

Project ID -554

Competitive Research Grant

Sub-Project Completion Report

on

Agricultural Imaging System for Rice and Mungbean Disease Detection and Management in Agro-Field

Project Duration

May2017 to September2018

Electrical and Electronics Engineering Department
Patuakhali Science and Technology University



Submitted to
Project Implementation Unit-BARC, NATP 2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215



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Published in: September 2018

Acronyms

AgRGB	Agricultural Red Green Blue
SMT	Sudipta Manish Taohid
ANN	Artificial Neural Network
CPE	Customer Premises Equipment
IP	Internet Protocol
MSE	Mean Square Error
PSNR	Peak Signal to Noise Ratio
RGB	Red Green Blue
WSN	Wireless Sensor Network

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Executive Summary

The research project entitled as **“AGRICULTURAL IMAGING SYSTEM FOR RICE AND MUNGBEAN DISEASE DETECTION AND MANAGEMENT IN AGRO-FIELD”** has been commenced under NATP Phase-2 with the duration of May, 2017 to September 2018. The project aims to develop a pathological system for crop disease detections and classifications through wireless networking and advanced image processing criteria in agricultural field. Total research project is planned on three main phases: equipments (sensors) assembles and data analysis and image processing; ANN based model development; wireless networking for real time monitoring in agro-field. The wireless sensor networking was incorporated with the research project to obtain soil properties in real- time field investigations. The project collected the disease samples of rice and mungbean from agro- field with the co-operations of Plant-pathology department in Patuakhali Science and Technology University. The analysis and image processing of rice and mungbean disease samples has been completed using the software of Matlab and Visual Studio -2017. The RGB range of rice and mungbean disease samples has been incorporated in the software AgRGB for rice disease detection and classification in agro-field management. Once the percentage of RGB from the affected region is extracted and grouped into various classes, they are classified according to classifiers called Naive Bayes and KNN. Naïve Bayes is used for the classification of rice diseases and KNN for the classification of mungbean diseases. This technique has successfully detected and identified rice diseases and mungbean diseases with an accuracy of above 90%. This technique is efficient and faster because it uses the features of RGB values for the affected portion which requires minimum computation time to identify and classify the diseases. Rather than processing the whole leaf, this technique successfully detects the diseases using only a small sample of leaf containing the affected portion. This research includes the simulation on wireless sensor networking (WSN) using Omnet+ + for automated real-time paddy field monitoring. By using our WSN agriculture field monitoring system, farmers can be able to real-time monitor their field up to 15km without internet. In addition, the networking system is very reliable, efficient and low-cost for agricultural field management.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. Sub-Project title :**Agricultural Imaging System for Rice and Mungbean Disease Detection and Management in Agro-Field**
2. Implementing Organization: Patuakhali Science and Technology University
3. Name and full address of PI and Co-PI with phone no; as applicable

Principal Investigator /Co-principal investigator with phone , cell and e-mail address:

Principal Investigator : **Dr. S.M. Taohidul Islam**
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Co-Principal Investigator: **Dr. Md. Mamun-or-Rashid**
Professor, Department of Basic Science
PSTU
Mobile: 01711466430
E-mail-mrashidpstu@yahoo.com

4. **Sub-project budget(Tk):**
 - a. Total: **21,98,650.00 Taka**
 - b. Revised (if any):

-
5. **Duration of the sub-project:**
 - a. Start date (based on LoA signed): 8th May, 2017
 - b. End date: 30 September 2018

6. **Justification of undertaking the sub-project:**

The incidence of rice and mungbean diseases is considered as very severe due to the adverse effects in agricultural sector. Table 1 shows the common type of rice leaf disease and their symptoms in agricultural field. Table 2 shows the common mungbean disease with causing agents and symptoms. Through the conventional technique, identification of rice and mungbean disease takes time to proceed the analysis in laboratory. The image processing is a powerful tool to quantify affected area by disease, to find shape of affected area in agricultural applications. Very few researches regarding

image processing in plant pathology has been completed in agricultural sector in Bangladesh. So the study will deserve a new area for the model of ANN and wireless sensor networking incorporating with image processing in disease management. Moreover, none of the research includes the sensing of agricultural parameters and near surface soil characteristics together to manage agricultural disease precisely. Hence, the research proposal is to detect and manage crop disease through leaf and plant image processing incorporating with the applications of wireless based soil sensors.

Table 1: Some of the Most Common Types of Rice Leaf Diseases and Their Symptoms

No	Disease Name	Disease Symptoms
1	<p>Bacterial Blight</p>  <p>Fig 2.1: Rice Leaf Affected by Bacterial Blight (Source: Rice Knowledge Management Portal)</p>	<p>This disease causes yellowing and drying of leaves and wilting of leaves as shown in figure 2.1.</p>
2	<p>Blast</p>  <p>Fig 2.2 Rice Leaf Affected by Bacterial Blight (Source: Rice Knowledge Bank, 2016)</p>	<p>The initial symptoms of this disease are white to gray-green lesions or spots, with dark green borders as shown in figure 2.2.</p>
3	<p>Leaf Scald</p>  <p>Fig 2.3: Rice Leaf Affected by Leaf Scald (Source: Rice Knowledge Bank, 2016)</p>	<p>The affected areas dry out and give the leaf a scaled appearance as shown in figure 2.3.</p>

Table 2 Causing agents and Symptoms of Mungbean diseases

S.N.	Name	Image	Disease description
1	Bacterial Leaf spot	 <p>Image Source [11]</p>	Frogeye leaf spot is caused by the fungus <i>Cercosporasojina</i> . Small brown water soaked spots are the basic initial symptoms. Overtime they grow into large roundish spot with grey centers and dark purple margin.
2	Powdry Mildew	 <p>Image Source [12]</p>	This disease caused by the fungus, <i>Podosphaerafusca</i> . Symptoms consist of greyish- white fungal growth on the surface of leaves, stems and pods.
3	Yellow Mosaic		The disease is caused by Mungbean yellow Mosaic virus. Mungbean yellow mosaic disease is characterized by a bright yellow mosaic on the leaves of infected plants

Benefits of Using Image Processing in the Agricultural Disease Detection

A. Accurate DiseaseDetection

Image processing techniques helps to identify diseases more accurately and within small period of time. To identify a disease, one has to take the sample to the experts and wait for their response to start the treatment, which consumes a lot of time. Also some farmers don't have idea about the experts. With the help of image processing techniques, this problem is eliminated and treatment can be started very early. Different image processing techniques have been developed to detect and classify rice diseases.

B. Cost Effective and Non-invasive DiseaseMonitoring

There are several rice and mungbean diseases in Bangladesh including viral, bacterial and fungal. These diseases effect the cultivation of rice and mungbean every year by degrading the quality and

quantity which creates major problem for the farmers as well as the country therefore rice disease should be dealt properly and in time. Disease Management which refers to detection, classification and finally treatment of the disease is very difficult task. To reach the treatment phase of disease management, detection and classification must be done first which is quite challenging. Laboratory based analysis are also tedious, time-consuming and costly for conducting rice and mungbean disease management in agricultural field. Diseases are identified based on colored spots or streaks which can be seen on leaves or stem. Different disease has different colored spots and patterns. Though manual observation can identify disease, it becomes obsolete while considering large fields and non-native diseases. In this case, image processing can be used instead of manual observation. Image processing plays a crucial role in the detection of plant diseases since it provides best results and reduces the human efforts.

Benefits of Using Wireless Sensors Network in the Agriculture Field

A. Cost Justification

To collect data physically from the field is time-consuming and it is very costly for farmers. It needs labour to collect data from the field. Wireless sensors networking reduce time, energy and money. Some actions can be taken through wireless networking from a remote area. Once implementing the system, there is no internet cost.

B. Remote (up to 15km) real-time monitoring

One of the important benefits of using wireless sensors networking in the agriculture field is remote monitoring. Remote monitoring can save lots of time. A farmer can be able to look after more than one agriculture field at a time while just staying at home.

C. Remote sensors data analysis

As data comes through wireless sensors networking, one doesn't need to go to the field by himself to collect and analyze data. It saves labour cost. One can easily take a decision about what type of treatment the paddy field needs from the remote.

D. Easy implementation

This wireless sensors networking system is easy to implement and also easy to maintain. Once this system is implemented there is no internet cost and the maintenance cost is affordable for the

farmers.

7. Sub-project Goal: Improvement of the existing rice and mungbean field management system with the development of farmers knowledge level and awareness through ICT

8. Sub-project objective(s):

Objectives	Activities in relation to objectives
1.To develop Software on image processing for rice and mungbean disease detection and classification	<ol style="list-style-type: none">1. Disease pattern findings and analysis of disease based on RGB and affected area2. Find out the way and criteria of software3. development The algorithm of the software4. development5. Rice Disease Detection and Classification option in the Software Mungbean Disease Detection and Classification option in the Software
2. To establish Wireless networking system	<ol style="list-style-type: none">1. Wireless networking devices assembled properly.2. Sensor devices are interfaced with wireless network and data can be received through wireless network.3. Photo of rice leaves can be obtained from agro-field through IP camera
3.To obtain ANN model in disease classifications	<ol style="list-style-type: none">1. Analysis of ANN model has been carried out through MATLAB software

9. Implementing location (s):

i. Electrical and Electronics Laboratory
Patuakhali Science and Technology University
Dumki, Patuakhali

ii. Agricultural field at Dumki Upazilla, Patuakhali
Agricultural field at Latachapli, Kalapara
Agricultural field at Ghatkhali, Chaora Amtali
Agricultural field at Nalua Union in Bakergonj Upazila

10. Methodology in brief:

The methodology is divided into two sections. Methodologies of the research includes rice disease detection and classifications in the first section and methodologies regarding mungbean disease detection and classification are shown in the 2nd section. The total research project is planned on four

main phases: **equipments assembles and laboratory based analysis; wireless sensor networking for agro-field characterization; ANN based model development; image processing for rice and mungbean disease detection.** The research project developed wireless sensor networking to obtain soil properties in real-time field investigations. The project collected the disease samples of rice and mungbean from agro-field with the co-operations of Plant-pathology department in Patuakhali Science and Technology University and completed the analysis and image processing of rice and mungbean disease samples using Matlab and Visual Studio 2017. The research also obtained the solution on image processing to get RGB range through Matlab software. A software AgRGB has been developed through Visual .NET programming based on the proposed algorithm for rice and mungbean disease detection and classifications.

i. Equipments assembles and Laboratory based Analysis

The research includes the procurement of different sensors including moisture sensors, pH sensors, conductivity meter and IP camera in the project. Wireless sensor networking system has been completed to obtain soil properties with the configurations and assemble of various components and equipments in Electrical and Electronics Engineering (EEE) laboratory of PtuaKhali Science and



Technology University.

