# Crop Health Monitoring Informatics System based on IoT

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*Abstract*— The health monitoring of the crop is very important for high yield of grown crop, the Internet of Things based crop health monitoring system consists the components namely camera module, microcontroller unit, SD card, Wi-Fi module in physical part and Normalized Difference Vegetation Index algorithm based OpenCV application in cyber part hence the crop health monitoring system is a cyber- physical system or Internet of things enabled system. The physical part will be implemented on 6 to 10 ft. above than the ground, vertically downward positioned and it will be static, the user switch will be connected to the microcontroller through General Purpose Input Output, the camera will be connected to the microcontroller unit through Serial Peripheral Interface, the SD card will be connected to the microcontroller unit through SDIO protocol, the Wi-Fi module will be connected to the microcontroller unit through UART and the Python scripted OpenCV application will be implemented at the cloud to calculated the Normalized Difference Vegetation Index. The camera module, Near Infrared filter based camera and Visible filter based camera will capture the image and eventually it will be transferred to the SD card by microcontroller unit, when the internet connectivity will be available it will send the data on cloud, The Python Scripted OpenCV application will calculate the Normalized Difference Vegetation Index and will provide the information of health of crop of the particular farm. The Internet of things based crop health monitoring system will be very useful as agriculture informatics to take right decisions to increase the yield of the grown crop.

***Key words:*** NDVI, IoT, Python, OpenCV, Embedded System

## I. INTRODUCTION

The Information and Communications Technology (ICT) plays an important role in different fields, one of the most important field where it is useful is Agriculture field.

Agriculture field have different sort of application toward enhancement and enrichment to increase yield, the Information and Communications Technology (ICT) and internet are two most important resources which can be used as most powerful tool to increase the yield as well as production of crop.

The combination of information related to agriculture toward advancement of the technology, development in agriculture sector and to motivate agriculture sector towards entrepreneurship. [5]

This is known as Agriculture – Services – Enhanced – Technology, which is formally known as Agriculture Informatics. [7]

The Agriculture Informatics is also known as e-Agriculture. [8] The Agriculture Informatics uses the data provided by various proper channels to the agriculture professionals and associates basically captured by the satellites. [10]

The image captured by satellites to be account further for image processing to extract useful information from it which can be used by the agriculture professionals to increase their yield of crop. [4][9]

In the Literature Survey, A number of papers reviewed to design an embedded system which can provide agriculture informatics as service to the professionals and then to implement as well as validate the designed embedded system hopefully.

In the literature review, the further chapters are regarding the review of surveyed papers, the second chapter is about literature review of surveyed papers, and third chapter is about the proposed embedded system.

### *A. Embedded System*

The embedded system is a computing system which accomplish one function or task at a time, it is a dedicated and efficient computing system.

The microprocessor can process well because it is more about processing whereas microcontroller can control well because it is more about inputs-outputs.

To develop any embedded application first of all the functionality of the embedded system or requirement of the embedded system is to be considered, then one specific algorithm is required for implementation of embedded system.

Other than the algorithm, mainly below mentioned four things to be considered:

- Processor Architecture
- Protocols and Interfaces
- Operating System or Firmware
- Programming Language

Processor Architecture is the representation of my processor as integration of various blocks entity useful from developers' perspective.

When the processor is needs to interface with some other entity or utility the protocols and interfaces standards must be followed.

The Operating system or firmware is required to fulfill the functionality from embedded software perspective.

The programming language is required to code properly. Sometimes Integrated Development Environment (IDE), Compiler and tool chains are required as well along with above mentioned utilities.

The simplest definition is that embedded is all computing that is not general purpose (GP).

### *B. Internet of Things (IoT)*

The internetworking of the physical devices connected through internet protocols is known as Internet of things.

The connected devices are known as smart devices may be sensors, software, actuators, etc.; the interconnection of which allows these objects to transfer the data.

The Internet of Things is a smart network having connections of all things to the internet for the purpose of exchanging information with agreed protocols so, any data or information can be accessed by any person, at any point of time as well as from any location.

In IoT, the smart sensors of tiny size are connected with objects things or networks where devices can interact with each other using network in the absence of any kind of human intervention.

The unique address is allocated to each object or thing by using of which by using which one object interact with other object in IoT.

The IoT is a development which allows everyday objects to send as well as to receive the data, these everyday objects are known as ubiquitous components.

The IoT contains Cyber-Physical Components.

The term Infotainment means the application of IoT in Automobile sector, which allows the internetworking of components in the automobile by using standard protocols and interfaces.

There are many other application areas, where IoT applications are used like Agriculture Sector, Industrial Application, Defense applications etc.

