Low-Cost Electronic Automation Unit for Plant Data Acquisition in Plant Phenotyping

Smart System Automation

Hari Krishna K S[1], Shwetha R[2], Manoj Varama S[3], G T Ramesh[4]
Department of Electronics and Communication Engineering
M S Engineering College
Bangalore, India

Sunitha P H
Associate Professor in Department of Electronics and Communication Engineering
M S Engineering College
Bangalore, India

***Abstract*—The present paper describes the Low-Cost Electronic Automation Unit for Plant Data Acquisition in Plant Phenotyping in which the whole system is made automatic controllable through the sensors. The image capturing of the plant that is the Plant Phenotyping process is done at different angles using a camera and a servo motor. The regular watering system is done automated by obtaining two different results of the water content of the soil present in that particular pot where the plant is present that is through Image Processing, and the Load of the Pot . Automated watering system to the Pot is done through the Solenoid water valve comparing with the results of the water content present in soil.**

Keywords—Low-Cost Electronic Automation Unit, Plant Data Acquisition; automatic; IR Sensor; Proximity Sensor; Image Processing; water content; Load Sensor; Plant Phenotyping.

I. INTRODUCTION

In the Smart Electronic Automation Unit for Plant Data Acquisition in Plant Phenotyping shows that the number of plants are placed in individual tray and are mounted on the belt of a DC Motor. The Automation Unit requires an Inductive Proximity Sensor to sense the individual metal tray and an IR Sensor to detect the object that is the Pot. For continuous motion to make all the plants move uniformly, we require a DC Motor and for angle rotation of the Pot to capture the pictures of the plant at different angles we use Servo Motor. Once the DC Motor shaft switches ON, the number of pots placed on that tray starts moving and the IR Sensor and Proximity Sensor gets activated. Once the IR Sensor and Proximity Sensor become high, the DC Motor stops rotating and the Servo motor switches ON. The Pot is rotated at required angles using Servo motor and the image of the plant is captured by the camera and is sent to the receiver either Mobile or PC through WiFi or Bluetooth. At the same time the Load sensor checks for the weight of the Pot and determines the amount of water absorbed by the plant. Later the image of the soil in the pot is taken by the camera to find out the water content in the soil through Image Processing. Once the water content is found to be low compared to the default value, automated watering system is done using Solenoid water valve and this process repeats for the remaining number of pots on the belt.

II. IMPLEMENTATION

A. Model Design

Initially the model is set up consisting of a Servo and DC Motors, Conveyor Belt, IR Sensor, Proximity Sensor, Arduino Controller, Raspberry-Pi, Camera, Load Sensor, Solenoid Water Valve, WiFi or Bluetooth Module.

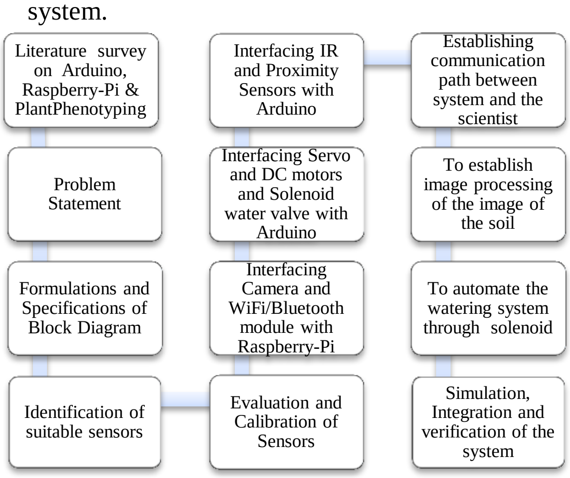
The conveyor belt is fixed to the DC Motor and the pots are placed on the respective trays on the belt. Once the process gets started that is the DC Motor switches on the conveyor belt moves, and an Inductive proximity Sensor and an IR Sensor is placed at a fixed place and when the Proximity Sensor and IR Sensor becomes high by detecting the Pot and the tray, the DC Motor immediately stops and triggers on the Servo motor and the Camera. Once the Servo motor is on the pot is made to rotate at different angles and the images of the plant is captured through camera and is sent to the receiver either by WiFi or Bluetooth. After this the weight of the pot is measured using a Load Sensor to check how much water has the plant has absorbed and then the image of the soil is captured and is processed to find the amount of water level in the soil of the particular pot. If the amount of water compared to the value in the database is less, the solenoid automatically opens the valve and waters that particular plant. The Sensors, Solenoid Water Valve, the WiFi or Bluetooth Module and the Motors are interfaced with the Arduino Diecimilia or Arduino Mega and the camera to the Raspberry-Pi to transfer the images.

