 972-975.
2. Vigneswaran Narayanamurthy, Fahmi Samsuri, and Gopalakrishnan Narayanamurthy "Microcontroller Based Handheld Support Device for Farmers" **National Postgraduate Conference - NCON-PGR 2015**, Kuantan, Malaysia. (Oral Presentation)

EXHIBITIONS AND AWARDS

1. N Vigneswaran, Fahmi Bin Samsuri and Balu Ranganathan "**Solar Energy Powered Farmer Digital Assistant**" CREATION, INNOVATION, TECHNOLOGY & RESEARCH EXPOSITION - **CITREx 2014**, Kuantan, Malaysia. (Poster Presentation and secured **Bronze Medal**)
2. N.Vigneswaran, Fahmi Bin Samsuri "**Farmer Digital Expert Assistant System**" CREATION, INNOVATION, TECHNOLOGY & RESEARCH EXPOSITION - **CITREx 2016**, Kuantan, Malaysia. (**Gold Medal**)
3. N.Vigneswaran, Fahmi Bin Samsuri "**Farmer Digital Expert Assistant System**" 27th International Invention & Innovation Exhibition - **ITEX 2016**, Kuala Lumpur Convention Centre, Malaysia. (**Silver Medal**)
4. N.Vigneswaran, Fahmi Bin Samsuri "**Agrisoft" MAHA 2016,** Putrajaya, Malaysia.

Commercial Out Comes

1. MOU signed with Rapid Genesis SDN BHD for testing and commercialisation.

2. Payment received for three units of RM 3510.

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ABSTRACT

In this proposed idea a global positioning system (GPS) based farmer digital assistant (FDA) is suggested which is capable of analysing the agricultural field and environmental factors associated with the field. The agricultural yield to be harvested depends on the liquidity content of the soil, mineral content of the soil, geographical position of the field, microbial content of the soil and temperature of the environment. The other parameters include irrigation, spraying of chemicals, animals or intruders getting into the field, etc. The embedded system proposed here monitors all these parameters and provides the appropriate values and suggestions to the farmer to attain the sustainable yield. The GPS system module when placed in the field of interest gathers the longitude and latitude values of the location of the field. The location is then compared with the existing databases say soil maps and provides the nature and type of crop to be cultivated with all specifications to obtain maximum yield at that location. Once the nature of crop for cultivation for particular period of time is chosen by matching the geographical characteristics of the field, the proposed system provides the complete list of specification and tasks to be done to obtain high quality food product with maximum yield. To make it happen several factors as mentioned are monitored using set of sensors. The temperature of the field environment is monitored using temperature sensor of high precision and accuracy. The innate liquid content of the soil is determined by the liquidity sensor and it provides the amount of water content to be irrigated to the field for sustainable usage of water source. Series of chemical sensors will be placed in the designed module which will monitor the concentration of the mineral content in the soil and will display the amount of insecticides, pesticides and fertilizers to be sprayed, within the permissive limits, to the field to obtain healthy yield. The microbe concentration and their activities in the field are monitored using gas sensor which monitors the concentration of the gas in the field and infers the nature of microbes present. Finally there will also be a camera employed to continuously monitor intruders and animals getting into the field and if detected alerts the farmer. All the above discussed sensor outputs and system can be integrated with a GSM modem which will send alert messages as SMS or IVRS recorded call alerts in region specific languages to farmer and representatives when required.

Keywords: Global positioning system, agriculture, sensors, GSM, SMS.

Chapter 1

Overview

Agriculture is the field which needs to be looked after by the advance technology developments for its efficient survival. Innovation has seeded the need to finance development and growth in rural regions. Developing sensitivity sensor systems to promote technology within the financial framework as an integrated approach to keep markets from busting and causing socio-economic panics has become a need today. Supervisory and regulatory authorities need to continue to strengthen energy financial market infrastructure to underpin the resilience of the ecosystem towards sustained development and clean tomorrow (Agarwal 2007). Any country is tagged as developed country only when the field of agriculture also grows in parallel or in pace with the other fields such as infrastructure, technology, equipments, etc. The agriculture at present has to be efficiently medicated by the engineers and their innovative ideas to make it more attractive and productive. The implementation of advanced and efficient electronic techniques by engineers to design a system that improves the quality and amount of the yield has become a necessary criterion (Stafford 2000).

Objectives

- To develop FDA system to assist farmers; this in turn increases the yield.
- To help the farmers in cultivation using advanced engineering techniques at low cost and there by reduces the gap between the farmers and latest technologies.
- To develop and commercialize the product.

