Agriculture Automation & Monitoring using NI my RIO & Image Processing to Estimate Physical Parameters of Soil

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Abstract— Smart agriculture involves the application of modern information technology in agriculture. Agricultural productivity is predominantly influenced by the availability of water and characteristics of the soil. Continuous monitoring of the field is essential to maintain optimal field conditions. The system proposed aims at automating irrigation by irrigating the field when the temperature exceeds the threshold. The system also determines the physical characteristics of soil such as specific gravity, liquid limit and several other physical parameters by estimating the fractal dimension using box counting method. The temperature sensor (PMOD TMP3), moisture sensor and motor were interfaced to NI my RIO and on-board wifi was configured. The various physical characteristics of the soil were estimated using image processing technique from the soil samples collected from field. This system can also incorporate the field temperature and moisture as a network-shared variable and enable its monitoring in NI Datadashboard.

Key words: NI my RIO, Irrigation Automation, WIFI Configuration, Fractal Dimension, Box –Counting Method Physical Characteristics

I. Introduction

Agriculture is the backbone of Indian economy. Due to the unpredictable and inconsistent nature of factors that influence farming in India, there arises a need to extend technology into agriculture thereby reducing the rapid decline in productivity. Optimum soil temperature and moisture levels should be maintained to augment crop growth. Macronutrient levels should also be maintained to adequacy for better yield. A smart monitoring platform is required to monitor the field conditions continuously. This system facilitates smart monitoring of several parameters such as optimum water and other soil properties that cumulatively influence productivity in primary sector. Automation is done by interfacing sensors to NI myRIO which is supported by Lab VIEW software. Image processing technique using suitable algorithm has been implemented to detect physical parameters of the soil.

II. Related work

The following works are based on various methods used for automated irrigation.

The authors, A. D. Kadage & J. D. Gawade (2009), have designed and implemented a system to monitor field conditions continuously by interfacing sensors to a microcontroller and notifying the farmer through SMS (Short Message Service) when field conditions deviate from normal. The system utilizes a GSM module and prompts for command from farmer to take necessary action. However, network availability and related constraints have not been considered. Thus, continuous monitoring is facilitated without emphasizing on automating the process of irrigation.

The authors Swarup S Mathurkar and Rahul B.Lanjewar(2014) proposed a system to develop a smart sensor based monitoring system for agricultural environment using field programmable gate array (FPGA) which comprised of wireless protocol, different types of sensors, microcontroller, serial protocol and the field programmable gate array with display element. The paper based on using sensors which helps in checking moisture , temperature and humidity conditions. According to the conditions farmer can schedule his work.

The authors, Bansari Deb Majumder, Arijita Das, Dibyendu Sur, Susmita Das, Avishek Brahma &ChandanDutta (2015), have attempted to develop an automated system which can measure different agricultural process parameters (like temperature, soil moisture, sunlight intensity, humidity, chemical contents etc.) and control using PID controller .These parameters can be remotely monitored and controlled. With the help of MATLAB interfaced with NI LabVIEW, a virtual simulation of the entire process on front panel is made feasible.Alarm systems are incorporated to generate necessary alarm signal in case of worst scenario in order to alert the farmer about the consequences. This will provide the farmer a remote control approach to look after his land and crops. It will also increase the productivity of land though efficient control and will reduce human efforts though complete automation of the harvesting process.

The authors, Anastasia Sofou, Georgios Evangelopoulos, and Petros Maragos(2005) proposed a system examine a sophisticated integration of some modern methods from computer vision for image feature extraction, texture analysis, and segmentation into homogeneous regions, relevant to soil morphology. The experimental results in images digitized under different specifications and scales demonstrate the efficacy of proposed system.

III. Design & implementation

A. Functional Requirements

The following requirements define the functions and the components of the system.

– Sense Temperature and moisture
– Update wirelessly to NI datadashboard
– Analysis of soil physical charecteristiccs
– Response to sensor readings to turn the pump on /off

B. Non-Functional Requirements

1) Availability

The system operates successfully at any point of time.

2) Reliability

The user is able to access the readings of sensors at all times.

3) Maintainability

The system can be easily upgrade by adding components with improved features.

