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Krishimitr: A Cloud Computing and Platform for Disease Detection in Agriculture

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Abstract: ***Automating disease detection is a cornerstone in the journey to achieving sustainable agriculture. We describe a framework utilizing Machine Learning, Cloud Computing and Internet-of-Things which brings experts to farmers, allowing for timely detection of diseases. This innovative and comprehensive framework provides agronomists and farmers with a solution for diagnosing plant diseases. By leveraging modern ICT capabilities, this extensible framework is currently trained for over 15 plant types and more than 51 disease types. Our framework employs a hybrid model combining use of both online and offline resources to provide up-to-date information to farmers even in case of patchy connectivity.***

Keywords: Machine Learning, Cloud Computing, Internet-of-Things, Plant Disease Detection.

I. INTRODUCTION

Improvements in technology have largely kept up with rapid increases in human population to generate enough food for the 7.7 billion people inhabiting our planet. Information and communication technology played an important role in bridging the gap between agriculturists and technologists. These technological improvements have been slow to reach the millions of small holder farmers who feed majority of people in Asia and Africa [1]. One major factor affecting crop yield is disease mitigation in early stages of infection. Fortunately, most diseases develop visibly identifiable symptoms. To detect and identify the plant disease, visible eye observation is the main approach adopted in practice .Expert has to monitor the farms in regular intervals of time. This approach is very time consuming and not cost effective as farmers has to travel very long distances[2]. Need of automatic plant disease detection is very important as infections in plants leads to overuse of pesticides resulting loss to humans and ecological system. Thus it is very important to create a solution for automation of plant disease detection.

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As farmer is not capable of adopting expensive technique for timely detection of plant disease, there is great need to build more automated version of fast and less expensive and accurate method. Not only their detection, but timely detection of diseases is paramount.

Fungal diseases in wheat, for example, rapidly progress before visible symptoms manifest [3]. Thus, in order to prevent significant crop loss, even small gains in detection times can make huge difference.

The recent popularity in application of machine learning to otherwise complicate computational problems has led to a number of studies utilizing machine learning in what was earlier a complex problem of automated disease detection. With the use of machine learning technique, at early stage, plant disease can be detected and recognize [4].Mohanty et al, discussed the Plant Village database for identification of leaf diseases[5]. Kamilairis discussed the various deep learning techniques like RNN, CNN etc.[6], Fuentes et al proposed a cloud platform for tomato plant type[7]. Wang et al discussed the VGG model for training of images using machine learning. Model achieved accuracy of approx. 90.4%[8]. A few examples of frameworks to detect diseases include Johannes et. al. [9], Lu et. al.[10] and Plantix [11]. However each of these requires constant connection to the internet for disease identification.

Reliable internet access to farmers in developing nations can be a challenge. Bad weather conditions and less signal coverage further degrade the quality of internet in large farms of developing nations. Automating mobile application data collection requires establishing network connection. Alternatives, existing long-range Internet-of-Things connectivity solutions such as LORAWAN, do not provide a well-established channel due to limited network range of internet. [12].

Till now, many solutions are in existence like LORAWAN but all those solution have limited bandwidth issues. Because of this limitation they do not support drones and cameras of high quality. In this paper, we present a tablet based device KrishiMitr, which can inform farmers about foliar diseases on time and help their management. KrishiMitr is system that can work properly even in bad weather conditions and power failure. KrishiMitr also implements cloud connectivity to collect diseased plant leaf images and to create a database for long term data analytics. We have implemented KrishiMitr in fields in India and used KrishiMitr to enable applications for the farmer: disease prediction, disease detection, two step verification of diseases and information dissemination to prevent epidemics.

II. FRAMEWORK

An always connected device sending signals to the cloud to process data is not practical in many parts of the world. Thus, KrishiMitr aims to solve this problem by combining an online-offline hybrid model with on-device computation. Furthermore, to achieve high accuracy, KrishiMitr assumes that the farmer knows the plant type under investigation. This makes training the models more robust, but at the same time increases the total size of database required on device (80MB/plant type). Thus, regular updates of the models become a big data transfer (compared to typical transfer speeds) problem in regions with slow network connectivity.
KrishiMitr framework consists of the following three components:

1. A cloud server: This acts like a central repository and a bridge between the farmers and experts for feedback/communication. Runs Linux OS.
2. IoT hub at village level: An always online module,which keeps local up-to-date information. It runs Linux OS.
3. Tablet device: A mostly offline device storing a local copy of the models to do on-device disease identification. This is a touchscreen tablet device based on the Raspberry Pi. Platform with camera running Linux OS.

Figure 1 details the dataflow between the three components during download (Figure 1a) and upload (Figure1b) stages.

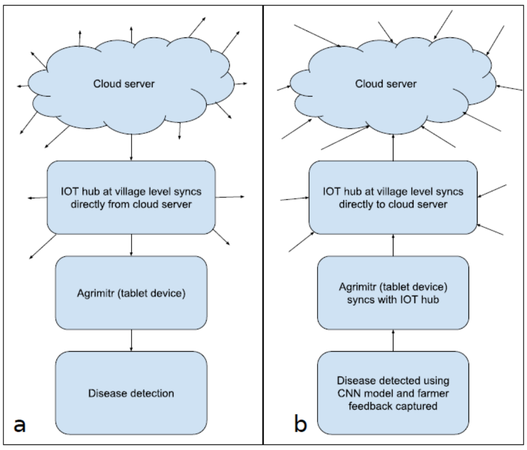

Figure 1: Workflow of KrishiMitr framework. (a) Data flow from Cloud to tablet device. (b) Data flow from tablet device to Cloud.