Chapter 2

Literature Review

Several publications have been made in the area of implementation of technology in agriculture and related field to improve productivity and sustainability. Laser level technology have been adopted by collecting farm-level information from the Moga district of Punjab and technique has shown that with laser levelling farmers could save irrigation water and energy by 24 per cent and obtain 4.25 per cent higher yields (Kaur et. al. 2012). Biotechnology innovating institutions have found to be highly complex and costly and it mainly exists in United States. The reason behind the inability of followers to attain the objective lies with the institutional fabric that fosters commercial biotechnology. Theories about biotechnology institutions and their evolution in sectoral innovation systems with concept and model application from complex system theory have been studied (Niosi 2011). Studies also have measured inequality and lagging states by applying the convergence principle by taking both per capita income and per capita agricultural income as the sources of convergence. Agricultural sector as is not performing in pace with the national economy, need for strategies for this particular sector is needed (Das et. al. 2010). Emerging trends and innovations in agricultural field demands private sector for productivity and public sector for governance (Gulati 2009).

Varieties of sensors and techniques are applied to perform diverse measures in wide research areas. Use of spectral reflectance techniques for aiding decisions relating to crop establishment, weed control, crop protection and crop nutrition have been studied. Uses, limitations, areas requiring further work and future potential as a commercial tool for precision agriculture have also been mentioned. Spectral reflectance techniques were concluded to be not suitable for measuring soil properties as other technologies are better suited to this application. It is also stated that spectral reflectance techniques are capable of detecting weeds against a soil background and is capable of providing useful information about the crop canopy that can be used as a component in determining the fungicide, growth regulator and nitrogen inputs to a cereal crop (Scotford et. al. 2005). Different sensing methodologies to provide accurate information on crop, soil, climate, and environmental conditions are strongly recommended for modern agricultural management. It is also stated that almost every sensing technique may find an application in agriculture and food industry (Li et. al. 2010). Stresses identification and removing them by suitable mechanical working on tool & ergonomic change in the design of handle to make it more comfortable have been studied. Body part discomfort score and overall discomfort rating experienced by the subjects were estimated. Oxygen consumption rate and heart rate were used for physiological cost estimation (Khidiya et. al. 2012). Central composite rotatable design based experiments were conducted to determine the optimum processing conditions of expansion ratios of extruded snacks made from millet and legume using response surface methodology. Variables evaluated included die head temperatures, barrel temperatures, screw speed, blend ratio and moisture content (Chakraborty et. al. 2011). Survey of current applications of GPS to distributed systems and networks states most efforts are in providing navigational guidance to drivers. Digitized city maps along with a GPS sensor on a mobile computer provide location and directions to drivers (Dommety et. al. 1998).

As an initiation step to the implementation of advanced technology in agriculture, this proposal is made in which the Farmer Digital Assistant (FDA) system will be developed which will act as supporting hand to farmers for most of the agricultural process. Before going in detail into the project, the need for the proposal is to help the farmers in cultivation using advanced engineering techniques at low cost and there by reduces the gap between the farmers and latest technologies. Most of the studies are on implementation of technologies to improve efficiency of seeds, pesticides and insecticides but we approach by incorporating electronic, instrumentation and information technology to devise and integrate a digital assistant. The system proposed bridges the gap between the farmer and scientific technologies by bypassing the complexities involved and exposing only simple operational procedures involved in it.

Chapter 3

Methodology

The FDA proposed, carries out a sequenced range of actions beginning before the process of sowing the seed to final stage of harvesting the crop. It constantly monitors the field and provides alerts, suggestions, solutions and inferences to farmer in audio, visual and SMS (Short Message Service) modes. The system proposed attains its complete success when it reaches all farmers and agriculturists irrespective of their economical background, nature of the crop they grow, area of farming land they own, etc. A typical FDA module schematic is as shown in figure 1.