Figure 1. Field survey and equipments assembles in the field

Figure 1 shows that the moisture contents of soil can be obtained from agro-field through wireless networking. To collect real data of rice disease samples, the field area were selected in the agricultural field nearby Patuakhali Science and Technology University for disease samples collection as shown in Figure1.



Figure 2. Soil characterizations through digital meter in mungbean field

Near surface soil characteristics was obtained using sophisticated digital meter in agricultural field. The Moisture level of the soil has been obtained digital moisture meter as shown in Figure. 2 which have a measurement range of 0 to 50% with 0.1% resolution. The microprocessor circuit of the moisture meter ensures highaccuracy.

Image acquisition is the initial step of image processing. The color images of rice leaves were manually captured using camera from paddy field in Patuakhali as shown in Figure 3 where some of the disease samples were collected by us from the Department of Plant Pathology (Faculty of Agriculture).



Figure 3. Image acquisition from paddy field in Patuakhali



Figure 4. Mungbean disease samples collection in the field

The research project collected the disease samples of mungbean as shown in Figure 4 consulting with the pathological experts Professor Dr. Shahidul Islam, Professor, Plant Pathology Department in Patuakhali Science and Technology University. The solution of real time monitoring of agro-field has been performed successfully in the research project.

ii. Wireless sensor networking for agro-field characterization

The proposed system architecture has different types of sensors in the agriculture field as shown in Figure 5.

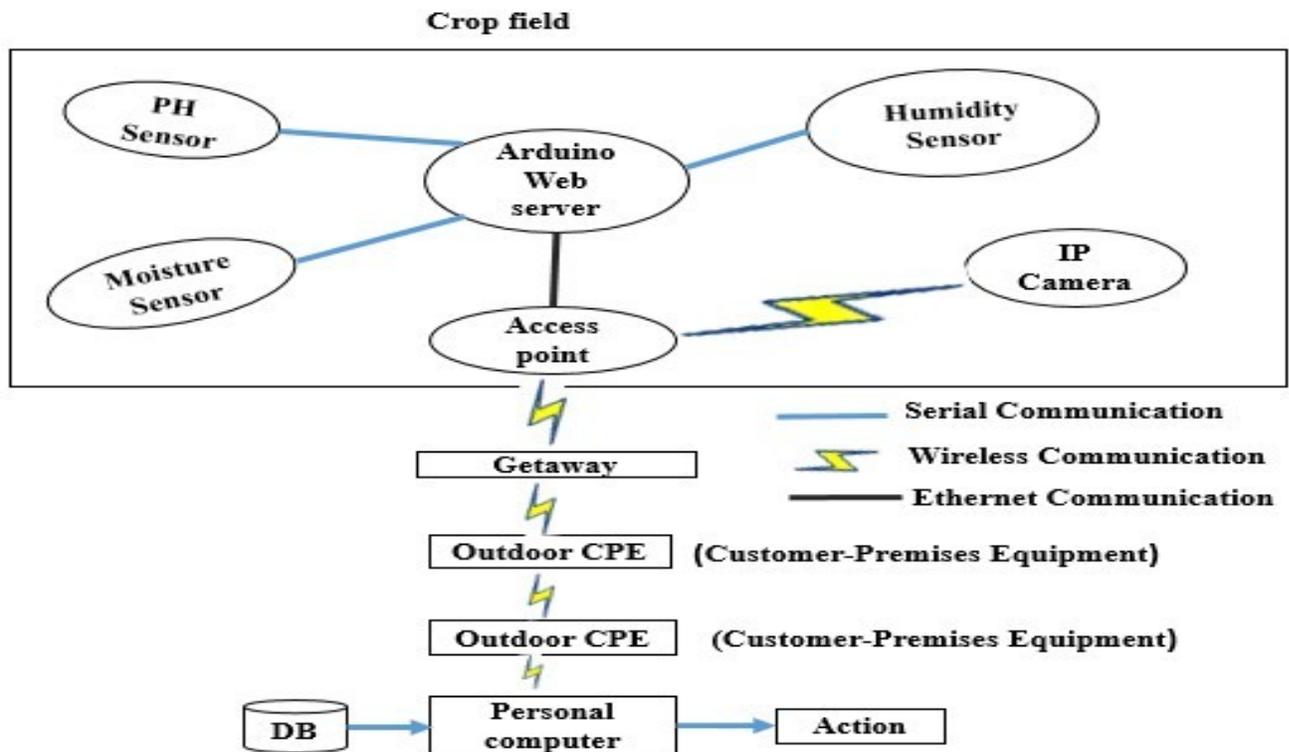


Figure 5. The flow-chart of Real-time agriculture field monitoring

Figure 5 shows how the sensors sense the physical phenomenon such as pH, humidity, moisture, the temperature of an agriculture field. The sensed data from different areas of the field is sent to the Arduino web server via serial communication. Arduino web server analyses those data and takes necessary actions if the data is not normal. Then data is sent to access point via Ethernet communication. IP cameras are connected Via Wi-Fi to the access point. Those data are sent to an outdoor CPE. 1st CPE (works as an access point) copies the signal and sends to another CPE (works as a client). Personal computers and mobile receive data from 2nd CPE. Then data are analysed in the personal computer and some actions can be taken.

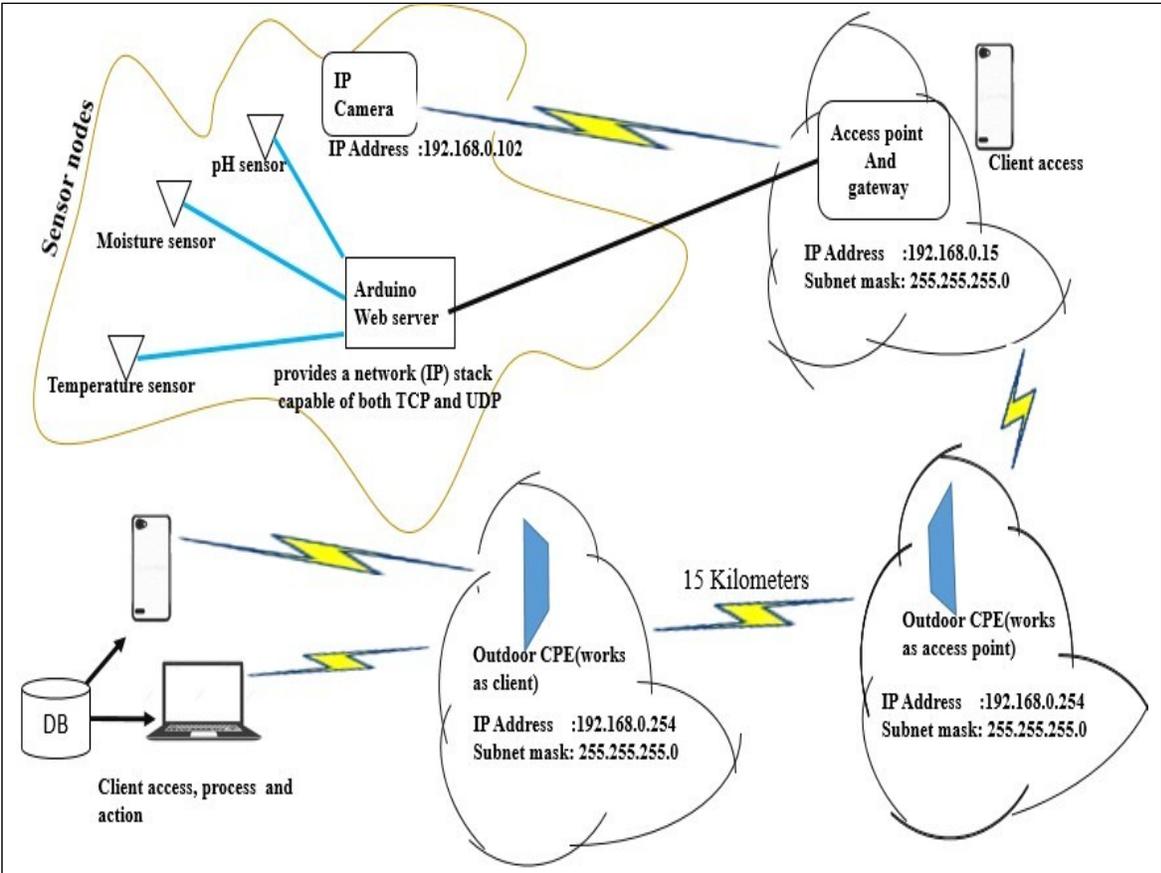


Figure 6. A typical view of wireless sensors networking for image and data acquisition in field

Figure 6 shows the general idea of wireless sensor networking for image and data acquisition in agricultural field. According to the model, the data sensing is to sense and combine data coming from multiple sensors, process them and send them ahead of destination.