### *C. Normalized Difference Vegetation Index (NDVI)*

The Normalized Difference Vegetation Index (NDVI) is an index for numerical indication which uses the visible as well as near-infrared frequency bands of the electromagnetic spectrum, and is adopted to analyze remote sensing measurements and assess whether the target being observed contains live green vegetation or not.

Where, NIR is Near Infrared Region and VIS is Visible Region of spectrum.

## II. PROBLEM STATEMENT

The satellite based Agricultural Information system means Agriculture Geo-Informatics have limitation in performance due to dynamic environment because of cirrus cloud, different temperature and soil type as well as the Information and Communications Technology (ICT) can be used, like Internet of Things (IoT) based system is required due to the timely information demand in agriculture sector to take various important decisions to increase the yield of the crop.

## III. PROPOSED SYSTEM

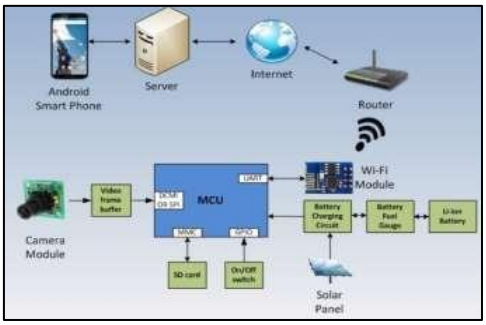


Fig. 1: Proposed System

The above shown diagram is pictorial representation of the proposed system. This camera will be installed in the farm at the certain angle and height may be 6 to 10 feet. The camera consists special filter as well as settings. This IoT based Agriculture informatics system is powered by battery. This battery is charged by the solar panel so basically it is powered by renewable energy source. For server connectivity, the Wi-Fi module will be connected to the nearest router. The images will be captured at the particular time and will be stored in SD card. The MCU is connected with the battery charging circuit, SD card, Wi-Fi module, camera module and video frame buffer. When the internet connectivity will be available at that time the images will be uploaded to the server for further processing.

The NDVI will be calculated as per the data available on the server on the basis of NDVI the health of plant will be calculated by application which can be accessed by the user by using smartphone or any other device.

## IV. RELATED WORK

As, this Internet of Things based crop health monitoring system is a cyber-physical system, it has cyber part as well as the physical part therefore, implementation of this system has been carried out by development of the physical part as well as the cyber part of the application.

The physical part of the system is an embedded system which will be installed on the farm land and the cyber part of the system is the python scripted OpenCV application which will be available on the cloud server.

### *A. Embedded System Development*

The physical part of the Internet of Things based crop health monitoring system is an embedded system which will be installed on the farm land, as shown in the proposed system this embedded system is a standalone system which is responsible to send the captured NIR and VIS images on the cloud to calculate the NDVI.

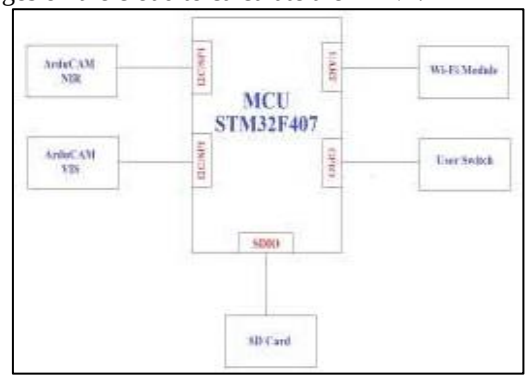


Fig. 2: Embedded System of Application

As shown in the proposed system this embedded system consists the camera module, microcontroller unit, SD card, user switch and the Wi-Fi module therefore to achieve this system there should be the following tasks needed to be performed.

- Switch interfacing with microcontroller unit
- Camera module interfacing with microcontroller unit
- SD card interfacing with microcontroller unit
- Wi-Fi module interfacing with microcontroller unit Switch interfacing with microcontroller unit - The interfacing of the push to on switch will be done by General Purpose Input-Output or GPIO.

| *Switch Status* | *System Status* |
|---|---|
| Released (default) | No operation |
| Pressed | Execute Operation |

Table 1: Switch Status Table

The push to on switch interfaced at the PIN 11 GPIO port and named as push to on switch on the STM32F407 board, we only need to program this switch to perform the task as per the switch status table i.e. When the switch is remain released or in the default status no operation will take place as well as when the switch will be pressed the operation of the system will be performed.