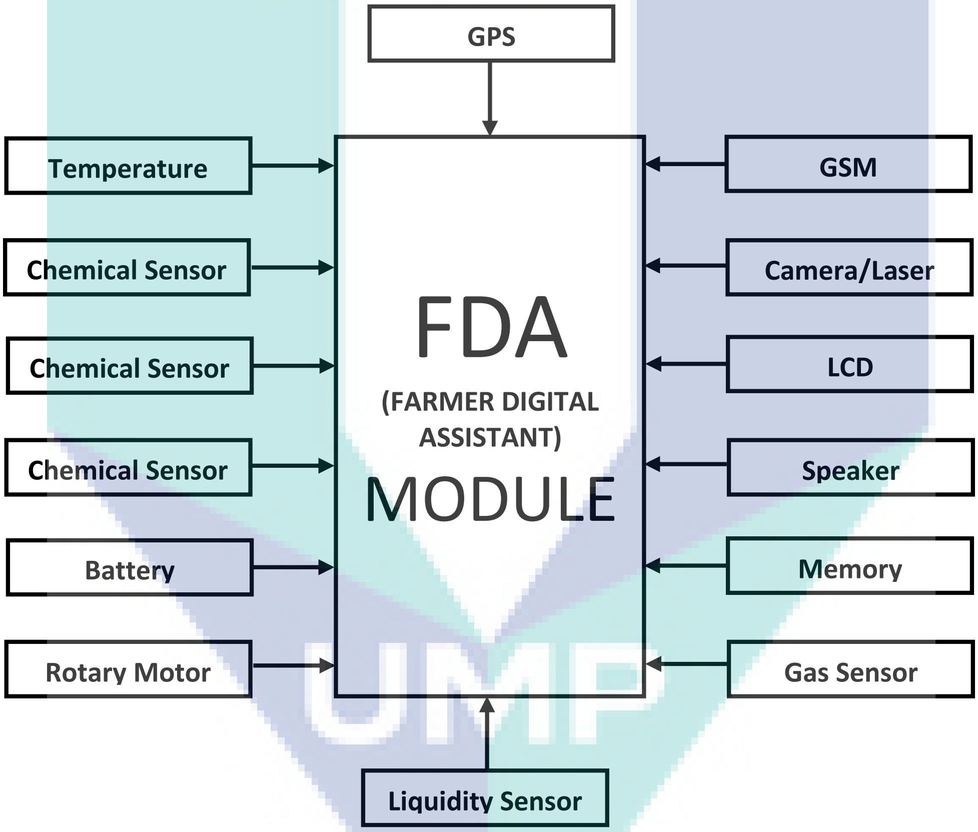

Fig.1. Schematic of Farmer Digital Assistant (FDA).

The FDA system comprises of several input modules and sensors to consider all the environmental factors that contribute to the quality and quantity of yield. FDA comprises of Global Positioning System (GPS) receiver, temperature sensor, liquidity sensor, chemical sensors, gas sensor, camera, LCD display, speaker, GSM (Global System for Mobile Communications) and power box charged by solar panel. The Heart of the FDA module is a microcontroller based system which acquires, analyses and evaluates various sensor information and stores data for future reuse. The system components mentioned can be customized by the farmer as per his budget for the FDA and the nature of the field. Flowchart depicting the procedure to operate FDA module is as shown in figure 2.