B. Softwares Used

The Software's used for this Design is Arduino 1.6.13, Matlab, and a Camera Application for Mobile Phone or PC. The main coding part has been done using Arduino 1.6.13 and the Image Processing has been done using Matlab and the images of the plant has been transferred to the Mobile or PC through WiFi or Bluetooth through a Camera application.

III. METHODS AND METHODOLOGIES

- Literature review for current phenotyping methods, motors and sensors has been carried out by referring journals, books, manuals, websites and industrial laboratories.
- Block Diagram has been formulated based on the desired specifications and the reviewed literature.
- Suitable Sensors are identified for the design.
- Sensors are interfaced to the system to perform the required operation.
- Establishing a communication path between the system and the scientist.
- Evaluation and calibration of sensors.
- To interface the motors for the movement of the conveyor belt and the pot.
- To interface a camera through WiFi module or Bluetooth module to send the captured images to the receiver that is the mobile or the PC.
- To image process the captured image of the soil to find the content of water present in the soil.
- Simulation, Integration and Verification of the system.



Phase I **Phase II** **Phase III**

Fig 1: Methods and Methodologies

The above figure 1 shows the diagram of methods and methodologies of the system operation which consists of three phases.

- Phase I shows the major role in finding the specifications and the best suited sensors required for the operation.
- Phase II plays a very important role in interfacing sensors and DC motors with the controller.
- Phase III shows the communication and image processing part of the system.

IV. FLOW CHART

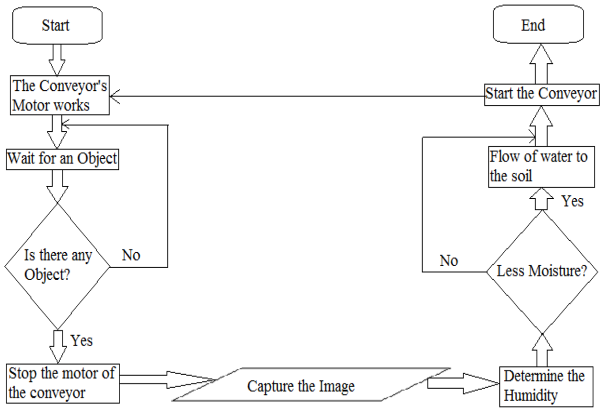


Fig 2: Flow diagram of the Smart System

The above figure 2 shows the diagram of the flow chart of the entire process. Initially the smart system begins with the DC motor with runs the conveyor belt and the sensors that is IR sensor and the Proximity sensor waits for an object and if there is any object the conveyor motor stops immediately or else the process repeats until further object. Once the conveyor belt stops the camera and the servo motor gets activated and captures the images. To find out the water content in the soil the image processing is done to determine the humidity and it compares for the less moisture. If there is less moisture than the default amount the solenoid water valve opens and the water flows to the pot and if the moisture content is greater than or equal to the default readings, the process continues for the next pot to come on field. This process repeats until all the pots are empty on the belt and the next instruction given by the scientist.

V. BLOCK DIAGRAM

The Block Diagram consists of a Transmitter part and the receiver part.

The transmitter part consists of two controlling boards that is Arduino Diecimilia or Arduino Mega 2560 and Raspberry-Pi. Arduino board is connected to the components such as DC and Servo motors, IR sensor, Proximity sensor, Load sensor, and Solenoid water valve and WiFi module or Bluetooth module. The Raspberry-Pi board is connected to the camera.

The receiver part consists of a mobile phone or a PC to receive the images from the transmitter either through WiFi or Bluetooth.