Camera module interfacing with microcontroller unit - As to calculate the NDVI the image captured through NIR filter based camera and the image captured through VIS filter based camera is needed therefore, to capture the respective images two cameras has been used first camera is camera have Near Infrared or NIR filter inside its structure which we had set by replacing the visible or BGR filter, the second camera is simple camera having visible filter.

| *ArduCAM (NIR) Pin* | *ArduCAM (NIR) Port* | *Microcontroller Unit STM32F407 Port* | *Microcontroller Unit STM32F407 Port details* |
|---|---|---|---|
| 1 | CSn | PC4 | SPI2_CS |
| 2 | MOSI | PB15 | SPI2_MOSI |
| 3 | MISO | PC2 | SPI2_MISO |
| 4 | SCK | PB13 | SPI2_SCK |
| 5 | GND | GND | GND |
| 6 | +5 V | -- | -- |
| 7 | SDA | PB7 | I2C1_SDA |
| 8 | SCL | PB6 | I2C1_SCL |

Table 2: NIR camera connection details

| *ArduCAM (VIS) Pin* | *ArduCAM (VIS) Port* | *Microcontroller Unit STM32F407 Port* | *Microcontroller Unit STM32F407 Port details* |
|---|---|---|---|
| 1 | CSn | PC4 | SPI2_CS |
| 2 | MOSI | PB5 | SPI3_MOSI |

| | | | |
|---|---|---|---|
| 3 | MISO | PB4 | SPI3_MISO |
| 4 | SCK | P13 | SPI2_SCK |
| 5 | GND | GND | GND |
| 6 | +5 V | -- | -- |
| 7 | SDA | PB11 | I2C2_SDA |
| 8 | SCL | PB10 | I2C2_SCL |

Table 3: VIS camera connection details

SD card interfacing with microcontroller unit - As we know that, to interface the micro SD card with microcontroller unit Secure Digital Input-Output or SDIO protocol being used as shown in the above figure the MCU will store as well as load the data to as well as from SD card, here 4 bit mode of operation has been taken.

| *Pin number* | *Pin Function* |
|---|---|
| 1 | DAT2 |
| 2 | DAT3 |
| 3 | CMD |
| 4 | VDD |
| 5 | CLK |
| 6 | VSS |
| 7 | DAT0 |
| 8 | DAT1 |
| 9 | -- |

Table 4: Micro SD card pin configuration

*B. Cyber Application*

Now, the cyber part for this system is to develop one OpenCV code in Python Scripting, this OpenCV code will take the NIR image as well as VIS image as input and will give NDVI image as output and by the analysis of NDVI image the health of the crop can be known.

1) Step-0: import all associated library
2) Step-1: import captured NIR image. (i.e. import NIR.jpg)
3) Step-2: Slice the NIR image into the pixels.
4) Step-3: Import captured VIS image. (i.e. import VIS.jpg)
5) Step-4: Slice the VIS image into pixels.
6) Step-5: subtract VIS pixels from NIR pixels of the same label.
7) Step-6: add VIS pixels from NIR pixels of the same label.
8) Step-7: Divide NUM to DEN
9) Step-8: Destroy all windows

## V. RESULT ANALYSIS

The processed NDVI image is resulted as shown in below figure, it has discrete colors only, the NDVI image which is being used for the precision agriculture have discrete five colors which are indicating the health of the respective crop.

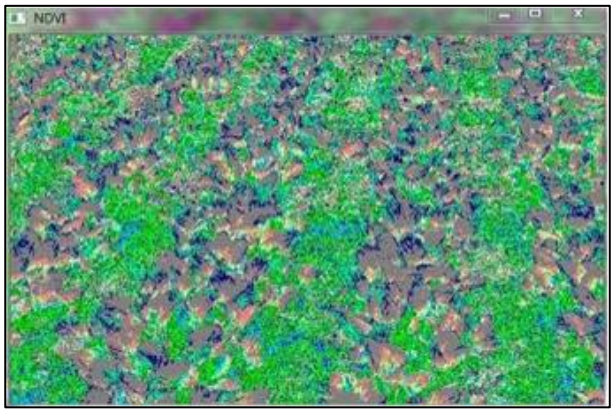


Fig. 3: Result Analysis of NDVI image

| *Color* | *Health of crop* |
|---|---|
| Green | Very Healthy |
| Yellow | Healthy Plants |
| Cyan | Moderate Health |
| Red | Poor Health |
| Pink | Under Stress |
| Blue | Severely Stressed |
| Black | No Plant Matter |