C. Hardware & Software System Design

1) NI myRIO

It is a real-time embedded evaluation board made by National Instruments. It is used to develop applications that utilize its onboard FPGA and microprocessor. It requires LabVIEW. It can implement multiple design concepts with one reconfigurable I/O (RIO) device. Featuring I/O on both sides of the device in the form of MXP and MSP connectors, it includes 10 analog inputs, six analog outputs, 40 digital I/O lines, Wi-Fi, LEDs, a push button, an onboard accelerometer, a Xilinx FPGA, and a dual-core ARM Cortex-A9 processor. The myRIO-1900 can be programmed with Lab VIEW or C. This Wi-Fi-enabled version allows for fast and easy integration into remote embedded applications.

2) Lab VIEW

Laboratory Virtual Instrument Engineering Workbench (Lab VIEW) is a system-design platform and development environment for a visual programming language from National Instruments, front panel serving as a user interface, or, when dropped as a node onto the block diagram, the front panel defines the inputs and outputs for the node through the connector pane. The Lab VIEW programming environment, with the included examples and documentation, makes it simple to create small applications.

3) Temperature Sensor

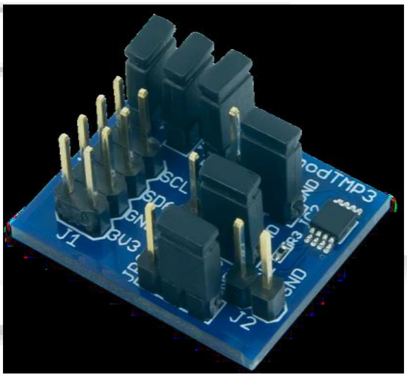

Fig. 1: PMOD TMP3 - Temperature Sensor

Fig. 1 shows the temperature sensorPmodTMP3. The PmodTMP3 provides three 3-pin headers for selecting the I2C address of the chip, and one 2-pin header for controlling external devices based upon temperature thresholds defined by the user in software .It is a Ambient temperature sensor with up to 12- bit resolution .Its typical accuracy is of ±1 °C.It has programmable temperature alert pin.there are multiple jumpersfor eight selectable addresses.its typical conversion time time is 30 to 40 ms.There is a small PCB flexible designs 1.0“ × 0.8” (2.54 cm × 2.0 cm)

4) Moisture Sensor

The soil moisture sensor YL-69 has built-in potentiometer, a power LED and a digital output LED. It operates at a voltage of 5V.The output analog voltage corresponds to the sensed moisture level.

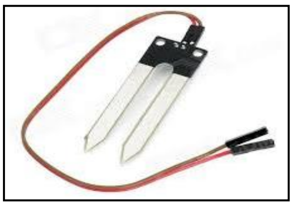

Fig. 2: Soil Moisture Sensor YL-69

In Fig.2, the soil moisture sensor YL-69 used for soil moisture determination is shown.

5) Motor

A motor connected to myRIO can be turned ON/OFF to automate the irrigation process.

IV. PROPOSED WORK

The work is aimed at automating irrigation process by interfacing the necessary sensors, namely, the temperature sensor and moisture sensors to NI myRIO and configuring the onboard Wi-Fi. When the power supply is on myRIO will get powered. The temperature sensor monitors the soil temperature, if it exceeds 30 degree Celsius it will automatically turn ON the motor and temperature can be viewed on Datadashboard by deploying it as a shared variable. When the temperature lies below threshold, the motor remains OFF.