Both the sides that is the transmitter and the receiver together makes a complete block diagram along with the software's used that is Arduino 1.6.13 and Matlab and the self created camera application.

The below figure named as Fig 3 shows the complete picture of the block diagram of the Smart Electronic Automation Unit with all the components.

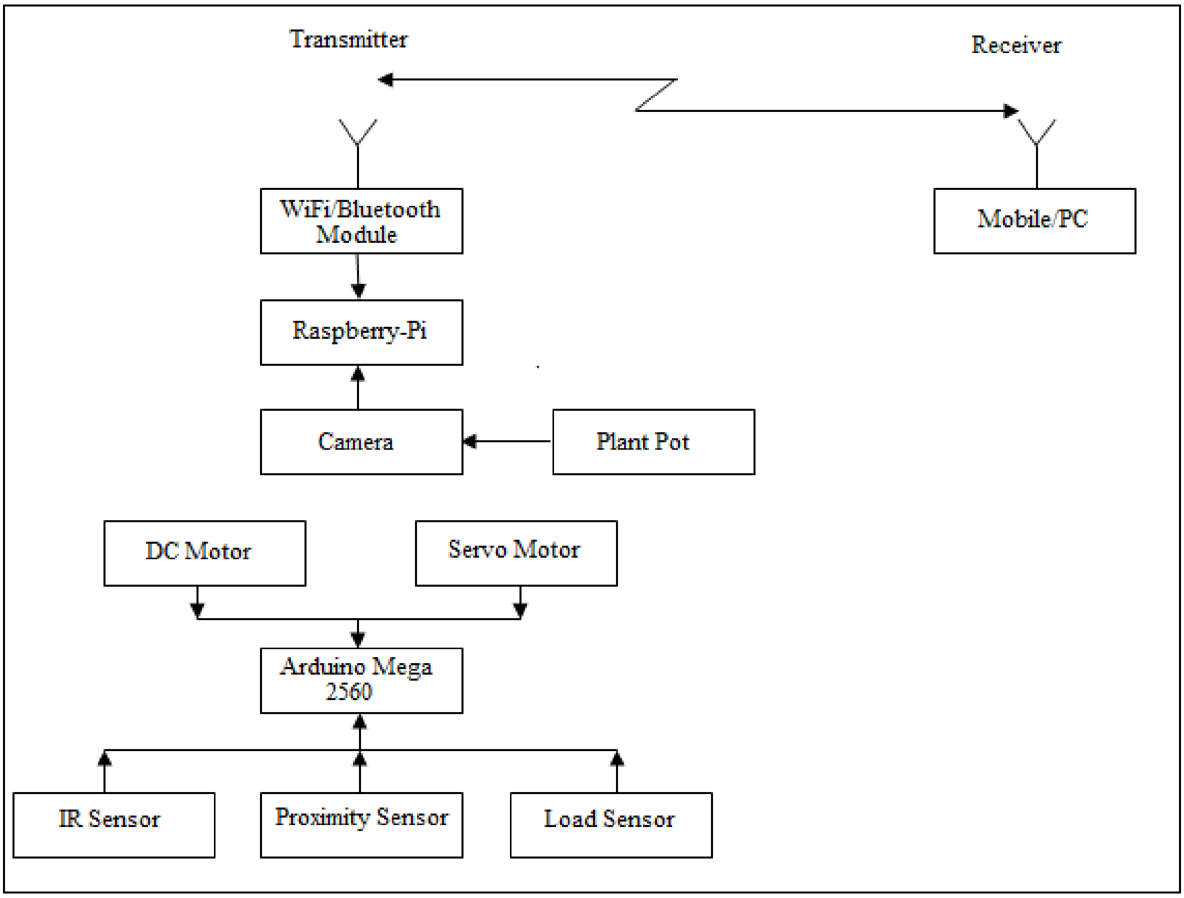


Fig 3: Block Diagram of Smart Automation Unit

A. Expected Outcome:

- Reduction in Time Consumption.
- Reduction in Power Loss.
- Increase in Speed and Accuracy.
- Replacing the scientist along with fast work.
- Automated watering system through solenoid
- Self-developed application for image transfer.
- Processing of image to find the water content in the soil.