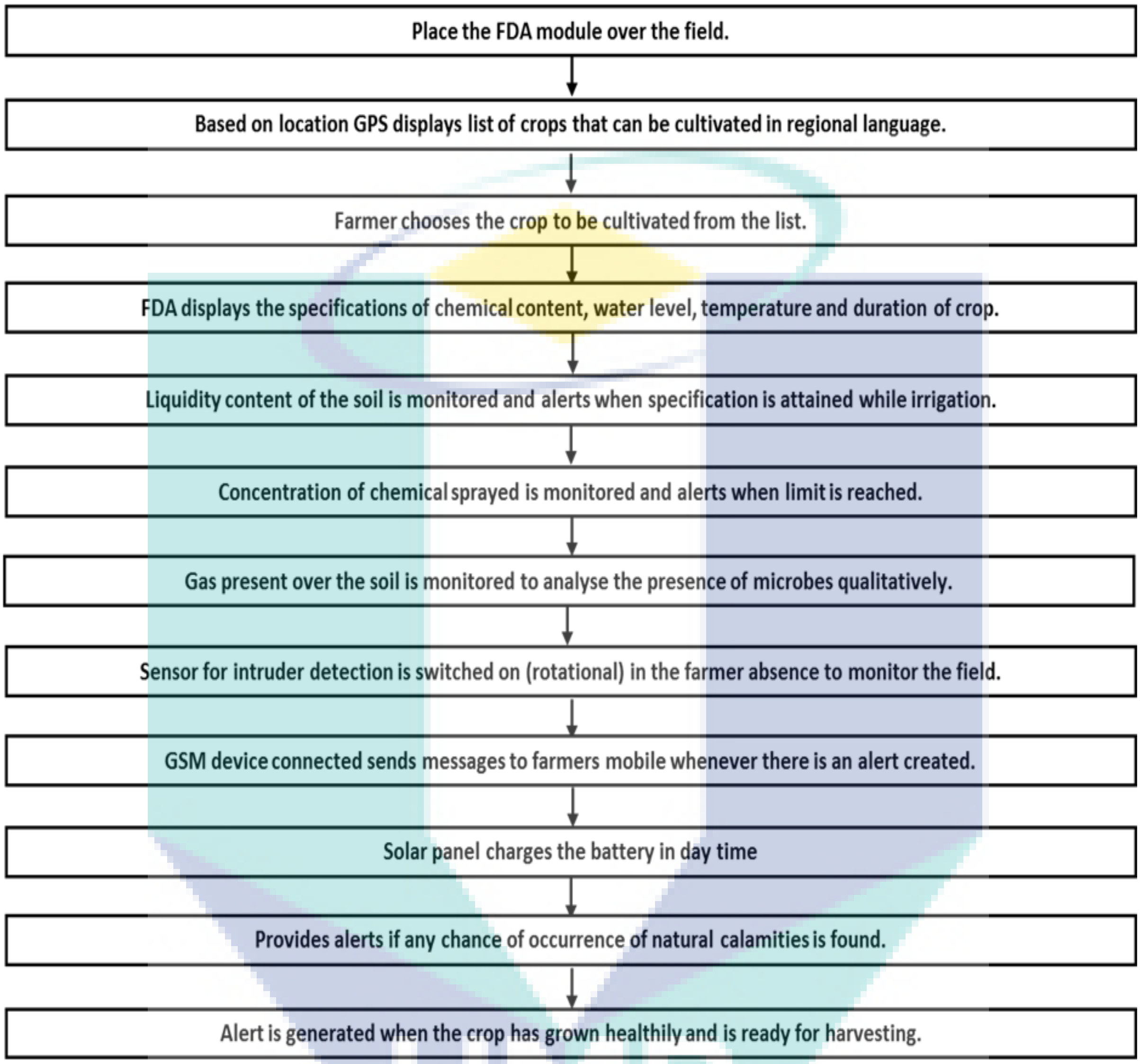

Fig.2. Procedure of FDA operation.

Global Positioning System (GPS)

U.S. space-based radio-navigation system called Global Positioning System (GPS) provides reliable positioning, navigation, and timing services to civilian users on a continuous worldwide basis which is freely available to all (Ahamed 2008). The GPS system in this module will perform the operation of detecting the location of the field where it is placed. GPS positioning is based on trilateration, which is the method of determining position by measuring distances to points at known coordinates. At a minimum, trilateration requires 3 ranges to 3 known points. GPS point positioning, on the other hand, requires 4 "pseudoranges" to 4 satellites. A signal is transmitted from each satellite in the direction of the Earth. This signal is encoded with the "Navigation Message," which can be read by the user's GPS receivers. The Navigation Message includes orbit parameters (often called the "broadcast ephemeris"), from which the receiver can compute satellite coordinates (X,Y,Z).There are four GPS segments namely the space segment, control segment, user segment and ground segment. The space segment includes the constellation of GPS satellites, which transmit the signals to the user and the control segment is responsible for the monitoring and operation of the space segment. The user segment includes user hardware and processing software for positioning, navigation, and timing applications. The ground segment, which includes civilian tracking networks, provides the user segment with reference control, precise ephemerides and real time services (DGPS) which mitigate the effects of "selective availability".

The location identified using GPS receiver is compared with the current database of *Soil and Watershed Atlas* developed by *Agricultural Engineering Department* of Indian Government (Agricultural Engineering Department 2013). The results of comparison provides the soil chemical properties, erosion factors, available water supply, soil qualities, list of crops that can be grown and the estimated amount of yield that can be obtained at that particular season and location. An example United States soil database (Web Soil Survey - United States Department of Agriculture Natural Services Conservation Service 2012) is shown in figure 3.