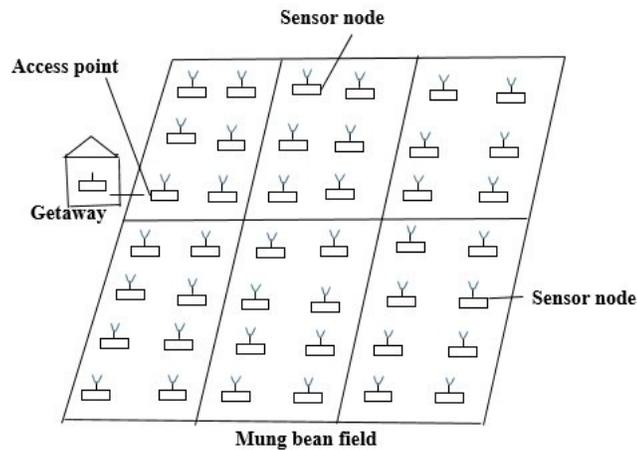


Figure 7. Example of a grid topology deployment in the agricultural field

It is important to install sensors and routers by maintaining a good topology. We have used Grid topology for installing wireless sensors in the agriculture field. To find the actual condition of an agriculture field we needed to collect data from all over the field. The important issues for wireless sensors networking application are to maximize the network lifetime and minimize the end-to-end network delay through grid topology as shown in Figure 7.

As we get real-time data and video through WSN, the video is segmented into frames because images are required for image processing due to disease detection. Figure 8 describes the operation of wireless sensors networking for image and data acquisition due to the agriculture field management. Here the rectangular and the diamond symbol represent the steps and decision respectively. Images are separated as frames from real-time video and stored in a folder. For keyframe extraction , an inputvideo

sequence $S_i(i=0, 1, 2, 3, \dots, N-1)$ is given which contains N number of frames. If i is the index of the

frame f_i is the feature vector of i -th frame. For representing visual content, a feature vector f_i is then

calculated for every new frame.

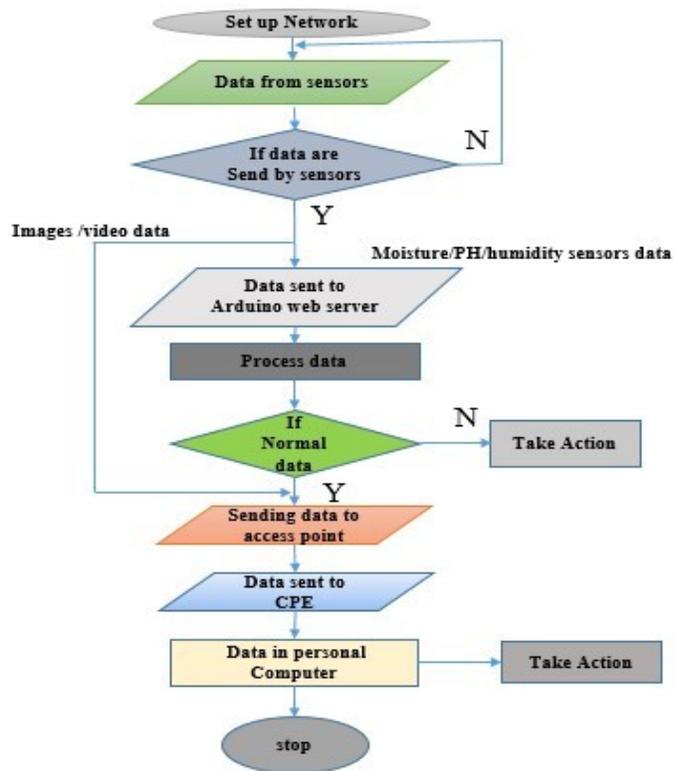


Figure 8. Flow chart of the image and data acquisition through wireless sensor networking

Real-time monitoring of an agriculture field, acquiring 1D data and 2D (video and image) data from field and sending those data more than 15 Kilometres long using Wi-Fi technology is a challenging task. To send data to such a long distance we use Customer-premises Equipment (CPE). It is a point topoint wireless communication system. This outdoor CPE has 13dBi 2x2 dual-polarized directional MIMO antenna which helps to create more than 15 Kilometres wireless communication.

Frame extraction from video streaming is also an important issue here because we need frames for image processing to detect diseases. For irrigation issue, in a regular agriculture field people have to irrigate all over the field but in this proposed method people could irrigate in a particular section of the field according to the sensor data. It saves water and energy for agricultural field management. The proposed method has been shown as a cost-effective and reliable system comparing to the other usual system.

It is also important to know the acid level of the soil to provide a certain amount of fertilizer in a certain area of the agriculture field. Figure 9 shows the experimental setup to receive the pH data using pH sensors from agricultural field. The temperature of the environment is an important element to the farmers. The temperature of the environment can be detected using temperature sensors connecting with wireless networking. Two outdoor CPEs play an important role here by sending data from a really long distance.



Figure 9. Experimental setup to receive pH data from agricultural field

We used IP cameras, various sensors (like moisture sensors, pH sensors, cameras), Arduino Uno, routers, two outdoor CPEs, software like visual studio, Arduino ide, Omnet++ to conduct the research on wireless sensor networking. IP cameras are used to capture photos and real-time videos as shown in Figure10.

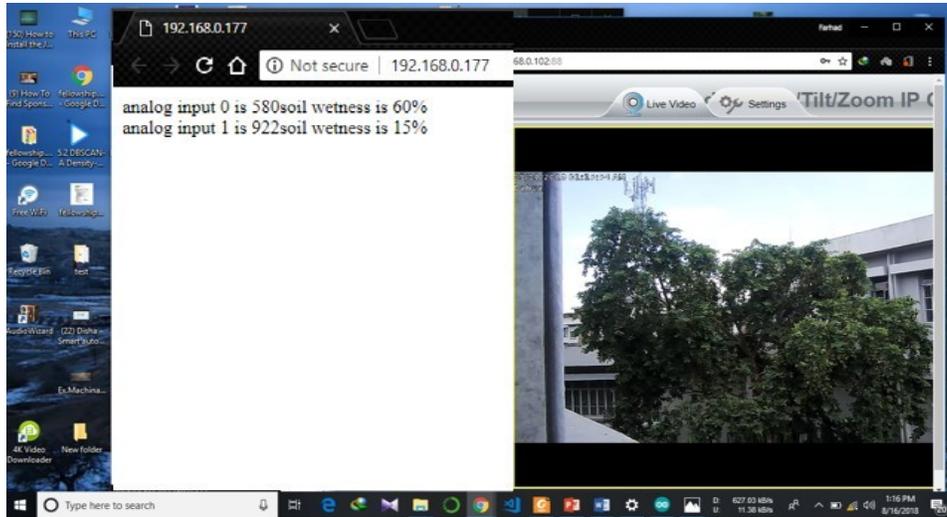


Figure 10. Implementation view of the Real-time monitoring

When the user calls the IP using a mobile device or laptop PC, the web server responds and sends data. Figure 10 shows an implementation view of real-time monitoring through IP camera. IP addresses help to communicate between IP camera and access point (router). And other sensors sense physical phenomenon and send it to Arduino. Arduino processes sensor data and makes the decision for the management of the agriculture field. This automated system helps to achieve power optimization.

iii. ANN based model development

To reveal the exact causes of crop diseases, soil properties and disease symptoms were investigated and recorded with agro-based innovations. ANN model was incorporated for rice and mungbean disease management with early prediction criteria through the analysis of Matlab software in Patuakhali Science and Technology University.

Naive Bayes classifier has been implemented for rice disease classifications into various categories. Gaussian Naive Bayes classifier with density function is far simpler for disease classifications as Eq. (1)

$$P(x, y) = \frac{1}{\sqrt{2\pi} \sigma_y} \exp\left[-\frac{(x - \mu_y)^2}{2\sigma_y^2}\right] \quad (1)$$

where, μ is the mean and σ is the standard deviation of the functions. The algorithm for this process is shown in Figure 11.