In the download stage, IoT hubs ateach village sync data from the Cloud server. Government programs such as the BharatNet project in India are enabling high speed internet access points in each village in the country, which the IoT hubs can leverage [13]. The Cloud server runs an implementation of the deep learning model described in Sharma et. al.[14]. This deep learning model uses Convolutional Neural Networks (CNN) and run on Tensor flow.. It has been trained using more than 80,000 images for 15 plant types and more than 50 disease types.

The communication from Cloud server to IoT hubs uses HTTPS protocol. The data from Cloud server to IoT hubs includes trained models for disease identification and any advisories/communication for farmers in the specific geographic area. The tablet device, when within the range of the IoT hub, syncs the models and advisories/communications from the IoT hub. These advisories/communications are then shown as notifications to the farmer according to geo-location of the device. Example advisories include region and crop specific advisories and disease warnings such as disease detected in region / high chance of disease occurrence due to specific weather conditions. These advisories can be community sourced (voluntary) or expert contributed(focused). Voluntary contributions are moderated by experts.

III. FARMERS' DEVICE IMPLEMENTATION

The workflow for Farmers' device implementation is shown in Figure 2 and screenshots of the device are Shown in Figure 3. After starting the application (Figure 3(a)), the user presses Snapshot to take a still image of a leaf. The user is then asked to select a plant type (Figure 3(b)). After this, the user can either select a region of interest (RoI) in the image or use the full image for running the model. Once the model output is received, the user is shown the detected disease type along with fractional accuracy (Figure 3(c)). If the user agrees with the result, the image is geo-tagged and the result is stored on the device. If the user disagrees, they can manually select the correct answer(Figure 3(d)), which is then stored on the device with the geo-tagged image. In addition to disease detection, KrishiMitr also recommends the appropriate steps required for disease mitigation. Once the tablet device is within the range of the IoT hub, all locally stored images and feedback are synced to the IoT hub. The IoT hub then syncs the geo-tagged images to the cloud server.

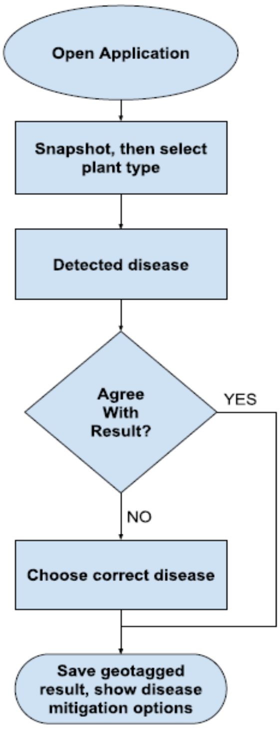

Figure 2: Workflow of farmer implementation.

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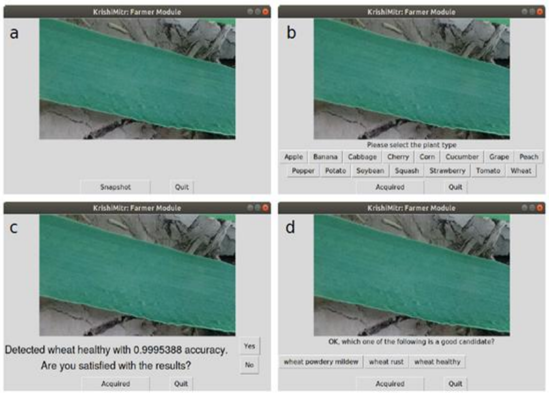

Figure 3: Farmer Module in KrishiMitr. (a) Welcome screen. (b) Plant choice screen. (c) Result screen. (d) Farmer feedback screen.

IV. IMPLEMENTATION FOR THE EXPERT SIDE

Periodically, experts receive notifications to verify and validate the images and feedback received from users. When the expert logs into their account on the device, they get a list of data to validate. This data includes a list of images, RoI and corresponding disease tags for their

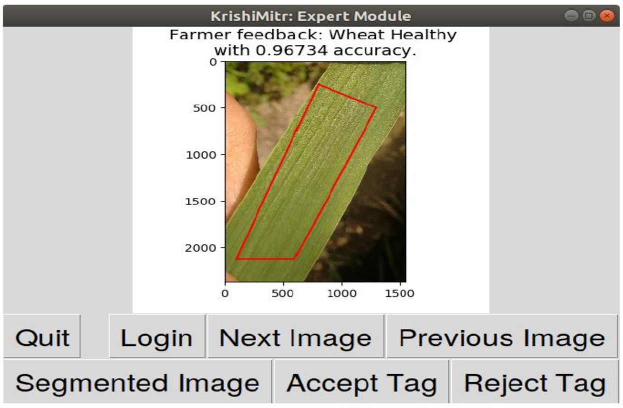

Figure 4: Expert Module in KrishiMitr. Area enclosed in red quadrilateral is the region-of-interest selected by the farmer for disease detection.

expertise area. The expert is also given the option to choose a different RoI. The expert verifies the feedback which was uploaded by the farmer and then validates the disease tag associated by the device Krishimitr. The following Fig 4 shows the working of Krishimitr. All the reviewed images checked by experts are then fed back into the CNN model, which then re-learns using a technique called 'Transfer Learning' [15]. If the features of datasets are similar, transfer learning allows retraining the model incrementally without the need for starting from scratch.

V. CONCLUSION

We have described a framework called KrishiMitr utilizing Machine Learning, Cloud Computing andInternet-of-Things, which allows for automated diseasedetection in plant leaves. Using a hybrid online-offline model, KrishiMitr provides up-to-date information tofarmers even in case of patchy connectivity. The frameworkis currently trained for over 15 plant types andcan easily be trained for new plant / disease types. Theframework automatically updates itself with user dataand uses expert verification for feedback.

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