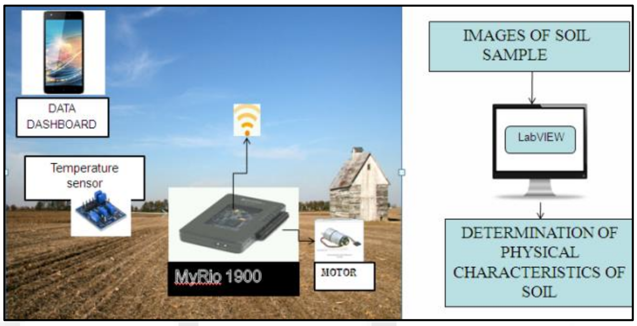

Fig. 3: Block Diagram of the Proposed System

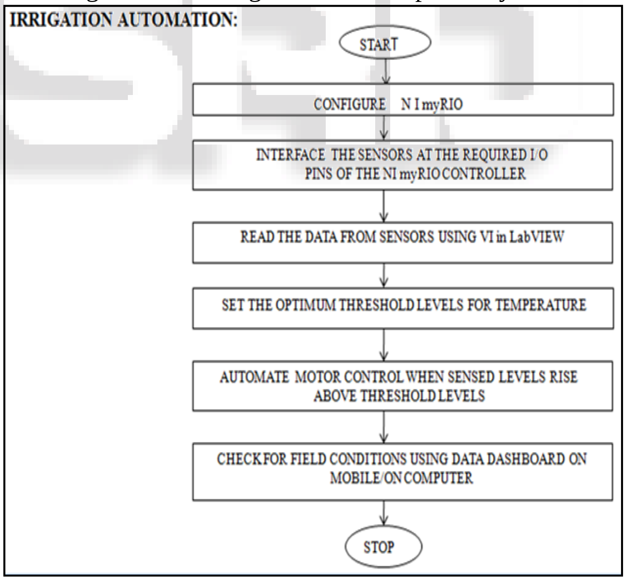

Fig. 4: Flowchart for Irrigation Automation

Fig .4 shows the flowchart for automation of irrigation system. Initially, the myrio is configured and then interfaced with the sensors. The datas are read from sensor, according to the threshold fixed the automation control of motor is done.

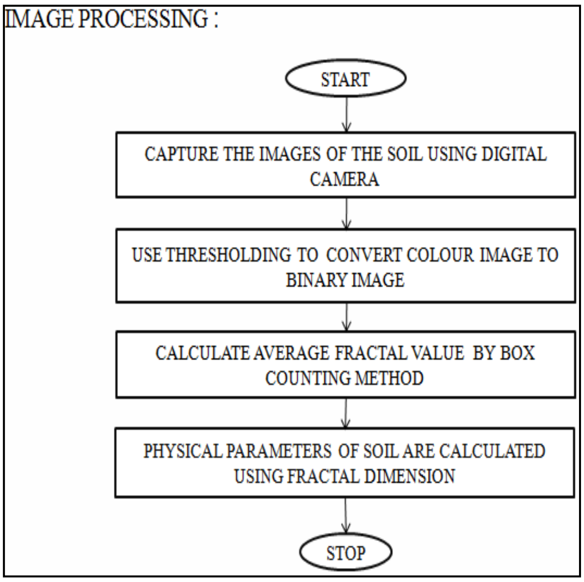

Fig 5: Flowchart for Image Processing

Fig.5 shows the flowchart for image processing. The image processing involves capturing the images of the soil and converted into binary image, and then calculating the average value using box counting method by which physical characteristics of the soil are obtained by fractal dimension calculation.

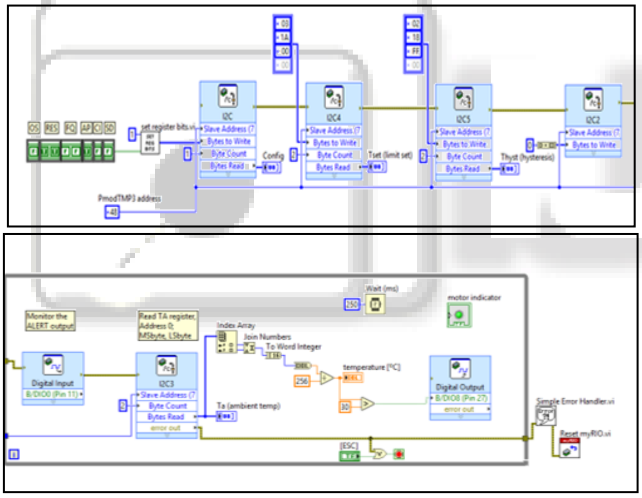

Fig. 6: Block Diagram for Irrigation Automation

In Fig.6, the block diagram in LabVIEW for irriation automation is depicted. The VI for reading temperature and moisture from respective sensors and motor control by testing for threshold optimacy is shown

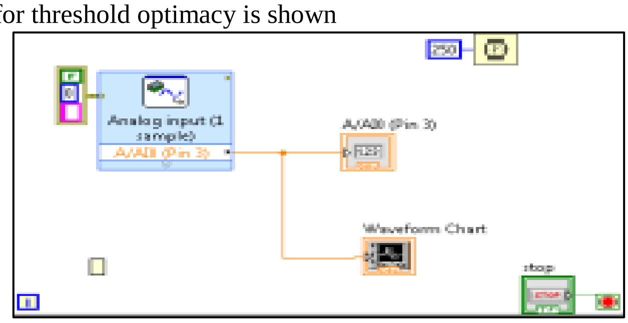

Fig. 7: Loop for Moisture Sensor

Fig.7 shows the while loop that runs continuously to sense moisture level in the soil.