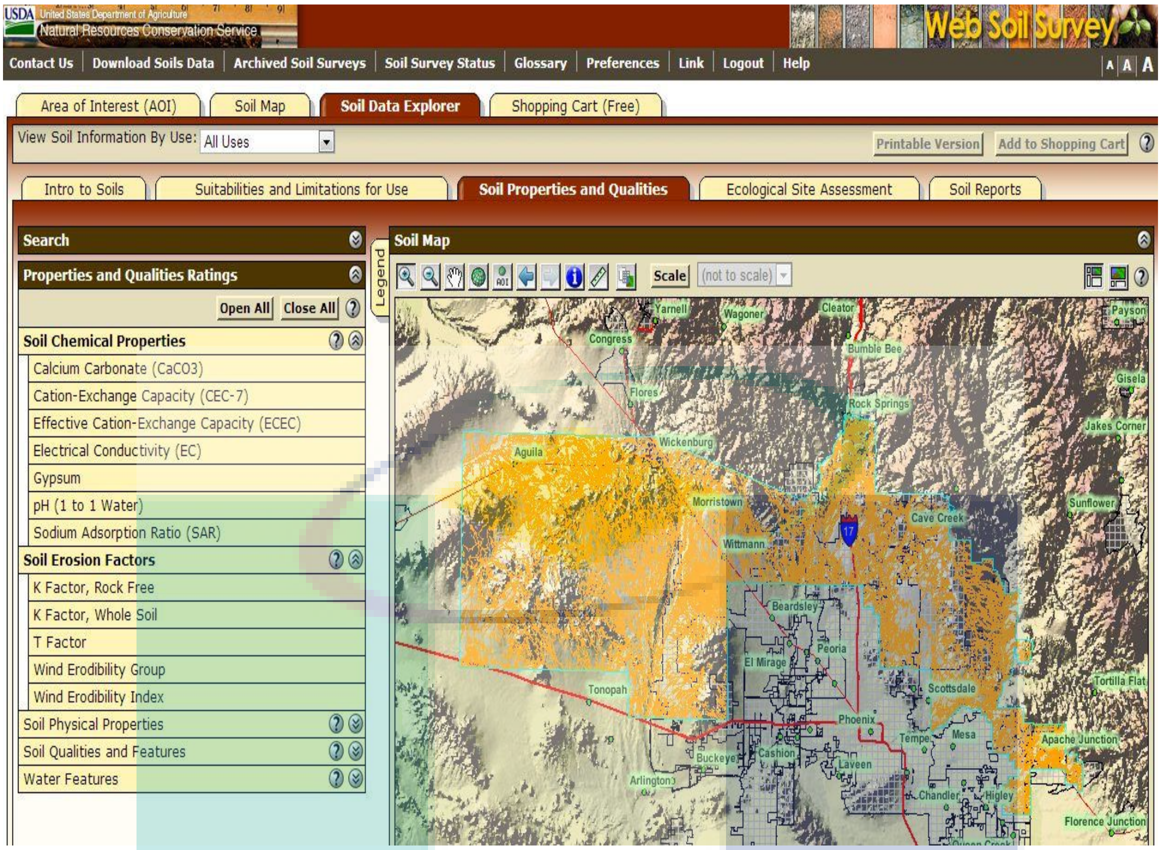

Fig.3. Soil Database.

This data is not known to many of the practising farmers in villages and they infer these details by trial and error method by cultivating different varieties of crops and checking their yields. It consumes a huge amount of time, labour and money to reach a simple decision of nature of crop to be cultivated in their field. Once the crop to be cultivated is chosen in the FDA it provides the complete specifications of the temperature, liquid content of soil, microbial activity and amount of fertilizers, insecticides, pesticides to be added for the perfect growth of crops. In addition, using the latitude and longitudinal information FDA module can be linked to a weather station database (Sanghi et. al. 2004) as shown in table 1 to evaluate the current temperature of the specified region. The proposed system simplifies this task and provides the results instantaneously.

Table 1: Altitude, Latitude and Longitude Information.

METSTN	DISTRICT	STATE/UNION_TERRITORY	ALTITUDE (m)	LATITUDE (o,/)	LONGITUDE (o,/)
AGRA	AGRA	UTTAR_PRADESH	169	27.1	78.02
AHMADABAD	AHMADABAD	GUJARAT	55	23.04	72.38
AHMADNAGAR	AHMADNAGAR	MAHARASHTRA	657	19.05	74.48
AJMER	AJMER	RAJASTHAN	486	26.27	74.37
AKOLA	AKOLA	MAHARASHTRA	282	20.42	77.02
ALIBAG	RAIGARH	MAHARASHTRA	7	18.38	72.52
ALIGARH	ALIGARH	UTTAR_PRADESH	187	27.53	78.04
ALLABABAD	ALLAHABAD	UTTAR_PRADESH	98	25.27	81.44
AMBALA	AMBALA	HARYANA	272	30.23	76.46