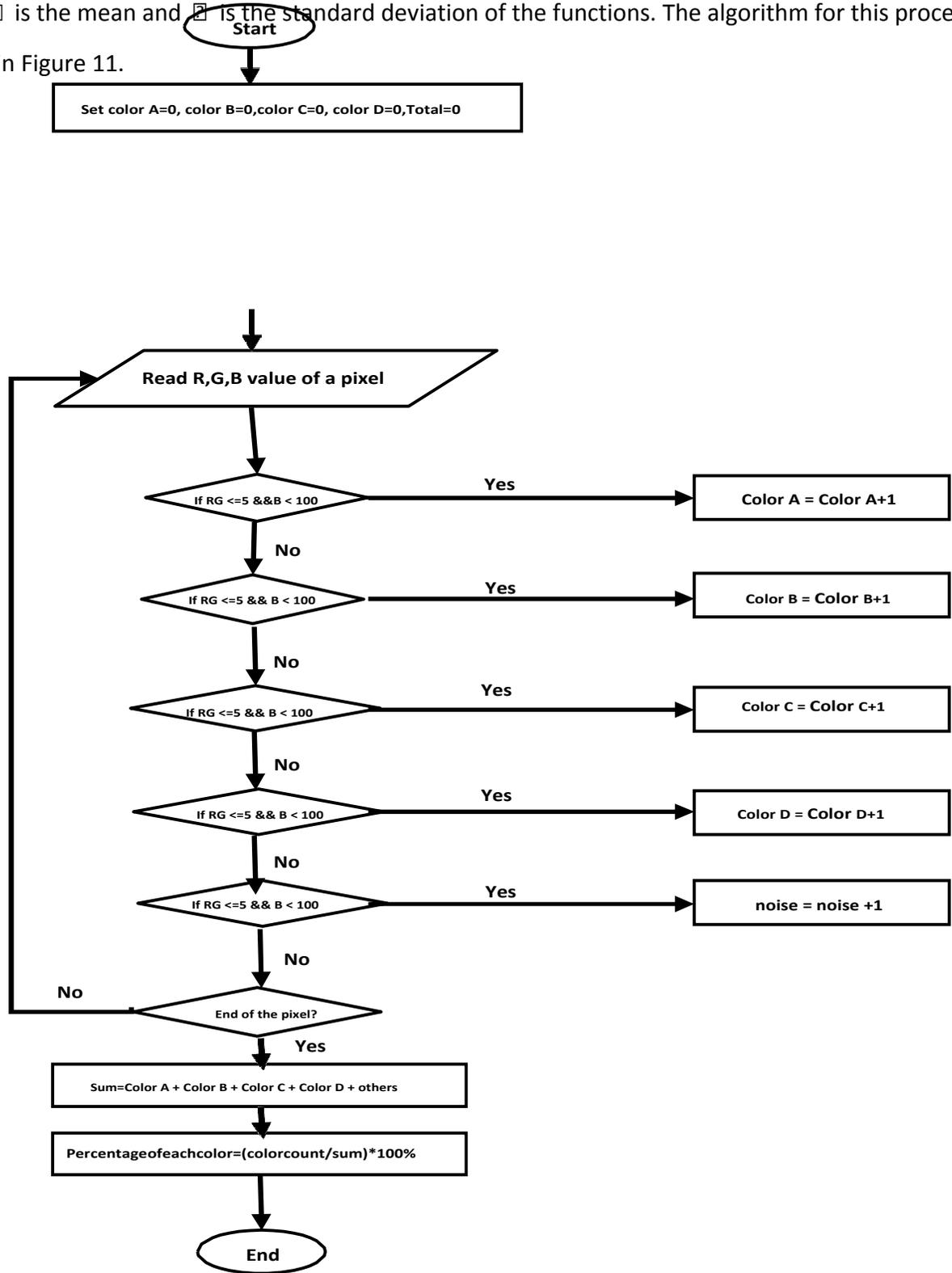


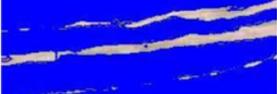
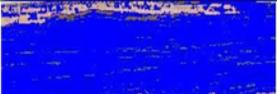
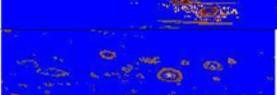
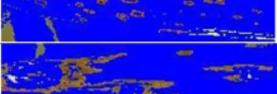
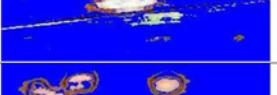
Figure 11. Algorithm of RGB percentage calculation

iv. Image Processing for rice diseasedetection

After obtaining images of different diseases, image processing was completed through Matlab and Visual .NET in the research. Rice disease samples had been obtained through the field survey and the co-operationsofpathologicalexpertinPatuakhaliScienceandTechnologyUniversity.Table3shows

the obtaining of threshold of RGB, mean and variances of color ranges through Matlab analysis for the affected area of rice disease samples.

Table 3 Finding Threshold RGB value through Matlab analysis

Image	Masked	mean	variance	Disease
		96.80	13360.63	Bacterial Blight
		97.35	12771.09	Bacterial Blight
		98.49	11656.38	Bacterial Blight
		85.97	12634.80	Brown Spot
		86.98	12059.84	Brown Spot
		85.25	12152.63	Brown Spot
		85.82	11398.82	Rice Blast
		91.34	13008.65	Rice Blast
		92.08	13309.34	Rice Blast
		91.63	11318.68	Rice Blast

The successful analysis had been implemented through the MATLAB software. The sample images are filtered according to the Gaussian function and σ is set to get the better results in noise reduction criteria. Here function of Gaussian filter is implemented as stated in equation(2).

$$G(x, y) = \frac{1}{2\sigma^2} e^{-\frac{[(x-x_0)^2 + (y-y_0)^2]}{2\sigma^2}} \quad (2)$$

Threshold RGB value had been set with the help of Color Thresholder Application in MATLAB software.

v. Image Processing for mungbean diseasedetection

The leaf of Mungbean plant was used for analysis in order to detect and classify various diseases. We collected images of leaf from fields as well as internet. We collected around 100 images of leaf sample affected by various diseases. We needed to analyze only the affected portion of leaf to detect various diseases. So it is unnecessary to examine the whole leaf. Therefore, we crop the collected leaves to outcast unnecessary objects from the image hence obtain the interesting region. Also the captured image has higher resolution which takes more time to process. So we resize all the image into a standard of 300*200 pixel.

Green pixels are considered healthy therefore is masked with some other pixel as shown in Figure 12. By analyzing the leaves we set a threshold specially for mngbean leaves to mask the healthy portion. In this process each pixel is evaluated and if the RGB value of the pixel exceed the threshold then zero value is assigned to red, green and 255 is assigned to blue component of the pixel. Here we masked the green pixel with blue color rather than black to avoid any collision between masked pixel and diseased pixels as some leaves may have black pixel due to certaindisease.

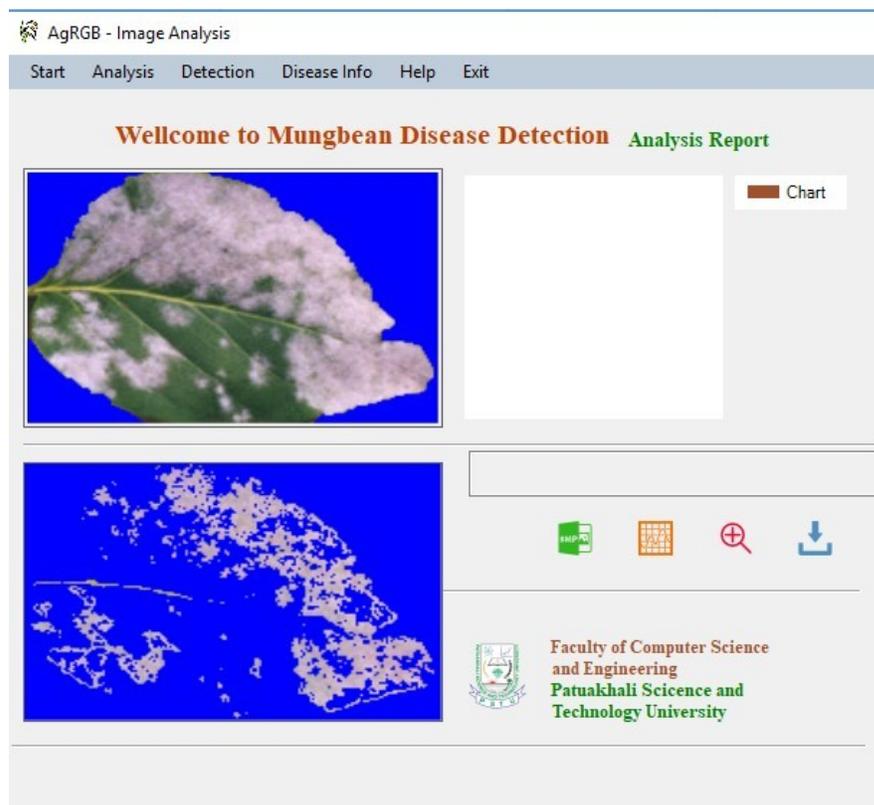


Figure 12. Masking the Healthy Pixels of mungbean leaves

a. Obtaining AgSMT image from RGB image and feature extraction

We obtained AgSMT representation of an image by developing an RGB to AgSMT conversion algorithm. The working of the algorithm is given in Figure 13. In this algorithm, the RGB value of each pixel is obtained and is compared with threshold values of all the four categories of color combinations in AgSMT model. We also used our obtained dataset to train a KNN classifier. KNN classifier is used because KNN algorithm is very simple robust and well suited for our dataset. In KNN Similarity among the data is defined according to a distance metric between two data points. A popular choice is the Euclidean distance given by equation (3).

$$d(x, x') = \sqrt{(x_1 - x'_1)^2 + (x_2 - x'_2)^2 + \dots + (x_n - x'_n)^2} \quad \dots\dots\dots(3)$$

The algorithm runs through the whole dataset computing d between x and each training observation. It then estimates the conditional probability for each class given by equation (4).

$$P(y = j | X = x) = \frac{1}{K_{\text{NeA}}} \sum I(y^{(i)} = j) \quad \dots\dots\dots(4)$$

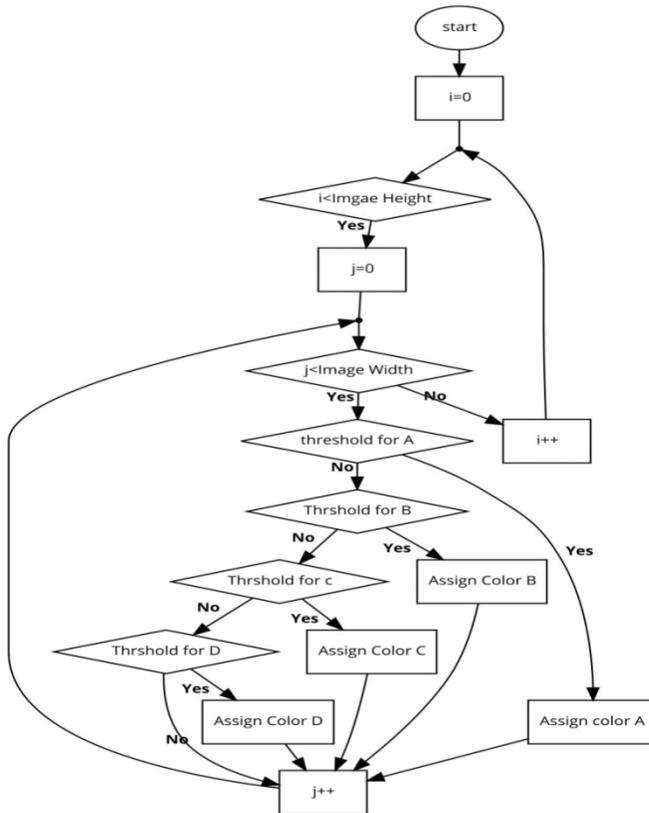


Figure 13. RGB to SMT Conversion Algorithm

The pixels are then placed in the corresponding categories and color of that pixel is replaced by the color used to represent that category. In this way, we get the AgSMT representation of an image. Figure 14 shows the Ag-SMT representation of diseased sample leaves. The pixel count in each category of the Ag-SMT image is used as feature for K-NN classifier. Figure 14 shows the visualization of a portion of sampled data.

