IOSR Journal of Biotechnology and Biochemistry (IOSR-JBB)
ISSN: 2455-264X, Volume 6, Issue 3 (May – June. 2020), PP 15-19
www.iosrjournals.org

Luminosity Based Non-Destructive Testing Method for Plant Vital Data Acquisition and Health Monitoring System

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Abstract: *The Paper demonstrates non-destructive testing (NDT) methodology for the purpose of testing and evaluating the parameters of the plant. Data is generated and processed to conclude different crop properties and crop vitals. The data can also be used to predict and monitor the health of the plant. The Presented and demonstrated design and also ensures a low-cost high sensitivity system. The modular design and easy upgradeable sensor interface allow us to tune and set the parameters for the required plant. Further plant classification and plant data assortment can also be added to the system. Data differentiation and classification models can be visualized on monitoring software and then can be used to predict health. The light sensitivity and colour of the leaves being one of the major parameters sets the data produced is classifiable and can be interpreted easily. Further the updated system and system classification method. The data set produced is classifiable into the MATLAB and processed to generate the data. The data from multiple leaves are processed and Processed in MATLAB software and then the data is used as a reference. The main aim is to produce low-cost high precision testing and monitoring devices for farmers. The method followed also allows capturing the data and storing it for research purposes.*
Key Word*: Non-destructive testing, Luminosity, Vitals*

Date of Submission: 01-07-2020 Date of Acceptance: 16-07-2020

I. Introduction

Plant diversity and plant processes possess how chlorophyll and green pigmentation affects the plant's biochemical reaction. The major cause of leaves colour is the presence of green pigmentation known as chlorophyll. The reference that has been used here in the context of understanding the plant quality and plant index is parameterized to check for the quality of plant health. Plant health is indexed with the data obtained from plant chlorophyll and also the change in the pigmentation of the colour denoted by delta. The presented design is categorized depending upon different parameter sets and different leaf samples collected. Parallel comparison and change in data is the method used here along with the presence of a controlled environment. The data samples of images shown are microscopic views of the leaves. The presented design and data evaluation are not only small but also takes up very little space for the purpose of understanding the vitals. The parts are easily replaceable and available. The system is self-calibrating and can be tuned for different sets of data and plants depending upon the requirement.

II. Related Work

H. Rizk [1] has performed the early process detection of plant health and how it can be performed at a lower and a simpler scale along with the factors like cost and overall evaluation.
H. M. Hashemian [2]used a wireless networking system that covers up both scaling losses and network parameters in the case of high-performance evaluation and
G. K. Zhang [3] covered the abnormal parameters and signal glitches that occur while facing the losses are controlled and limited with the help of filters and notes
A. Tanaka [4] implies a sample wireless device that is acting as a biomedical implant and embeds the functionality of data capturing and processing. The processed data not only tells us biomedical impedance but also describes us, more in a deep approach towards data conversion and sorting.
R. Izumi [5] defines quantitative sensing of plants parameters, the data sensors being used are quantized to produce results
B. F. Wang[6] worked on a boost converter for power management and distribution. The device used allows us to control the power and also to produce high-quality outputs.

Sachidananda Mishraa[7] explained about a remotely operated chlorophyll sensing device that can be used to sense and send out chlorophyll data from one data point to the other and further process it to capture and process the data from a remote location

J.Dash[8] analyzed the crop production in Indian territories and concluded how the production method is heavily affected by the propagation of crop production, crop damage, and crop distribution.

III. Data sensing module

A) Mechanical Design

The simple design has been chosen for the rig for flexible usage of the leaf analysis. The design consists of various components which include Spatio-temporal a luminosity sensor, a microcontroller and a 3.7V battery. A low-cost high-performance module was aimed to approach the basic need for monitoring useful parameters of a plant.

A custom 3D printed case was designed to serve the purpose of proper housing and alignment of the Light-emitting source and the Luminosity sensor. The gap between the light source and the luminosity sensor is purposely made for the position of the sample(leaf) whose characteristics are to be monitored.

B) Electronic counterparts

This module was built taking into consideration the low cost and easy availability. To justify the need low-cost sensors and microcontrollers and constant power supply were used for the purpose. SY3511D boost converter and charge controller input circuit were specially designed in order to maintain a healthy supply to the battery as well as the peripherals. The input circuit uses an SY3511D IC which is a linear charge synchronous step-up IC. The board also deals with giving feedback to the user about the battery voltage level and indicates when to recharge the battery using a LED indicator.