Sensor Components

FDA system proposed will consist of seven sensors namely temperature sensor, liquidity sensor, absorption technique based chemical sensors, gas sensor and a camera whose functions will be as listed in figure 4. The required AC voltage to power up the system is generated by means of a dynamo modified as a miniaturized wind turbine. A rectifier circuit converts the generated AC power to DC power which is subsequently stabilized using voltage regulators to produce a constant DC Output. A set of secondary (rechargeable) batteries are used in conjugation to serve as an alternative backup.

Temperature Sensor

The atmospheric ambient air temperature can be detected using commercially available linear Temperature sensor like LM35. It includes thermocouples/RTD and can be employed in a wide range of varying temperature conditions from -40 degree Celsius to 100 degree Celsius. This sensor is said to have a sensitivity of 10 mV per degree Celsius (DFRobot LM35 Linear Temperature Sensor 2013). Temperature sensor circuit is as shown in figure 5. The output from this chip can be directly interfaced with the microcontroller board (say Arduino) for further conversion of sensor voltage to temperature readings. Since the output of the sensor is linear, there is no necessity to include linearization techniques. The sensor constantly monitors the atmospheric temperature and alerts the farmer stating whether the temperature is favourable or not so that the farmer could perform certain remedy measures.

Moisture Sensor

Liquidity sensor is placed under the ground to determine the liquid content present in the soil. The sensor has two probes. Current is passed through one probe, through the soil and read at the other. Depending upon the moisture content of the soil, its conductivity varies. Thus a moisturized soil has low resistance to the flow of current, whereas soil which is dry has poor conductivity. The analog output voltage readout is further processed by the microcontroller. If the threshold of soil water content has not been reached, the microcontroller may release a mechanical valve to irrigate the field. Once sufficient water content has been attained in the soil the microcontroller senses this change and closes the valve.