The other part of the work is image processing.The soil image is taken with an 8-mega pixels digital camera and using image processing technique in LabVIEW ,we can find the physical characteristics of the soil(i.e.,water content, liquid limit, plastic limit, shrinkage limit, specific gravity etc.

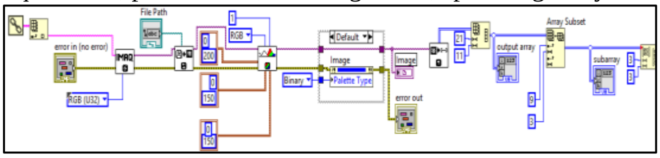

Fig. 7: Block Diagram for Image Thresholding and Subarray Extraction

Fig.7 depicts the blocks that are required to perform colour thresholding on the obtained image and to extract the 3x3 matrix that is required for fractal dimension computation

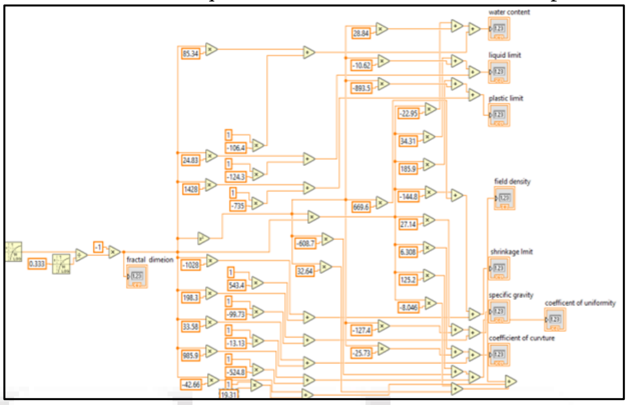

Fig. 8: Physical Characteristics Estimation

Fig.8 shows the various numeric blocks that are needed to compute the physical characteristics of the soil samples.The physical characteristics computed include water content, liquid limit, plastic limit, specific gravity, and shrinkage limit, coefficient of uniformity, field density and coefficient of curvature

V. RESULTS

A. Automation of Irrigation

TEMPERATURE READING (in degree Celsius)	Threshold level(in degree Celsius)	MOTOR (Turned ON/OFF)
28	30	Off
33	30	On
32	30	On
29	30	Off

Fig. 9: Tabulation of Results for Temperature Sensor and Motor Status

The table shows the results obtained by placing the temperature sensor in the soil and monitoring the field temperature for its optimum level.

B. Image Processing To Determine Physical Characteristics

The images of different soil samples, collected from various field are processed in Lab VIEW

Fig. 10: Alluvial Soil Samples

In Fig.10, the images of alluvial soil that were processed for physical characteristics determination are shown.

Fig. 11: Red Soil Samples

In Fig.11, the red soil samples that were considered for analysis to determine physical characteristics are shown.