B. Disadvantages by existing device:

- The cost of multispectral or hyper-spectral cameras is relatively expensive.
- The system cannot work under normal conditions without the help of the scientist.
- Time consumption is very high for the entire process.
- Economically complex methods to find humidity of the soil.
- No procedures or process to find the water content of the soil through the image.
- There is no automated watering system with the existing device.

C. Advantages:

- Reduction in Time Consumption of the system using Electronic Automation Unit.
- Replacing or simplifying the work of the Scientist.
- Economically simple methods to find the moisture content of the soil.
- Images of the plant at different angles.
- Live images of the Process from the system to the scientist.
- Automated watering system through the measurements of the humidity of the soil.

D. Problem Statement:

- Since the number of plants are more, it is necessary to develop a system which captures the images of the plant in a required way in a short time span.
- There is a requirement to design a system to overcome the problems such as power consumption, time consumption and high cost.
- A smart system is required where the desired pot is bought to capture the images and process it and water it automatically.
- Work of the scientist to be simplified or replaced by the smart system.

E. Applications:

- Can be widely used in the field of Agriculture.
- Can be used in the field of Horticulture.
- Can be used in Plant Research Centers across the world which is cheaper.
- The system idea can be implemented in Traffic system.
- Cheaper way of determining the water content and the same procedure can be implemented in different fields.
- Concept is best suited for industrial applications and hence can be widely used in machineries.
- Can be successfully applied to all the Plant Phenotyping Labs at any place.

F. Conclusion:

The problems solved by our system is, it is cheaper compared to present system, the plant is watered when the humidity is less than the desired value, the system can be controlled by the scientist without being present in the lab, the pot can be rotated at different angles and the images are transferred through the self developed camera application either through Bluetooth or WiFi.

Acknowledgment

This work is deemed incomplete without acknowledging the various individuals immensely instrumental in ushering in a great deal of effort, time and valuable guidance. I would like to thank our Dean and Head R&D at MSEC, Dr. Cyril Prasanna Raj P**,** for providing valuable suggestions, relentless support, help and guidance during this project. I would also like to thank our guide, Prof. SUNITHA P H, Associate Professor, Department of Electronics & Communication Engineering for providing valuable suggestions and for guiding throughout the course of our project.

References

[1] C. Granier, L. Aguirrezabal, K. Chenu, S. J.Cookson, M. Dauzat, P. Hamard, J.-J. Thioux, G.Rolland, S. Bouchier-Combaud, A. Lebaudy, B. Muller,T.Simonneau, and F. Tardieu, “PHENOPSIS, anautomated platform for reproducible phenotyping ofplant responses to soil water deficit in Arabidopsisthaliana permitted the identification of an accessionwith low sensitivity to soil water deficit.,” New Phytol.,vol. 169, no. 3, pp. 623–35, Jan. 2006.

[2] M. Bylesjö, V. Segura, R. Y. Soolanayakanahally, A. M. Rae, J. Trygg, P. Gustafsson,S. Jansson, and N. R. Street, “LAMINA: a tool for rapid quantification of leaf size and shape parameters.,” BMC Plant Biol., vol. 8, no. 1, p. 82, Jan. 2008.

[3] A. Hartmann, T. Czauderna, R. Hoffmann, N.Stein, and F. Schreiber, “HTPheno: an image analysis pipeline for high-throughput plant phenotyping.,” BMC Bioinformatics, vol. 12, no. 1, p. 148, Jan. 2011.

[4] D. Houle, D. R. Govindaraju, and S. Omholt, “Phenomics: the next challenge.,” Nat. Rev. Genet., vol. 11, no. 12, pp. 855–66, Dec. 2010.

[5] R. T. Furbank and M. Tester, “Phenomics--technologies to relieve the phenotyping bottleneck.” Trends Plant Sci., vol. 16, no. 12, pp. 635– 44, Dec. 2011.

[6] M. Yamasaki and G. Arturo, “FieldBook : development of the bar-coded phenotyping system and the integration into plant breeding and genetics(Proceedings of the 40th Symposium),J. Crop Res., no. 57, pp. 55–59, 2012.