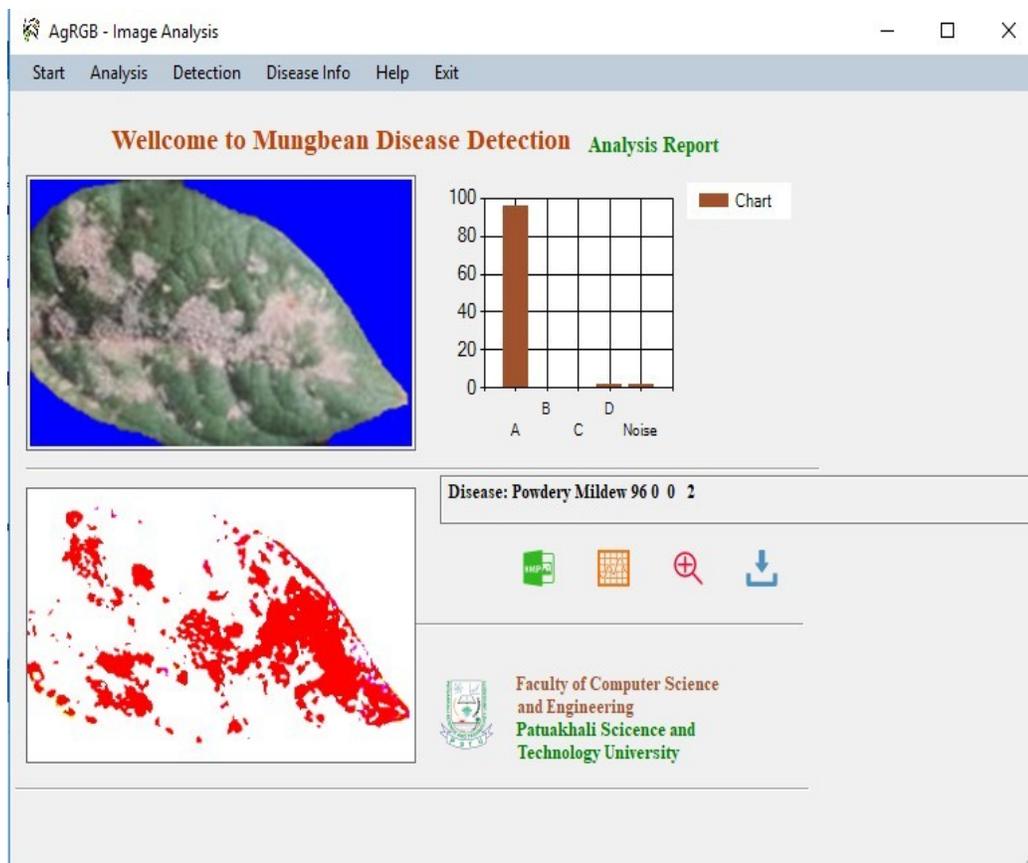


Figure 14. RGB to AgSMT conversion using our software

The number of pixels in each category is obtained and their percentage is calculated. The percentage of pixels inside each category is calculated using the following formula:

$$\text{Percentage of each category} = (\text{number of pixels in that category} / \text{total number of pixels in all the category}) \times 100\% \dots \dots \dots (5)$$

The percentage values thus obtained for each category is used as features to train the classifiers.

b. Color combinations for disease detection and classification

The number of pixel has been counted for new color combinations obtained from red, green and blue color. The color combinations are divided into multiple classes for mungbean disease classifications. A threshold depends on 6 parameters. Red, blue, Green, rg, gb, br

First we get red, green, blue from the pixel

Rggbbr are calculated as follows

```
rg = Math.Abs(red - green);
```

```
gb = Math.Abs(green - blue);
```

```
br = Math.Abs(blue - red);
```

Now using these parameters we set Color combination of A,B, C and D.

```
if(rg<= 5 && blue < 100)
{
black++; // color A
Img.SetPixel(i, j, Color.FromArgb(0, 0, 0));
}
else if (red > 140 && green > 140 && blue > 140)
{
w++; // color B
Img.SetPixel(i, j, Color.FromArgb(255, 0, 0));
}
else if (rg> 0 &&rg< 10 && red > 98 && green > 98 && blue < 190)
{
yl++; // color c
Img.SetPixel(i, j, Color.FromArgb(238, 255, 0));
}
else if (rg> 0 &&rg< 150 && blue < 150)
{
grey++; // color D
Img.SetPixel(i, j, Color.FromArgb(255, 0, 220));
}
```

Using this threshold values of six parameters, the combination of Color A, B, C and D has been done more efficiently. But it needs some more inspection and tuning to implement in the software. As the software was not our main focus we did not tuned it in its full potential. The table 4 shows some classification result according to the proposed methodology.

Table 4 Classification results as detected by proposed technique

Disease Name	Leaf Sample	Processed Sample	Extracted Features				Detection result
			Color A	Color B	Color C	Color D	
Bacterial Leaf spot	BL1	P1	52	14	11	21	Bacterial Leaf Spot
	BL3	P3	50	7	1	40	Bacterial Leaf Spot
	BL7	P6	42	0	0	56	Bacterial Leaf Spot
	BL9	P9	0	0	3	96	Yellow Mosaic
Powdery Mildew	PM1	P10	94	0	0	3	Powdery Mildew
	PM2	P11	88	1	0	9	Powdery Mildew
	PM3	P12	97	0	0	1	Powdery Mildew
	PM4	P13	93	0	0	5	Powdery Mildew
Yellow Mosaic	YM1	P14	11	9	6	72	Yellow Mosaic
	YM2	P15	8	5	5	81	Yellow Mosaic
	YM3	P16	8	13	11	65	Yellow Mosaic
	YM4	P17	4	12	14	68	Yellow Mosaic

11. Results and discussion:

This research work is significant due to the applications of wireless sensor networking and image processing. The use of WSN with Wi-Fi technology in agriculture field is an efficient and reliable system for real-time monitoring.

a. Soil pH and moisture contents through wireless sensor networking

Soil pH values and moisture contents are obtained from agricultural field through wireless sensor networking. It is clear that there is a negative relationship between pH and moisture. The results of soil characteristics have been obtained from the installed pH sensors and the moisture sensors in the field as shown in Figure 15. The sensor data appears in the client computer via a wireless sensors network.

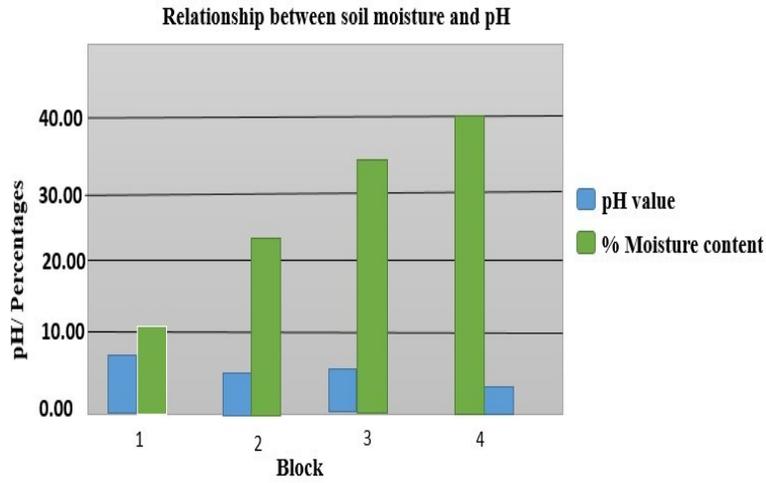


Figure 15. Relationship between soil moisture and pH

Figure 16 shows that when soil moisture increases soil pH decreases. According to the testing data when moisture 40 % then pH falls to 2. Similarly when soil moisture contains 10% then pH rises to 8. From this analysis, we can say that there is the relationship between soil moisture and soil pH.

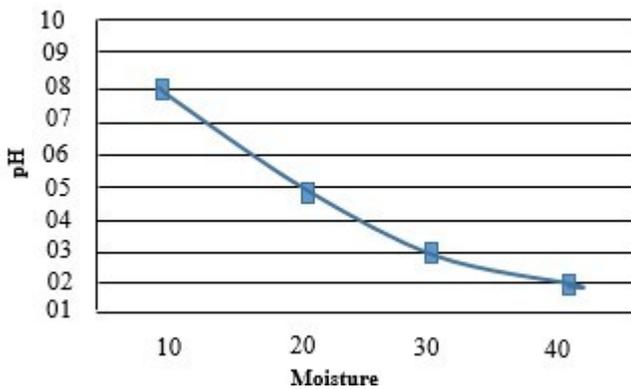


Figure 16. Soil moisture and pH analysis

We have successfully done field test at PSTU (Patuakhali Science and Technology University, Bangladesh). We get plant leaves images from agricultural field using WSN to analyze the images in computer. Our research objectives include plant disease detection using image processing and ANN model. This work will be helpful for farmers to easily find out plant disease.

b. Automated Image Processing with GaussianFilter

Automated rice and mungbean disease detection also includes the Gaussian filter for obtaining better

performance in image processing. Using of Gaussian filter shows innovations to reduce noise for image processing of rice and mungbean leaves. The performance of Gaussian filter has been compared with various filter performance based on Mean Square Error (MSE) and the Peak Signal to Noise Ratio (PSNR). The function for MSE and PSNR are shown in equation (5) and (6) respectively.

$$MSE = \frac{1}{MN} \sum_{y=1}^M \sum_{x=1}^N [I(x,y) - I'(x,y)]^2 \quad (5)$$

$$PSNR = 20 \cdot \log(255 / \sqrt{MSE})$$

(6) Where $I(x,y)$ is the original image, $I'(x,y)$ is the approximated version and M, N are the dimensions of the images. These measures give simple mathematical deviation between original image and reconstructed image. For finding the values of MSE and PSNR first the original image was corrupted by mixed noise. Then the values of MSE and PSNR for different noise ratios were calculated using MATLAB software as listed in Table 5.

Table 5 Noise ratio, MSE and PSNR

Noise Ratio (%)	MSE	PSNR
10	3.142	43.024
20	3.875	39.872
30	4.793	38.295
40	5.375	37.136
50	6.361	36.431

From the table 5 it could be said that Image with lower MSE and a higher PSNR is considered to be the better one. Now by calculating the MSE and PSNR values for different kind of filtering techniques (Gaussian filter, Median filter and Wiener filter) the following table 6 is presented.