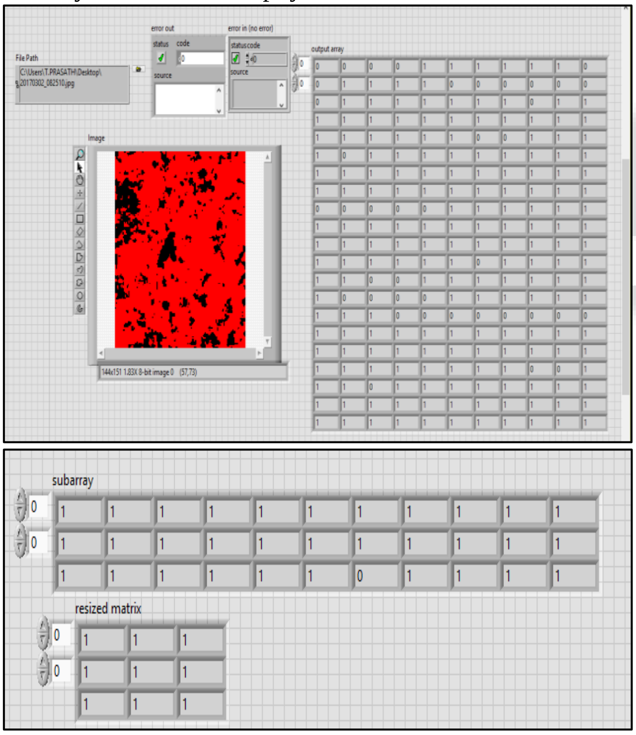

Fig. 7: Colour Thresholding & Subarray Extraction

Fig.7 shows the results obtained on applying colour thresholding to the image. The resized subarray is used for fractal dimension estimation which is consequently

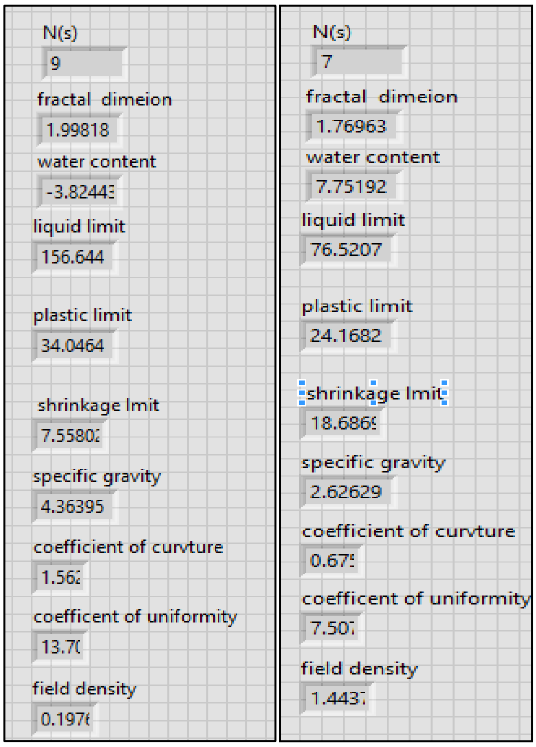

Fig. 8: Front Panel Results for Physical Parameters of (I) Alluvial Soil (Ii) Red Soil

In Fig.8, the results of values of various physical parameters obtained for the alluvial and red soil samples taken are displayed

SOIL TESTED:ALLUVIAL SOIL		
S.NO	**PHYSICAL CHARACTERISTIC**	**VALUE OBTAINED(averaged over 3 samples)**
1	Fractal Dimension(FD)	1.57
2	Water content(%w)	4.39
3	Liquid limit(%l)	66.79
4	Plastic limit(%p)	25.18
5	Shrinkage limit(%S)	16.08
6	Specific gravity(G)	3.06
7	Coefficient of curvature(CC)	1.02
8	Coefficient of uniformity(Cu)	7.34
9	Field density(fd)	1.014

Fig. 9: Physical Characteristics Averaged of Alluvial Soil

Fig.9 lists out the physical parameters that have been estimated by image processing of alluvial soil samples.The readins shown were obtained by averaging the readings over three samples taken.

SOIL TESTED:RED SOIL		
S.NO	PHYSICAL CHARACTERISTIC	VALUE OBTAINED(averaged over 3 samples)
1	Fractal Dimension(FD)	1.76
2	Water content(%w)	7.75
3	Liquid limit(%l)	76.52
4	Plastic limit(%p)	24.168
5	Shrinkage limit(%S)	18.686
6	Specific gravity(G)	2.62
7	Coefficient of curvature(CC)	0.675
8	Coefficient of uniformity(Cu)	7.507
9	Field density(fd)	1.443

Fig.10: Physical Characteristics of Red Soil

The table in Fig.10 displays the values of physical characteristics obtained by averaging the values obtained for three red soil samples.

VI. ADVANTAGES

- Enhanced productivity and safety
- Easier agriculture procedures
- Simplified determination of physical characteristics as compared to conventional procedures.

VII. CONCLUSION

In this paper, we propose a smart Agriculture System that can analyse an environment and intervene to maintain its adequacy. The system also allows for future extensions improve efficacy. Monitoring and automation of agricultural process has been achieved.

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