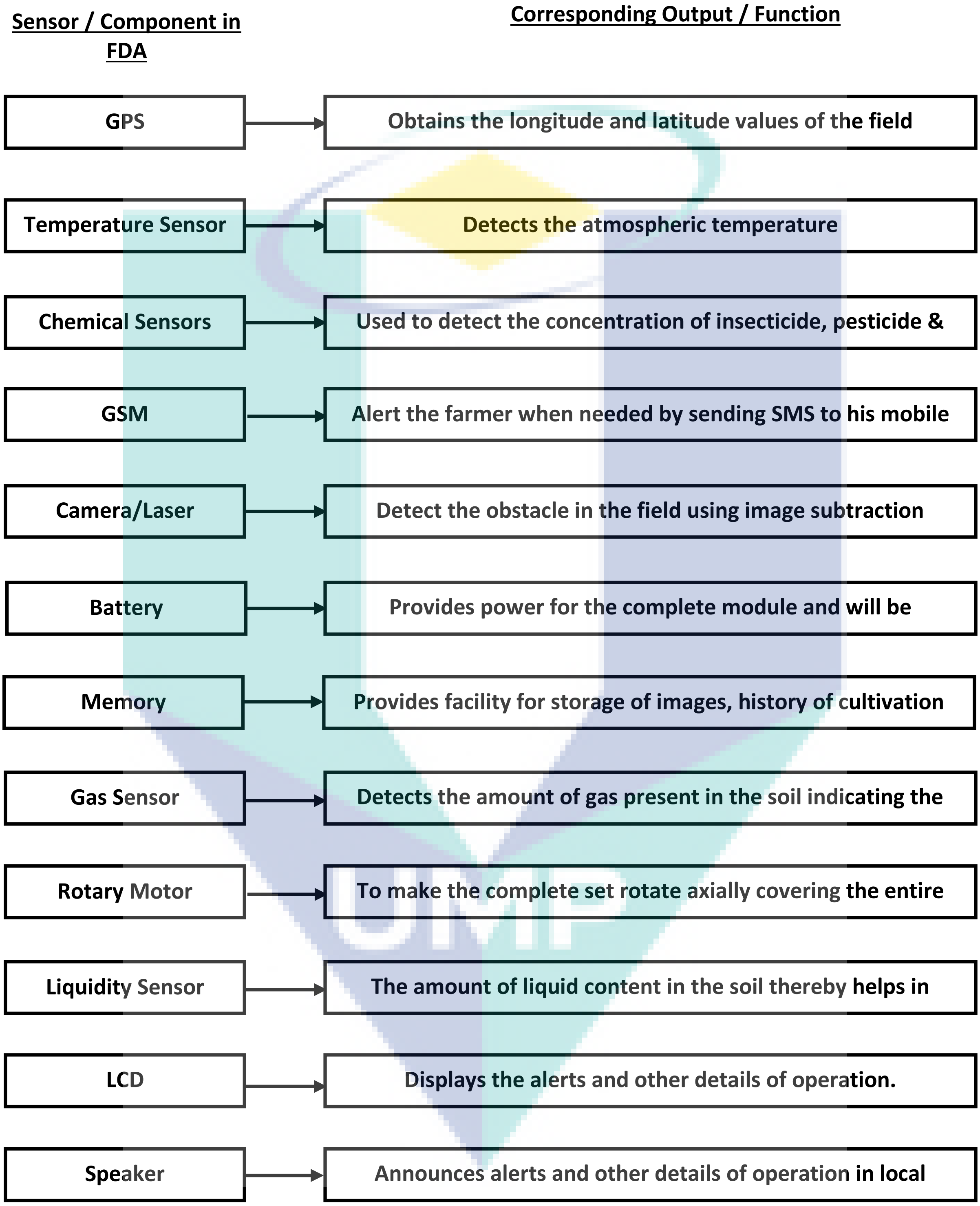

Fig.4. Functions and outputs of components in FDA.

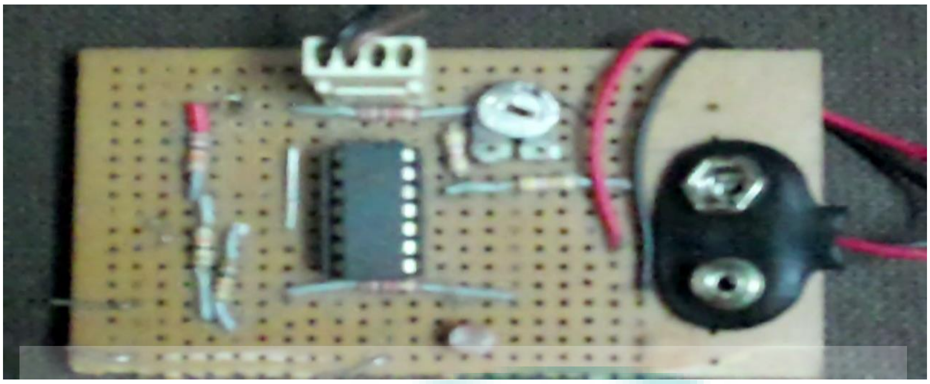

Fig.5. Temperature sensor circuit.

Chemical Sensor

Chemical sensors are more than one in number and are used to monitor the concentration of fertilizer, pesticide and insecticide applied to the soil and sprayed to the crop based on absorption technique. These are provided with a threshold of safety limits which when exceeded would create alerts to the farmer to stop process of spraying chemical. The thresholds can be varied based on the nature of crops cultivated. In this way the chemical content in the crops grown are maintained within the permissive limits and hence does not enter into bio-magnification chain like that of popular DDT and other chemicals.

Gas Sensor

Microbes play a major role in healthy growth of crops and to perform efficient cultivation the amount of microbes present should be monitored constantly. To achieve this task N_2O and other types (depending on nature of microbes) of gas sensors will be employed which will monitor the concentration of gas liberated by the microbes which is directly proportional to the number of microbes. The nitrous oxide sensor employed is a typical infrared sensor which can measure concentrations ranging from 0-1000 ppm. In addition, these sensors are temperature compensated and thus they are capable of producing a linear output in order to make the computation and decision making activities easier.

Camera

Camera is employed to provide security to FDA system and also to the crop from theft and intruders. It employs simple image subtraction technique in which templates are stored as reference. The subtracted value of the currently captured image from that of the template shows any movement activity in the field as shown in figure 6 and automatically generates alerts to the farmer. This can also be extended to detect the animal grazing and presence of other life threatening animals. As another alternative, a set of motion sensors widely distributed throughout the field can be used which communicates its status to the FDA module using wireless protocols. This would be of importance if the field to be monitored is vast, where the field of vision is a limitation to the camera.

(a) (b) (c)

Fig.6. (a) Empty Field (b) Intruder in the field (c) Intruder Detection.