Table 6 Filter technique with MSE and PSNR

Filter	MSE	PSNR
Median Filter	7.17	39.5764
Gaussian Filter	5.66	40.898
Wiener Filter	7.96	39.119

As it was stated that an image with lower MSE and a high PSNR is considered to be the better one, we came to a conclusion that Gaussian filter would be more reliable for this research. There is one single image in Fig. 17 where Gaussian filter is used with different values of σ (0.1, 0.5, 1, 1.5, 2, 3). From Figure 17, it can be seen that if the value of σ is increased the image becomes more blur and the image details are removed.

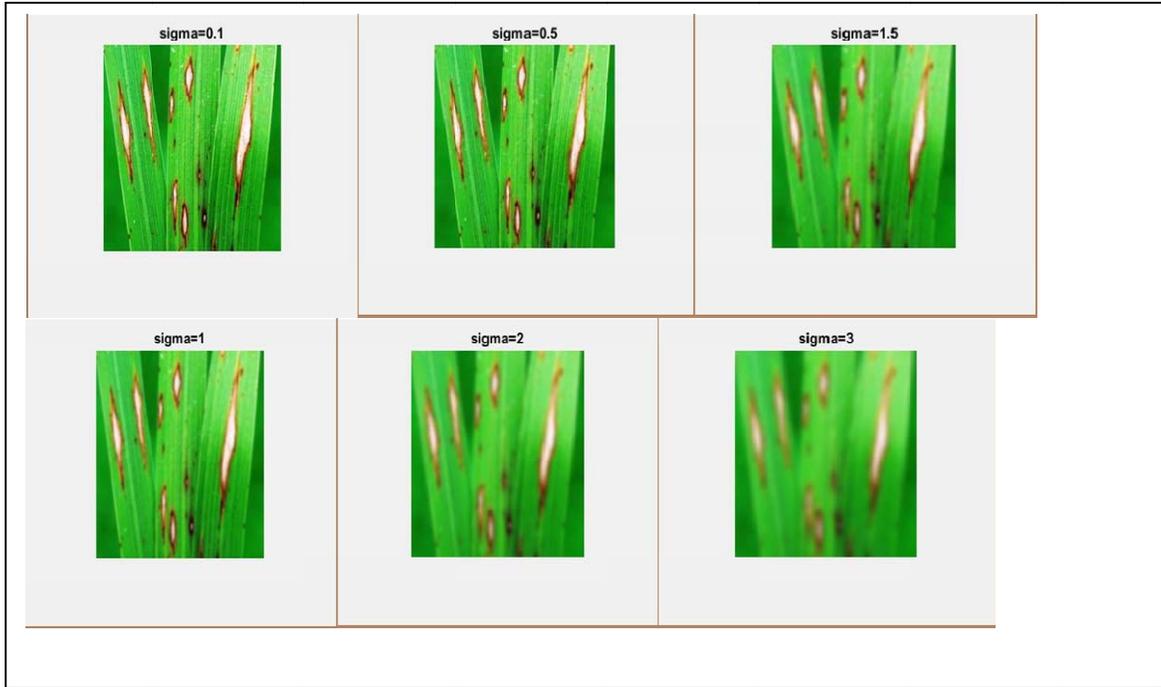


Figure 17. Different values of σ used for Gaussian filtering

The table 7 indicates that the value of PSNR for $\sigma = 0.5$ is the highest so the image having the value $\sigma=0.5$ is the best among the rest. This is the reason why we have chosen the value of σ as 0.5 for the research.

Table 7 Value of σ and PSNR

Value of Sigma (σ)	PSNR
0.01	33.407
0.05	33.38
0.1	33.404
0.3	33.467
0.5	35.897
0.7	35.679
1	33.902
1.5	31.714
2	30.830

A research based analysis on pixel values (RGB) of colored image has been conducted for detecting the rice and mungbean leaf disease using the MATLAB software. In preprocessing step, Gaussian filter

was applied with congenial σ to reduce noise as it is considered to be more effective than other filtering techniques to reduce sensor/camera noise. In disease detection and grading step first the threshold RGB values of healthy green leaf is set. Each and every pixel value of input image is compared with this threshold RGB value to detect the disease. A percentage of the affected portion in the image is also calculated. In order to get more accurate result two different ranges of threshold RGB values are set for two different sample classes (sapling and plant). The software AgRGB has been developed based on the proposed algorithm, AgSMT incorporating with image processing and ANN model which will be able to detect and classify the type of rice and mungbean disease more accurately.

c. AgRGB software development for RICE and Mungbean diseasemanagement

The software is based on new technique of detecting and classifying of rice and mungbean disease by directly using the percentage of RGB value of diseased portion. The software has been developed through the programming of Visual .NET. Unlike other techniques which are based on calculation of total area of leaves, this technique is based on percentage calculation. Therefore, it is efficient and lot faster than other technique as it can detect and classify disease from a small sample of leaf containing diseased portion.



Figure 18. AgRGB for rice and mungbean disease detection and classifications

The nobility of the software AgRGB includes the phenomenon of increased efficiency, faster detection and simpler implementation and reduced sample size. The new technique is based on “color percentage” of affected portion, so the small portion of leaf containing the diseased region can be used to detect disease accurately. From Figure 18, we can conclude that the technique is independent of sample size to detect diseases successfully as long as there is affected portion in the sample.

Matlab analysis shows how the disease detection and classification technique is performed through RGB analysis with ANN model in agricultural applications. The percentage of different color class obtained above is fed into Gaussian Naïve Bayes and using neural network, different diseases are detected and classified. Table 8 shows the criteria of disease classification based on RGB in image processing.

Table 8 Disease Classification based on ANN model

SL No	Name	Image	Color A	Color B	Color C	Color D	Detected Disease
1	Bacterial Blight	<p>Bacterial blight is a bacterial disease which is caused by bacterium called <i>Xanthomonas oryzae</i> pathovar <i>oryzae</i>. The basic symptom of bacterial blight is the wilting of seedlings and yellowing and drying of leaves.</p>  <p>Image source [5]</p>	75%	3%	1%	21%	Bacterial Blight
2	Rice Brown Spot	<p>Brown Spot is a fungal disease caused by <i>Bipolaris oryzae</i>. The basic symptom is the formation of minute spot on the leaf blade, leaf sheath, etc which later becomes cylindrical or oval dark brown or black spots.</p>  <p>Image source [6]</p>	0%	8%	14%	78%	Brown spot
3	Rice Blast	<p>Blast is a fungal disease which is caused by the fungus called <i>Magnaporthe oryzae</i>. All the parts above the ground can be affected by rice blast. The basic symptom is Diamond-shaped or elliptical or spindle-shaped spots with gray or white centers and brown margins</p>  <p>Image source [7]</p>	35%	1%	1%	63%	Rice Blast

The proposed system is compared with some existing rice disease detection tool using image processing shown in the Table 9. We were able to successfully detect and classify different types of rice and mungbean diseases using the proposed technique in this research. The disease detected and classified so far are rice blast, rice bacterial blight, and rice brown spot. The efficiency of this technique for classifying different diseases is given below in Table 9.

Table 9 Classification accuracy of the method implemented in AgRGB

Disease	Classification Accuracy
Rice Blast	Above 90%
Bacterial Bligh	Above 92%
Rice Brown Spot	Above 89%

Efficiency of classification may vary upon image’s light, contrast, and capturing angle which affects the color of the image. Though there is no automated technique to detect and classify mungbean diseases, some researchers proposed the technique for specific rice disease detection. AgRGB software performance has been compared with their proposed techniques outcomes. Comparison in the Figure 19 shows that AgRGB software based on AgSMT algorithm performs as an efficient technique comparing with other proposed technique is rice disease detection.

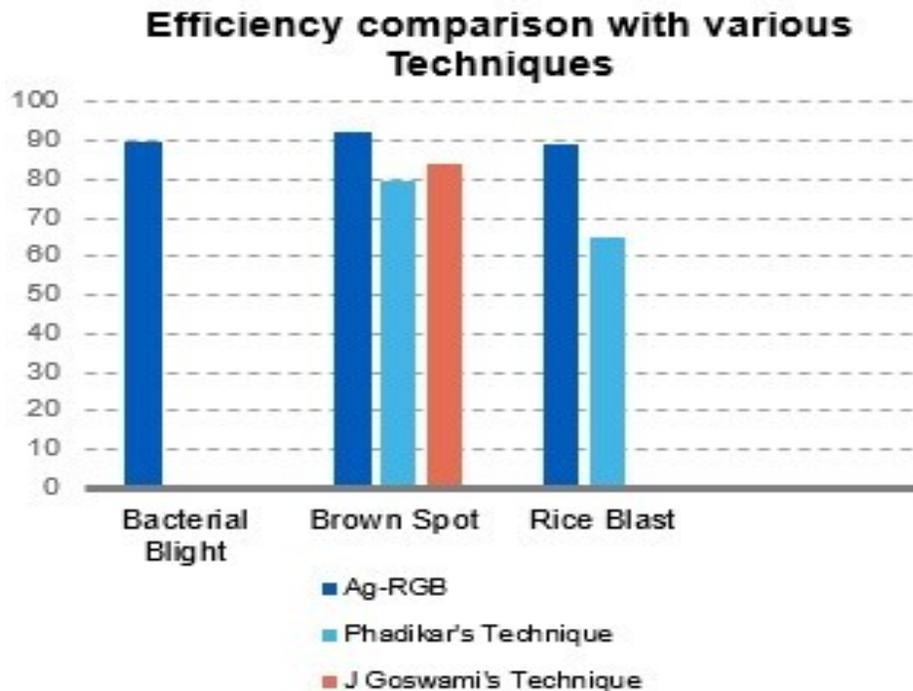


Figure 19. Comparison of AgRGB with other techniques

The objective was to develop an efficient technique for disease detection of rice and Mungbean plant using the colored images of leaves. AgRGB software includes the two menu bars for rice and mungbean disease detection and classifications. Table 8 shows how rice disease has been classified using the color combination of A,B,C,D in ANN model which color has been obtained as the newly developed

algorithm in the research. Since rice and mungbean diseases have their own distinct visual characters i.e. different rice and mungbean diseases can be differentiated from one another visually, there were problems in using RGB model. The RGB color model produces broad array of colors by adding three lights i.e. Red, Green and Blue which are also known as primary colors. Each light has intensity level from 0 – 255. By varying the intensity of these lights, around 16M colors can be produced. So, a pixel is represented by one of the 16 million colors. The first problem with this is that there are millions of colors in RGB and therefore it is computationally tedious and inefficient to analyze all the colors. But if we used only the percentage of Red, Green and Blue in a leaf, then the features were not enough to classify various rice and Mungbean diseases. To address these problems, we developed a new color model which is a derivation of RGB model in which all the colors from RGB are categorized into only four categories as shown in Figure 20.