TSL2561 luminosity sensor:

A 650 nm wavelength LED is chosen as the light-emitting source which provides the absorption of light intensity depending upon the chlorophyll index of the leaf. For dataset analysis, Arduino Nano is used as the main microcontroller for the module which acts as the main brain and processes all the dataset obtained at the output of the luminosity sensor which is connected to the controller in real-time. The module uses a 3.7 Volts Li-Ion battery which is used to provide power to all the sensors and the microcontroller.

Represented below is the block diagram of the system which tells the working and synchronisation of the system over different data types and data bits. The data flow in and out are monitored with the help of different protocols. The synchronous system behaviour helps in getting timestamp and sensor value both at the same time.

The System is divided into 2 major sections mainly the Monetary system and the Controller System. The sections are described below as;

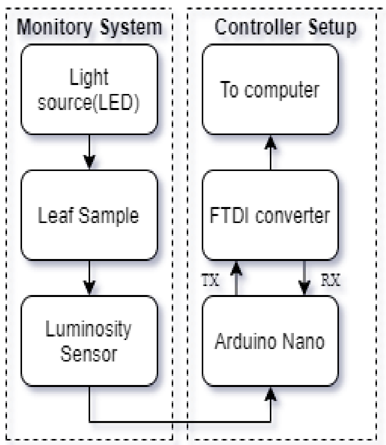


Figure1: Block diagram of the setup

Monitory System- This is the external system which comprises of the LED source and the Sensor clip both of this hardware is essentially used for getting the physical data from the leaves and then sending it into the system.

Controller Setup- The controller setup is used to process the data, on the processing side we have the Arduino nano which takes the data in and starts to process it. The data is then visualized and sent to the computer system with the help of FTDI protocol. The computer used the stock Arduino IDE to display the data in the graphical format and letting the user understand the variation on the sensor value.

Figure 2: Leaf samples from different plants

Figure 2 shows the leaf samples from different plants at different weather and light conditions and are examined under the luminosity module and the microscopic inspection.

IV. Mathematical Modeling

Kalman Filter is used to improvise the data produced by the TSL sensor. The data produced is an analogous type over which a filter is induced in order to remove the unwanted noise.

The state conditions that are required to change the parameters or the noise that is generated was cleared with the help of Kalman filter that not only clears the deflection but also allows to improve the data set profile. The major areas of improvement can be done even with the help of adding a stronger Data acquisition system and improved performance parameter.

Initial states are stated with Variable A and new state with B and the error offset allows to figure out the

Project State Defined - $\hat{y}k = Ayk\text{-}1 + Buk$

Error function Generated $Pk = APk - 1A + Q$

Computation formula = $K = PkH(HPkH + R)$

Legends; ŷ = Final State of the variable

A = Previous State Coefficient

B = New variable Added to the data set

P = Total error

Q = State constant

K = Kalman Parameter

Where Y is the transformation function which allows integrating the values from 0 to k.

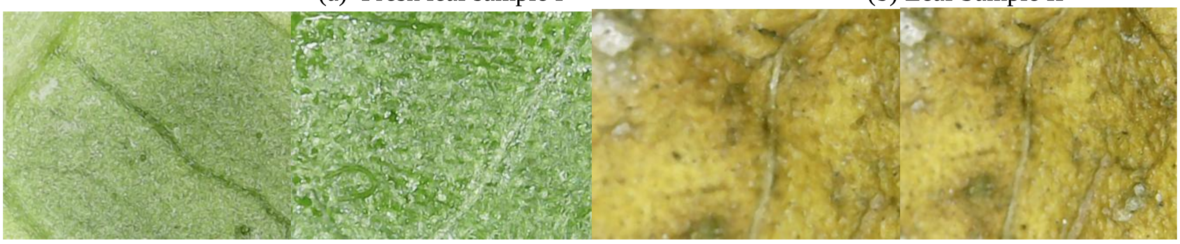
Finally, the data is summed up to an averaging function to generate Kalman values of value function H.

V. Microscopic Visual Inspection

With the capturing of the images using a 100x Microscope, we can see the captured footprint of the chlorophyll and the analyzed values of the chlorophyll are tuned and matched with the results. The captured results and outputs are formulated visually with the representation of the differential leaf colours. The colour profiles also help us to feed and improve the data which is set in the controller. The set of data can be taken from an external source in terms of .csv file and excel files can be exported for the collected data set.

