Beetles: A Mobile Application to Detect Crop Disease for Farmers in Rural Area

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Abstract— We have presented our work Beetle designed to support farmers in rural area to detect crop disease. The system shows promises in terms of disease detection. We present our technique here. We have started our software development process with user's requirement analysis. We wanted to complete this cycle by taking Beetles back among the farmers and find out about their opinion on such tool. The farmers received the tool positively and provided us with valuable insights presented in the paper.

Keywords— Plant disease; Mobile Phone Application; Image processing; Human Factors; Design; Measurement; Crop Disease and Fertilizer.

I. Introduction

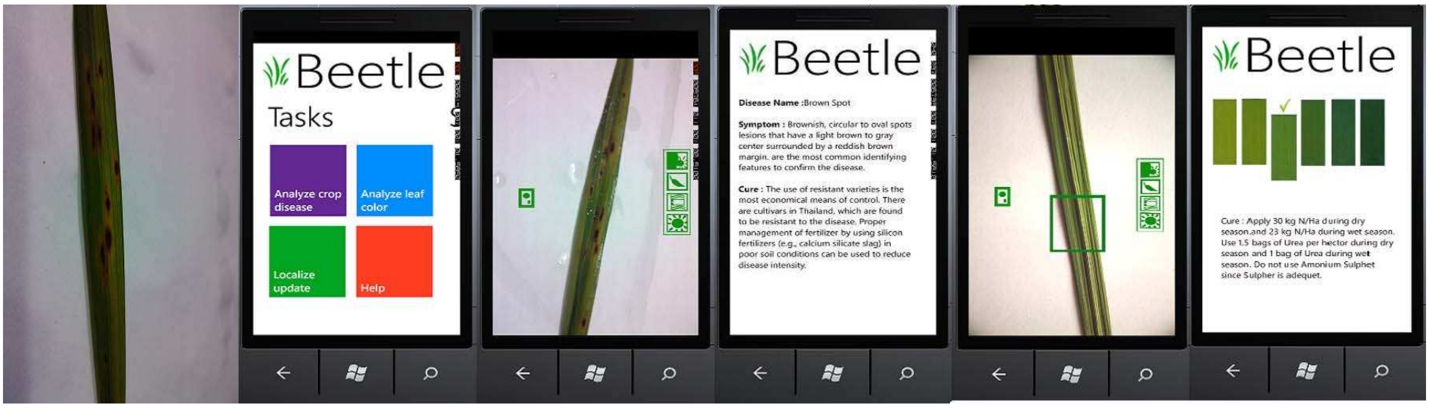
Recent proliferation of cell phone has created unique opportunities in developing countries like Bangladesh. On one side the technology has created communication and compute capabilities all around the country. On the other hand, there is a demand for support at rural places where this cell phones are available. We have focused on an application developed for farmers to detect crop disease which is a major problem among farmers. We developed a cell phone based application "Beetle" that detects crop disease from the image captured by a cell phone and detects the disease in real time. We have studied Beetle among a small group of farmers in our evaluation process along with the evaluation of the software performance itself. Disease detection is a major concern among farmers in the rural areas of Bangladesh. They make their decision based on experiences and assumptions. We have focused on image processing based techniques to detect crop disease. Current image processing algorithms require high quality images [1, 2, 5, 6] which is not the case for cell phone based images. The acquired image must be processed within the cell phone to serve farmers in absence of internet connectivity. We have developed an application that is able to detect crop disease within the limited compute capabilities of cell phone using histogram and color information of captured image. Similar approach has been proposed by [6] to detect the shapes of medicinal plants unlike our approach. There has been various cell phone based applications [add] focused to support rural people. Our approach is complementary to other cell phone based applications as our approach can gain advantage of internet connectivity in terms of information sharing. However, Beetle is able to perform independently. Beetle can detect five different crop diseases successfully and they are Narrow brown leaf spot, Bacterial blight, Brows spot, Ufra and Rice Blast. We have conducted user studies before and after our software development process. We wanted to find out about the burning problems for farmers and then we have showed our complete application to the farmers and got their feedback. We focused mainly on the accuracy and performance of Beetle which was well received among the farmers. We got suggestions about improvement of the current application in terms of its interface and features. Beetle shows promises and gives us future direction for a robust application. Our user study provided us with insights about desirable features such as use of native language and familiarity. The rest of the paper is organized as follows, we present our system design in next section, followed by the results, related work and finally, the conclusion.

II. System Design

We present our system design in two phases. We first present the user interface which is carefully designed to be simple keeping in mind the low literacy (or lack of literacy) level among farmers followed by the actual system development process.