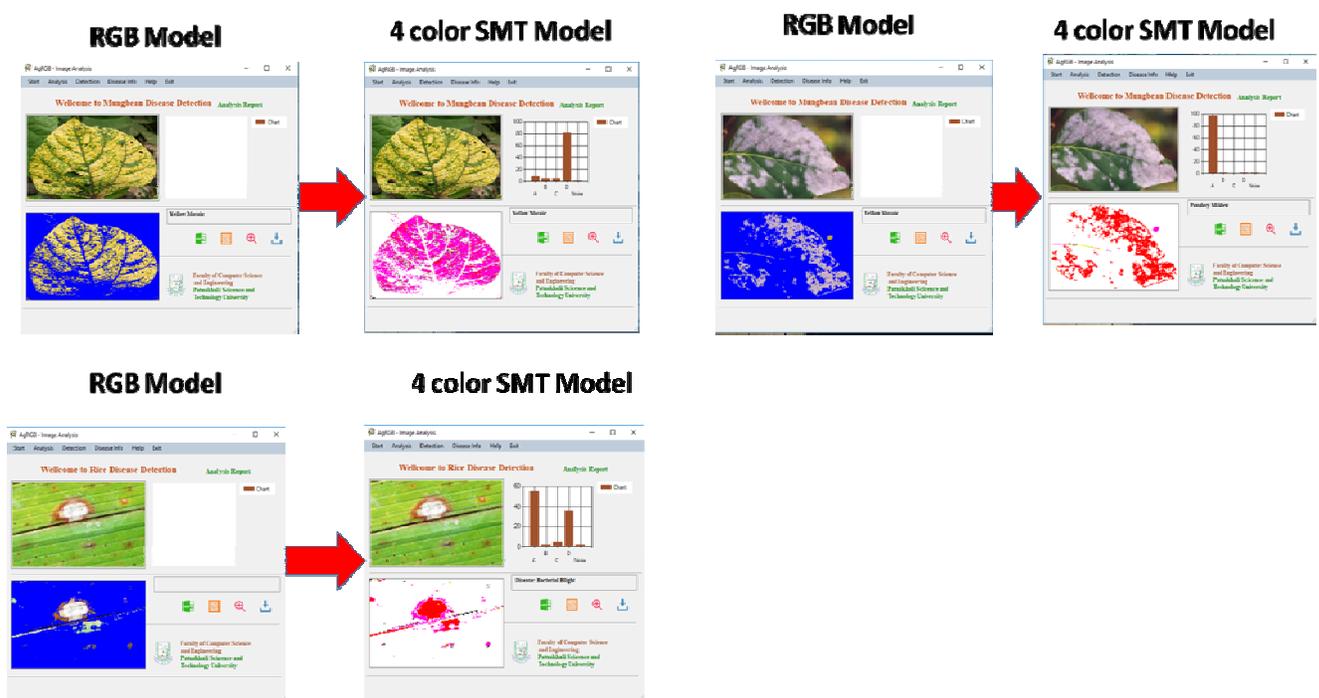


Figure 20. Image processing in AgRGB software based on AgSMT model

The image of around 150 leaves from rice and Mungbean collected from cultivation field as well as internet were used in ANN model where 70% of those images were used to train the classifier and remaining 30% of the images were used for testing. While analyzing the leaves, we categorized the pixels of the affected area into only four classes of colors namely Color 1, Color 2, Color 3 and Color 4 because most of the rice and Mungbean diseases can be classified by observing only the percentage of pixels (of infected region) belonging to these four classes. Number of classes can be increased to detect additional diseases and increase efficiency. As an example, different diseases have different values for the four color categories. For instance, the value for different categories of colors in YM are: 13,0,4,9 whereas the values for PW are:56,0,9,8. The classifier analyzes these variations in values for different diseases while training and later on predicts the diseases accurately for new samples.

In AgSMT model, each category of color has its own predefined threshold value. According to these threshold values, colors represented in RGB model are mapped into different categories of AgSMT model. That means there are only four colors to consider while analyzing a leaf and it is computationally easy and reliable. Also in this technique, image processing of the complete leaf is not required. Only the infected portion of leaf is analyzed to classify diseases successfully into an AgSMT image. The four categories were defined specially for the detection and classification of Mungbean diseases. These four categories can be modified to detect and classify diseases in other crops where the diseases have distinct visual characters.

d. The recognition of research innovations for RICE and Mungbean diseasedetection

The significance of the research is obtaining the new algorithm to develop the software through programming language Visual Studio- 2017 for rice and mungbean disease detection and classification. The research work on image processing of the project has been demonstrated in the IT-Carnival 2018. The research idea secured the champion award in the competition due to the research innovations on rice disease detection and classification as in Figure 21.



Figure 21. Champion award for the innovations on rice disease detection and classifications.

The research aims to obtain the real time agricultural field characterizations through wireless sensor networking and ANN based image processing in agricultural innovations. The research outcomes have already been published in International Journal, *European Journal of Scientific Research* (SCOPUS and ISI indexed journal) as shown in Table 10. The research innovations on agricultural imaging system and wireless sensor networking have been presented in International Conferences including IEEE where one of the article secured the best paper award in the conference as shown in Figure 22. The awarding certificates and journal documents have been enclosed in AppendixC.



Figure 22. Best paper award in IEEE conferences

Table 10. Research publications on agricultural imaging and wireless sensor networking

Journals
1. Islam, T., Hossain, F. and Rashid, M., 2018 Wireless Sensors Networking for Image and Data Acquisition due to the Agriculture Field Management. 3rd Student IEEE conference on Science and Engineering, November 2018.
2. Islam, T., Rahman, T., Akter, M., Rana, M., 2018. Noise Reduction in Rice Leaf Disease Detection using Gaussian Filtering Technique, <i>European Journal of Scientific Research</i> , 149(1): 24-33.
3. Islam, T., Sah, M., Baral, S., Choudhury, R.R., 2018. A Faster Technique on Rice Disease Detection Using Image Processing of Affected Area in Agro-Field. <i>Proceeding of the 2nd International Conference on Inventive Communication and Computational Technologies (ICICCT 2018)</i> , 62-66.

12. Research highlight/findings (Bullet point – max 10 nos.):

i. A software, AgRGB for detection and classification of rice and mungbean disease automatically
ii. A new algorithm development for rice and mungbean disease analysis through image processing with ANN model.
iii. Wireless networking system for real time monitoring of agro-field with obtaining near surface soil characteristics.

13. References

- Khairnar, K. and Dagade, R. (2014) Disease Detection and Diagnosis on Plant using Image Processing A Review. *International Journal of Computer Applications*, 108(13), pp.36-38.
- Phadikar, S. and Goswami, J. (2016) Vegetation indices based segmentation for automatic classification of brown spot and blast diseases of rice. *2016 3rd International Conference on Recent Advances in Information Technology (RAIT)*.
- Ramya, V. Anthuvan L.M. (2016) Leaf Disease Detection and Classification using Neural Networks, *International Journal of Advanced Research in Computer and Communication Engineering*, 5, pp.208-210.
- Rehman, A., Abbasi, A. Z., Islam, N., and Shaikh, Z. A. (2014) A review of wireless sensors and networks' applications in agriculture, *Computer Standards & Interfaces*, 36, pp. 362-270.
- Sahitya, G., Balaji, N., and Naidu, C.D. (2016) Wireless Sensor Network for Smart Agriculture, 2016 2nd International Conference on Applied and Theoretical Computing and Communication Technology" July 2016.
- Singh, V. and Misra, A. (2017) Detection of plant leaf diseases using image segmentation and soft computing techniques, *Information Processing in Agriculture*, 4, pp.41-49.
- Yadav, P., Kumar, K. and Gupta, R. (2011) A Review Paper on ZigBee- New Era in Agricultural

B. ImplementationPosition

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
Office equipment					
i. Laptop with accessories	1		1		
ii. Printer	1		1		
iii. Scanner	1		1		
vi. Digital camera	1		1		
v. Moisture sensor	1		1		
vi. pH sensor	1		1		
vii. External Harddisk	2		2		
Software					
i. VisualStudio	1		1		
ICT tools and accessories					
i. Soilsensor	10		10		
ii. IPCamera	6		6		
Book- Shelf	1		1		
File- Cabinet	1		1		

2. Establishment/renovationfacilities:

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	

3. Training/study tour/ seminar/workshop/conference organized:

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training	130	10	140	4days	
(b) Workshop	100		100	3days	

C. Financial and physical progress

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	407459	407459	407459	0	100	
B. Field research/lab expenses and supplies	700241	700241	700241	0	100	0
C. Operating expenses	266100	266100	266100	0	100	0
D. Vehicle hire and fuel, oil & maintenance	270000	270000	270000	0	100	0
E. Training/workshop/seminar etc.	100000	100000	100000	0	100	0
F. Publications and printing	100000	40175	40175	0	41	59825
G. Miscellaneous	154850	154850	154850	0	100	0
H. Capital expenses	200000	200000	200000	0	100	0
Total	2198650	2138825	2138825	0	98	Total 59825 Tk Fund for Publications and printing