Table 5: NDVI image analysis

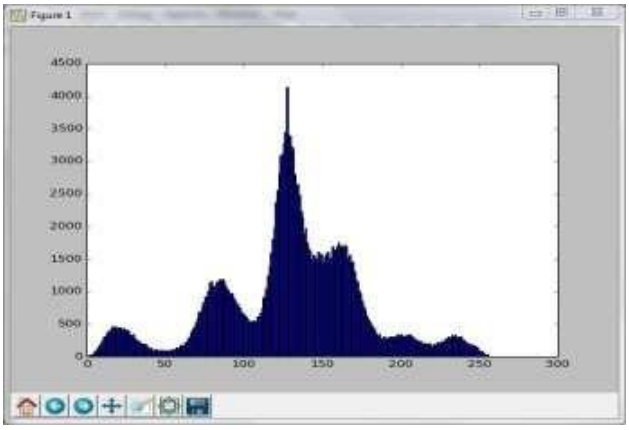


Fig. 4: Color Histogram of NDVI

The above color histogram of NDVI image shows pixel wise distribution of colors like that one can know the amount of colors in overall image.

## VI. CONCLUSION

The crop in farms can be yield very efficiently if the health of crop will be monitored continuously, the IoT based Crop Health Monitoring System is an embedded system based on Internet of Things and having functionality to monitor the health of the crop efficiently and provide the information to the agriculture professionals to strengthen the agriculture sector by e-Agriculture or Agriculture Informatics.

## VII. FUTURE SCOPE

The IoT based Crop Health Monitoring System can be installed on a drone so that this system will able to monitor the health of the grown crop in large area by its one flying operation and the data will be useful for further decision making by the agriculture professional to increase the yield of the grown crop.

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## REFERENCES

[1] Huang, H. Wang, Q. Dai and D. Han, "Analysis of NDVI Data for Crop Identification and Yield Estimation," in IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol. 7, no. 11, pp. 4374-4384, Nov. 2014.
[2] R. K., P. M. M. M and M. R. R. Varma, "Effect of cirrus cloud on normalized difference Vegetation Index (NDVI) and Aerosol Free Vegetation Index (AFRI): A study based on LANDSAT 8 images," IEEE Advances in Pattern Recognition (ICAPR), 2015 Eighth International Conference on, Kolkata, 2015, pp. 1-5.
[3] N. Dlodlo and J. Kalezhi, "The internet of things in agriculture for sustainable rural development," IEEE Emerging Trends in Networks and Computer Communications (ETNCC), 2015 International Conference on, Windhoek, 2015, pp. 13-18.
[4] M. Ghazal, Y. A. Khalil and H. Hajjdiab, "UAV-based remote sensing for vegetation cover estimation using NDVI imagery and level sets method," 2015 IEEE International Symposium on Signal Processing and Information Technology (ISSPIT), Abu Dhabi, 2015, pp. 332-337.
[5] L. Leroux, C. Baron, B. Zoungrana, S. B. Traoré, D. Lo Seen and A. Bégué, "Crop Monitoring Using Vegetation and Thermal Indices for Yield Estimates: Case Study of a Rainfed Cereal in Semi-Arid West Africa," in IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol. 9, no. 1, pp. 347-362, Jan. 2016.
[6] T. Zhao, B. Stark, Y. Chen, A. L. Ray and D. Doll, "A detailed field study of direct correlations between ground truth crop water stress and normalized difference vegetation index (NDVI) from small unmanned aerial system (sUAS)," Unmanned Aircraft Systems (ICUAS), 2015 International Conference on, Denver, CO, 2015, pp. 520-525.
[7] Arnab KUNDU, Suneet Dwivedi, Dipanwita Dutta "Monitoring the vegetation health over India during contrasting monsoon years using satellite remote sensing indices" Arabian Journal of Geosciences 9(2) Springer Publication February 2016, Pages 1-15.
[8] Yongfei Ye, Li Hao, Minghe Liu, Hongxi Wu, Xiao Zhang , Zhisheng Zhao "Design of Farmland Environment Remote Monitoring System Based on ZigBee Wireless Sensor Network" Frontier Computing Springer Publication Volume 375 of the series Lecture Notes in Electrical Engineering pages 405-416.

[9] HG Goh, ML Sim, HT Ewe "Agriculture Monitoring" Chapter Sensor Networks and Configuration Springer Publications 2016 Pages 439-462.
[10] G. Meera Gandhi S. Parthiban Nagaraj Thummalu A Chris 3rd International Conference on Recent Trends in Computing 2015 (ICRTC-2015) "Open Access Ndvi: Vegetation Change Detection Using Remote Sensing and Gis – A Case Study of Vellore District" Procedia Computer Science Elsevier Publication Volume 57, 2015, Pages 1199-1210.
[11] Javier Arroyo, María Guijarro, Gonzalo Pajares "An instance-based learning approach for thresholding in crop images under different outdoor conditions" Computers and Electronics in Agriculture Elsevier Publications Volume 127, September 2016, Pages 669–679.