A. User Interface

We have focused on a simple interface so that the users can select their options in minimal number of steps. Beetle has two major parts – one is disease detection and then it suggests for in suggestion for fertilizers. The disease detection process goes through four steps. First, we need to place the leaf of observation on against a white background and take a photo using a single click in the current smart phone. Then we may choose our desired step from the list of tasks named Analyze Crop Disease. Then our algorithm uses its internal mechanism to calculate the disease in real time and finally, displays the result in an output screen. Text to speech option is also available for illiterate farmers who are unable to read the output result of Beetle. The fertilizer selection process goes through the first two steps as before. The third step requires the user to select a portion from the leaf as shown in the figure. The fertilizer suggestion is based on the leaf color as shown in Figure 1.



(a) (b) (c) (d) (e) (f)

Figure 1: User Interface for Beetle (a) Leaf Placement (b) User Options of Operations (c) Photo Capture for Disease Detection (d) Output for Disease Detection (e)Photo Capture for Fertilizer Selection (f) Output for Choices of Fertilizer.

B. User Interface

The system considers two major algorithms. The YCbCr algorithm and the Histogram algorithm. We discuss the algorithms briefly.

Figure 2: Algorithm for Fertilizer Determination

In this fertilizer suggestion option beetle is taking the snap and then it will convert the RGB image into YCbCr image to find the color code of the crop leaf. This color space separates the luminance (light intensity) and chrominance in the image (differences of two color components) as shown in Figure 3.

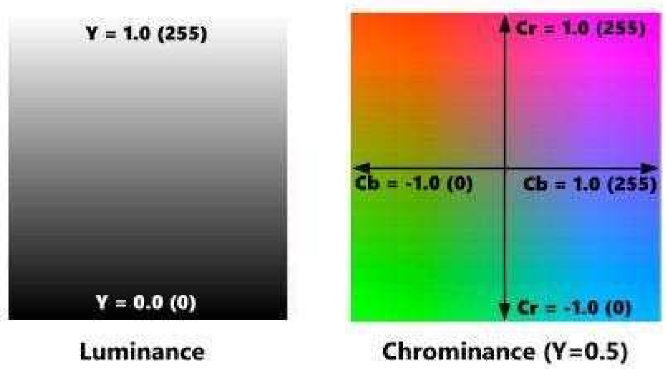


Figure 3: Color Separatin in YCbCr image

Advanced image coding codec converts the source image from RGB to YCbCr color space. The luminance of the image will be stored in the Y channel and Y describes the intensity of the pixels. The Cb and Cr channels hold the chrominance values in blue and red directions. All three have the same amount of contrasts and information. Y channel is perfect but Cb and Cr channel are much less in contrast. When we take a photo and acquire a frame from the camera preview buffer that image will become a one dimensional array of byte values. To optimize the performance of the camera, each Windows Phone device “quarter-samples” the chrominance components of the frame. This means that for every 4 bytes of Y information, onloy one byte of Cb and one byte of Cr is used to describe the corresponding 4 pixels of the image. Furthermore, some of the bytes in the array may be unused to allow room for padding (potentially varying between device models). The image is first converted to one dimensional array of byte values. The byte values and pixel information are compared to define a particular color code according to leaf color. This color code determines the amount of fertilizer by comparing it with predefined value in our system as can be seen in Figure 2.

Figure 4: Generating the Histogram Image

The image is scanned in a single pass and a running count of the number of pixels found at each intensity value is kept. This histogram is a graph showing the number of pixels in an image at each different intensity value found in that image. We can find Histogram (intensity) if we take the total number of pixels divided by total number of pixels at the intensity. We generate the probability of every intensity from the value of the histogram and number of pixels which ranges from 0 to 255 in current scenario [$0 \leq k \leq 255$ is CDF(k) = P(intensity$\leq$k)]. We use this intensity information as the coordinate value of 255 points. We divide this coordinates into 12 different phases. Now we divide this 255 coordinates into 12 different phases and add all the coordinates of each phase and obtain 10 different straight lines. We find the value of each angle using its tangent value. We obtain 10 different values which are stored in an array. We consider the first 6 angel or value of that array. We will consider these values as the unique id for each crop disease and will compare it with the stored unique id. At the same time we run YCbCr algorithm here to find out the exact color code of the leaf. If the matching rate of those id is above 80% and the color code of the infected crop matched with the stored color codes then we can tell that we have successfully detect that crop disease through this process and reply the disease name and cure to the user.

III. RESULT

We evaluate our system in the perspective of system performance, detection rate and then in the light of user experience.

Disease Name	YCbCr (second)	Histogram (second)	Result	Image	Detection Rate (%)
Narrow Brown Leaf Spot	2.05s	1.40s	Narrow Brows Leaf Spot		93%
Brown Spot	2.66s	1.32s	Brown Spot		89%
Bacterial Blight	2.34s	1.56s	Bacterial Blight		86%
Healthy Leaf	1.30s	1.15s	No Disease Detected		98%

Table 1: Performance of Disease Detection Algorithm

Our Beetle can detect five different crop diseases and they are Narrow Brows leaf spot, Bacterial blight, Brown spot, Ufra and Rice blast. We have collected 120 infected crop leaf and we have used 60% of them for training purpose, 20% of them for validation and 20% of them for testing purpose. Overall disease detection rate of Beetle is more than 85%.