Shown below are the images captured. Fig3(a) Shows the fresh leaf of the plant with the highest chlorophyll, Figure 3(b) shows the sample of the different leaf with lesser chlorophyll, Figure 3(c) Shows the fresh leaf of the plant sample 3, Figure 3(d) Shows the fresh leaf of the plant with the lowest chlorophyll.

(a) Fresh leaf sample I (b) Leaf Sample II



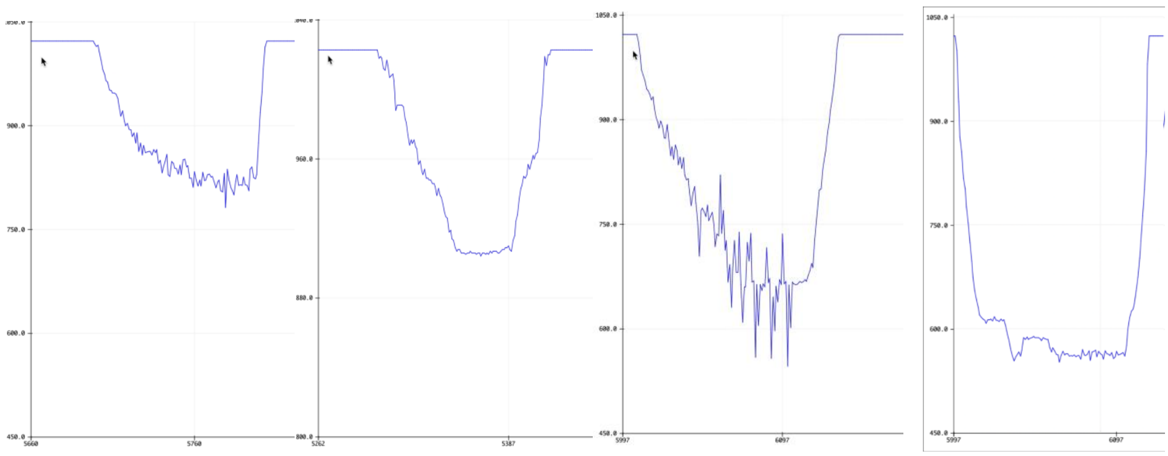
(c) Leaf Sample III (d) Leaf Sample IV

Figure 3: Chlorophyll analysis of sampled leaves with a 100x microscope

Four samples of leaves with different levels of chlorophyll are taken and visually examined for chlorophyll content.

VI. Results and Discussions

The output graph was obtained using a serial plotter which gives the variation of the amplitude with different luminosity parameters with respect to time.



(a) **(b)** **(c)** **(d)**

Figure 4: Plotter output readings from the luminosity sensor (a) Sample I Output (b) Sample II Output (c) Sample III Output (d) Sample IV Output

The varying values can determine the amount of chlorophyll present in a leaf which in turn is used to determine the health of a plant. Four cases with different leaves are taken and tested using the module. In Figure 4, the output graphs of 4 leaves with different levels of chlorophyll are taken and tested. The level of chlorophyll present in the leaf determines the passage of light through it. The leaf with the most chlorophyll content will absorb most of the light and will not pass all the light to pass and fall over the luminosity sensor which can be read at the output of the TSL sensor.

Output (a) displays the case of a freshly plucked leaf form a healthy plant, the leaf could not pass most of the light through it because of the high content of chlorophyll present, which in turn implies the healthy state of the plant. The output (b) and (c) shows the fall in the sensor values which co-relate to the direct impact of considerably lesser chlorophyll in the leaf. This also states that the TSL sensor value is related to the chlorophyll. Output (d) considers a case of a dried leaf which allows most of the light to pass through it whose data can be also obtained at the sensor with the least output values because of its lesser content of the chlorophyll, which determines that the leaf does not have sufficient chlorophyll levels, hence having an unhealthy state.

VII. Conclusion

The photo evaluation parameter is one of the prime non-destructive methods used for the purpose of plant health monitoring evaluation. The use of high-performance Sensors like TSL sensors allows us to capture high-resolution signal parameters which can be recorded and analyzed later. Achieving a data set using a compact and inexpensive design setup for the purpose of evaluation and analysis of plant health depending upon the chlorophyll content of a leaf. Data serves as an easy method for analysis of the plant which can be made easily available to the remote areas which are not exposed to the latest technology. Along with the stock dataset and trained data model, predictive modelling can be performed that is resourceful to transfer the data for further use.

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