D. Achievement of Sub-project by objectives: (Tangible form)

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output(i.e. product obtained, visible, measurable)	Outcome(short term effect of the research)
To develop Software on image processing for rice and mungbeandisease detection and classification	<ol style="list-style-type: none"> 1. Disease pattern findings and analysis of disease based on RGB and affected area 2. Find out the way and criteria of software development 3. The algorithm of the software development 4. Rice Disease Detection and Classification option in the Software 5. Mungbean Disease Detection and Classification option in the Software 	AgRGB software development	<ol style="list-style-type: none"> i. Rice and Mungbean disease detection through software ii. Three conferences (including IEEE conferences) and one journal (ISI indexed) iii. Degree awarding of two masters students and five undergraduate students iv. An international research project has been awarded including five countries of Asia by Asia@Connect (ADB Fund) based on this research background where MoU would be signed between BARC, Bangladesh and Asia@Connect
To establish Wireless networking system	<ol style="list-style-type: none"> 1. Wireless networking devices assembled properly. 2. Sensor devices is interfaced with wireless network and data can be received through wireless network. 3. Photo of rice leaves can be obtained from agro-field through IP camera 	Real time monitoring of agricultural field	<ol style="list-style-type: none"> i. Wireless networking establishment through IP camera ii. Training to the farmers (about 160 farmers are trained) iii. About 200 students (B.Sc Engg.) get the training on wireless networking

To obtain ANN model in disease classifications	Analysis of ANN model has been carried out through MATLAB software	Incorporating ANN model in disease classification	<ul style="list-style-type: none"> i. Rice and mungbean disease classification ii. Demonstration of the idea in a2i competition iii. Knowledge sharing meeting with Jica and Netherlands team

E. Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.			
Journal publication	1 for high impact journal	1 Journal	Noise Reduction in Rice Leaf Disease Detection using Gaussian Filtering Technique, <i>European Journal of Scientific Research</i> , 149(1): 24-33
Information development		Best Researcher Award in Innovation Fair and a2i fair	24-26 February, 2018 Patuakhali Digital Fair
Other publications, if any		2 proceedings in IEEE conferences	<ul style="list-style-type: none"> 1. A Faster Technique on Rice Disease Detection Using Image Processing of Affected Area in Agro-Field. <i>Proceedings of the 2nd International Conference on Inventive Communication and Computational Technologies (ICICCT 2018)</i>, 62-66 2. Wireless Sensors Networking for Image and Data Acquisition and Due to The Agriculture field Management , Conference SCSE in Dhaka University, 24 November 2018 3. Best Paper Award in IEEE Conference

F. Technology/Knowledge generation/Policy Support (as applied):

i. Generation of technology (Commodity & Non-commodity)

The software AgRGB has been developed in the research project which is able to detect and classify rice and mungbean disease easily and accurately. Real time monitoring of agricultural field through wireless sensor networking has been also developed in the research project.

ii. Generation of new knowledge that help in developing more technology in future

The new algorithm AgSMT has been developed to carry out the agricultural image processing for rice and mungbean disease detection. In the algorithm, four color combination, color A, B, C and D has been established based on the threshold values of different color.

iii. Technology transferred that help increased agricultural productivity and farmers' income

Mobile APPs development based on the AgSMT algorithm would help the farmers to identify rice and mungbean disease easily and accurately. Hence, the technology transfer would increase agricultural productivity and farmers' income.

iv. PolicySupport

The innovation also ensures the real time monitoring of agricultural field through wireless sensor networking. The research is significant to obtain the policy for disease management in agricultural field.

G. Information regarding Desk and FieldMonitoring

i) **Desk Monitoring** [description & output of consultation meeting, monitoring workshops/seminarsetc.):

Monitoring team	Date(s) of visit	Total visit till date (No.)	Remarks
Technical Division/ Unit, BARC			
Workshop with Farmers	30 September, 2018	100	Khepupara, Patuakhali

ii) **Field Monitoring** (time& No. of visit, Team visit andoutput):

Item/Topics	No. of Participants			Venue & Date
	Male	Female	Total	
PIU-BARC, NATP-2	1 Team		1 Team	16 and 17 Feb, 2018 PSTU
Internal Monitoring	16 different internal groups About 160 students and teachers visit		About 160 students	27 Feb 4,7 March, 12 April, 17 & 20 July- 18 PSTU
Others Visitors i. Netherland ResearchTeam ii. JICA Research Team	2 group		2 group	19 April, 18 5 Sept, 18 PSTU

H. Lesson Learned/Challenges (if any)

i. The research project demonstrates the disease detection and disease management of rice and mungbean in agro field. The research work is conducted according to the research plan in Patuakhali Science and Technology University. The university is situated in coastal area of Bangladesh. The collection and monitoring of disease sample of rice and mungbean shows the constraints due to the seasonal variations in crop cultivations in Bangladesh. As an example, to get the disease sample and pattern of mungbean, it is needed to stay the image acquisition until March and April in the country. The paddy field can be easily surveyed from August to November due to the Aman cultivation near by the campus of PSTU.

ii. The research work is conducted according to the research plan in Patuakhali Science and Technology University. The university is situated in coastal area of Bangladesh. According to the socio-economic perception of Bangladesh, most of the brilliant and talent students of CSE faculty are enthusiastic to be engaged with job in software farm in Bangladesh. Very few graduates of CSE faculty are intended to reveal their research and innovations with Masters and PhD. Hence, it is difficult to obtain the consistent research outcomes according to the research plan.

iii. It is needed to involve the prompt and enthusiastic lab technician having sound understanding to conduct the research on sensor networking. Most of the skilled lab technician has intention to go to Dhaka to be involved with any kind of jobs rather than research based jobs. Hence, it seems to be the problem to get outstanding performance in the research project.

J. Challenges (if any)

i. Since Patuakhali Science and Technology University is far from Dhaka, so it is difficult to purchase the equipments and accessories timely. It takes time to solve any problems concerned with hardware and software installation in the university.

Signature of the Principal Investigator

Date

Seal

Professor Dr. S.M. Taohidul Islam
Principal Investigator, Project ID-554
Professor and Chairman, Dept. of EEE,
PSTU

Counter signature of the Head of the
organization/authorized representative

Date

Seal

Appendix A



Figure A.1. Training program on ICT based Agro-field management



Figure A.2. Farmers' opinions on ICT based agricultural disease detection



Figure A.3. Agricultural field monitoring through soil sensors in Kuakata, Patuakhali



Figure A.4. Training program on disease detection technique of rice and mungbean

Appendix B



Figure B.1. Attend in innovation fair in Barishal and Patuakhali arranged by a2i



Figure B.2. Attend in innovative competition arranged by PSTU



Figure B.3. Idea sharing on automated disease detection with Jica team



Figure B.4. Idea sharing on wireless sensor networking with Nederland's team

Appendix C



Figure C.1. Best paper award in IEEE conference in Dhaka University

Ref: EJSR149103
Date: 03-04-2018

Taohidul Islam
Faculties and Researchers
Department of Electrical and Electronics Engineering
Patuakhali Science and Technology University

Tarina Rahman
Research Students
Faculty of Computer Science and Engineering
Patuakhali Science and Technology University

Mahfuza Akter
Research Students
Faculty of Computer Science and Engineering
Patuakhali Science and Technology University

Masud Rana
Faculties and Researchers
Faculty of Computer Science and Engineering
Patuakhali Science and Technology University

Dear Authors,

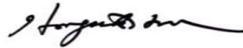
After having carefully evaluated your article titled "**Noise Reduction in Rice Leaf Disease Detection Using Gaussian Filtering Technique**" and taken the referees' advice into consideration, the editors came to the conclusion that your paper is suitable for publication in our Journal.

As part of our evaluation process, we normally ask the opinion of two referees who are experts in the relevant field of research. The paper is also read by the editor. If both of the referees and an editor concur in their view, their decision is final. We consult a third referee if there is a difference of opinion. The choice of referees and the fact that we require a consensus view between the referees and an editor ensures, however, that the process is as fair as possible.

Your article has been accepted for publication based on the reports of two referees and will be published in **European Journal of Scientific Research, Volume 149 Issue 1.**

Thank you very much for choosing us as an outlet for publishing your research.

Yours sincerely,



Adrian Marcus Steinberg, PhD
Managing Editor



Figure C.2. Acceptance letter of publication in European Journal of Scientific Research



**International Conference on Inventive
Communication and Computational Technologies
(ICICCT 2018)**

ACCEPTANCE LETTER

To 24th February, 2018
Taohidul Islam , Manish Sah, Sudipto Baral
staohidul@yahoo.com, sahmanish20@gmail.com, sudiptobaral.me@gmail.com

Acknowledgement Number/Paper ID: ICICCT 164
**Title: A FASTER TECHNIQUE ON RICE DISEASE DETECTION USING IMAGE
PROCESSING OF AFFECTED AREA IN AGRO-FIELD**

**Subject: Acceptance Letter – 2nd International Conference on Inventive
Communication and Computational Technologies (ICICCT 2018) – Reg.**

Dear Author,

2nd International Conference on Inventive Communication and Computational Technologies (ICICCT 2018) is being organized on 20-21, April 2018. 2nd ICICCT 2018 will provide an outstanding international forum for sharing knowledge and results in all fields of engineering and Technology. It provides quality key experts who provide an opportunity in bringing up innovative ideas. Recent updates in the in the field of technology will be a platform for the upcoming researchers. The conference will be Complete, Concise, Clear and Cohesive in terms of research related to Innovative Mechanisms for Industrial needs. The organizing Committee is pleased to inform you that the following peer-reviewed & refereed conference paper has been accepted for Oral presentation at the 2nd International Conference on Inventive Communication and Computational Technologies (ICICCT 2018) on 20-21, April 2018.

All the registered papers will be published in IEEE Xplore.

Yours sincerely,

Dr. G. Ranganathan,
Conference Chair
ICICCT 2018.
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Note: Find our previous conference papers at IEEE Xplore.
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Figure C.3. Acceptance letter of publication in IEEE conference ICICCT-2018