Crop Name	YCbCr (second)	Total Time	Image	Result
Healthy Rice Leaf	0.72s	0.72s		Leaf Color Chart Range: 3 Fertilizer: 30 kg N/Ha during dry and 23 kg N/Ha during Wet Season

Table 2: Performance of Fertilizer Determination Algorithm

IV. SYSTEM PERFORMANCE

The runtime of the system varies where we have studied the system using the crop disease for rice considering six different diseases. The average runtime along with the worst case averages are considered. For run time, the fertilizer suggestion takes 0.72 seconds and disease detection algorithm takes 1.32 seconds while the worst case situation takes 4.23 seconds (If both algorithm works together).The crop leaf run time algorithm takes less than a second (0.72 seconds) in average and worst cases. The memory consumption of the system is 5.05 MB (.xap file) where the usage of the system during image processing is 35% (20%-22% usage increase. Running time performance of some key algorithms are shown in Table 1.

V. USER EXPERIENCE

We have studied ten users, all of them are full time farmers ranging the age of 35 to 45 and all of them are male participants which is the case of traditional farming in Bangladesh. All the participants had a cell phone of their own which was our motivation behind a cell phone centric application. Among the participants 90% of them believed plant disease to be a serious problem and all of them mentioned a loss which varied from as small as 5% to as high as 20% each year. The average loss was around 9.8% on average. We have taken our mobile phone based solution and let them take a look at how it works to get their feedback. We had a fixed set of questionnaire ranging from Not Useful, Normal, Good and Very good that was noted down by interviewer. We also got verbal comments along with this fixed answer. One of the farmer thought the solution not to be useful and was skeptical about the ability to detect crop disease telling us “I don’t think this software can successfully detect crop disease.” There was a response where a user was indifferent to the solution and mentioned about the cost of a smart phone as “this phone is very expensive “. Among 40% of the users thought the software to be useful (Good in our data collection set) and mentioned practical problems about the cost of the cell phone, difficulty to operate a high end cell phone as main concerns. We got 40% of the users to like the software (Very Good) and they mentioned the cost, other interfaces available in Bengali.

They suggested “If this software suggest us seed and other fertilizer to according to the plant condition and environmental condition then it will be the complete solution for farmers" and "we need proper training to use such cell phone" as suggestions for improvement. The study with our users gave us a motivation towards improvements that would be impactful to users such as providing possibilities so that multiple users can share a cell phone to support them in information gathering, exchange and proper detection of disease. We also found it useful to have an interface in native language and making the touch screen based interface available to users to get comfortable with.

VI. RELATED WORK

We have looked at work that relates to our work for image processing as well as an easy to use interface for rural people. We have developed this Application of smart phone technology for detecting paddy crop diseases and suggesting fertilizer on windows phone platform. Smart phones contain very sophisticated built in camera which has less focus and zoom capability than our digital camera. In this case the picture quality is not that much high so that edge detection algorithms most of the time fails to find out differences between infected crop spot and branches of leaves. Even smart phones have limited computing capacity so that they could not process a high quality image or run a high processing algorithm. For that reason we have written codes lightly and efficiently so that device could perform its task in less computing process. There are existing work of advanced image processing by Alom. et. al. using Gaussian Mean Based Paddy Disease Segmentation [1], Wang et. al [2] who have used edge extraction, Revathi et. al. [5] Homogenous Segmentation based Edge Detection methods. The methods work great for edge detection. However, we had to take care of the poor image quality where the lighting may not be adequate , uneven disease structure and low compute capabilities of cell phones. Kumar et. al [3] use histogram to detect different tree leaves which is similar to our histogram based idea, however, we have used this technique to detect the leaf disease instead of the leaf structure. Hannuna et. al. [4] uses manual process to determine the leaf color whereas we have used YCbCr algorithm to find the leaf color through an automatic process after taking the image.

There have been work that focus on mobile application based approaches. Amos et. al [8] have developed a system through which farmers, field officers, experts, buyer, doctor, government ministry, banks are connected with each other, could communicate with each other and work together using their internet based mobile application. But internet connection is not available in most of the rural areas of Bangladesh. Our solution Beetle is totally an independent solution. It is not required to have internet connection to use this mobile phone application.

It is evident that there is a burning requirement for innovative applications even for the rural user's especially rural farmers.

VII. CONCLUSION

We have developed a cell phone based application to support farmers residing in rural areas of Bangladesh to detect crop disease. The application is able to detect ten major crop disease in Bangladesh using the cell phone's camera image of the infected crop. Image processing in a resource constrained device like a cell phone is only useful when the processing time is short. Our application is able to detect the disease within five seconds of time even in the worst case scenario. Our user based study provides us with valuable insights on the wide spread possibility of such an application that would improve the lives of farmers. We look forward to extend our application to play a positive role on plant disease detection as well as in the lives of rural residents like farmers.

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