Output Modes

In the output modules, three modes of communication to farmers are proposed which are LCD, Speaker and SMS using GSM (Aswin et. al. 2011). All the sensor alerts discussed above will be displayed in the LCD present in the FDA module. To keep the farmer continuously updated even during his absence, two more output modules namely the speaker and SMS using GSM is added. Figure 7 and 8 shows the hardware setup. The voice output in the speaker is pre-recorded in the system. The SMS through GSM is also sent stating the nature and message of alert to the farmer whose contact number is stored in the program of processor (Guoxiang et. al. 2005). Table 2 summarizes various output modes based on inputs.

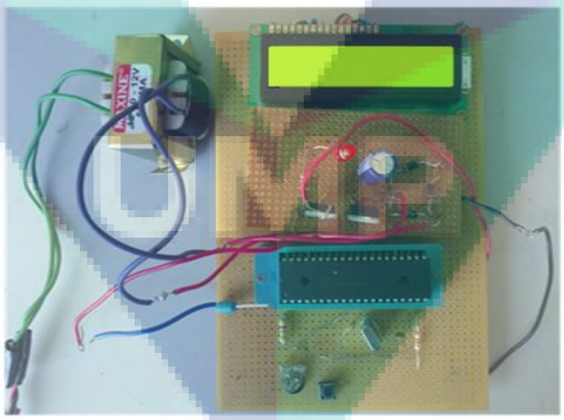

Fig.7. LCD module.

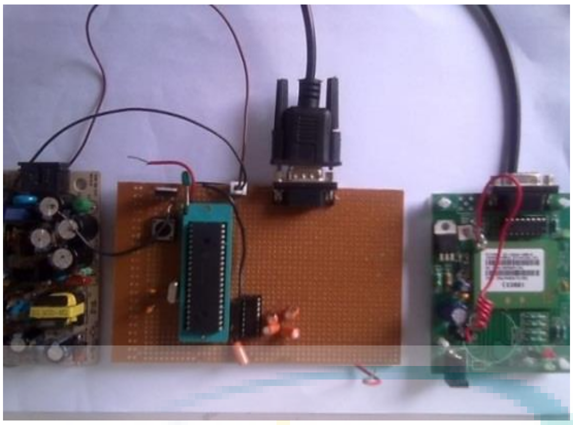

Fig.8.Setup for GSM module Developed.

Table 2: Different outputs based on sensor inputs.

Sensor alert	LCD	Speaker (in regional language)	SMS
GPS	Nature of crop to be cultivated	Announces the list of crops to be cultivated	-
Temperature	Temperature in degree Celsius	Announces the current and forecasted temperature	Text containing current and forecasted temperature is sent
Chemical	Concentration of chemicals	Audio output of concentration of chemicals	Message containing chemicals concentration and their limits is sent
Camera	Intrusion detected	Announces the detection of intruder and raises alarm	Text notifying detection of intrusion is sent
Battery	Level of charge available is displayed	Announces when battery discharges below threshold	Message sent when battery discharge crosses certain percentage levels
Gas	Displays the different gas concentration of the soil and minimal level required	Announces the concentration of gas present and level required for the crop	Message containing different gas concentration and their required limits is sent
Liquidity	Liquid content of soil present and amount required for the crop is displayed	Audio output of present and required level of water content and raises alarm when attained	Message containing present liquid content with required content is sent at regular intervals

Chapter 4

Conclusion

FDA system will provide clear picture of the crop to be cultivated in that particular field. It will continuously monitor the field for chemical levels, temperature, liquid content and intrusion. Farmer alerts through SMS keeps him updated even in his absence near the field. Battery is charged by solar energy and hence provides long run sustainable utilization of renewable source of energy. Though the system is of huge benefits initial awareness is to be created in the farmers about the system to make them use it. System should be made much secure to theft and should also be made robust to tough climatic conditions without any trade-off in its functionalities and accuracy. The sensors calibration is to be checked and corrected in regular intervals. Initial cost is still high as it involves monitoring of several parameters but affordable for the service rendered by the system. Since the system is a standalone type, the optional accessories of sensors can be omitted depending upon the budget of the farmer to enable each and every farmer irrespective of the amount of field they have to buy them. Support from government by providing subsidies in manufacturing the FDA system would help in reducing the cost structure which will enhance the accessibility of the system to farmers. FDA would render its helping hand throughout the cultivation process leading to high benefit cost ratio to farmers.

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