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Design of Plant Disease Detection System: A Transfer Learning Approach Work in Progress

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Abstract

The use of ICT has become essential to help farmers collect important and updated information and knowledge which are valuable resources that farming depends on. The study embarked investigates the problem sources of unavailability or lack of timely, relevant and accurate farming information and knowledge for small-scale farmers. The main target is to deal with plant diseases and how to manage them by carefully diagnosing the plants leaves. This work proposes to use image analysis and convolutional neural networks and the ever increasing capability of machine learning such as supervised learning to offer a mobile solution. A Design Science Research Methodology was followed in shaping skeleton of the proposed prototype. The developed prototype will be subjected to three usability measures to test if indeed it is timely, relevant and accurate as the farmers need it to be.

Key words: Image Analysis, Machine Learning, Transfer Learning, Plant Diseases

Introduction

A growing population has led to an increasingly complex challenge especially when it comes to provision of food. This is made more difficult by the need to assure equitable and sustainable development. Scientific and technological progress is generating the knowledge and tools to make this possible [1]. The global per capita food supply has risen and so has the spending on agricultural research and development and the hope is that the increase should be happening in developing countries. Information and communication technologies (ICTs) advances has opened new avenues in knowledge management that could play an important role in meeting the prevailing challenges related to sharing, exchanging and disseminating agricultural knowledge.

As a way to poverty eradication and minimizing unemployment, Botswana government had sought to encourage the population to venture into farming of any kind. This is shown by the country providing funds to the youth in the farming business. CEDA (Citizen Entrepreneurial Development Agency) Young Farmers Fund makes it possible for the youth to enter the cattle farming business [2] for example. Even as these youngsters venture in farming, there exist the established farmers who have years of experience in farming. The established farmers have experience in farming enough to share the knowledge with the new farmers. This kind of farming knowledge will initially be of word-of-mouth when these farmers interact and share the little they know from each other. Regardless, this knowledge shared needs to be preserved for the next generations to come.

A small-scale farmer refers to individuals who rear less or about twenty-five cattle for beef production. This group solely rely on knowledge and information to manage and maintain their farming. It is evident that the knowledge from our forefathers about farming is not shared; it is not captured and structured in a way to assist the farming sector. The information and knowledge is also susceptible to being altered in transit from one recipient of the other. Whilst the Ministry of Agriculture, Botswana, provides information to the farmers, there is a question to how timely, relevant and accurate is it upon access.

Science and technology provides both fertile ground and ingredients for innovation through new knowledge and ways of understanding the world, new problem solving techniques, new technology and new businesses. It allows enriching the quality of life [3]. The article states that globally, innovation through the exploitation of science and technology allows advances in communications, information, health, agriculture and basic technologies which are now converging to expand the pace of technological change. It is also stated that Botswana must have the capacity and capability to recognize technological opportunities that emerge from these advances which have historically played a critical role in alleviating hunger and rural poverty.

Problem Statement

Despite all these mentioned issues and the government working at availing resources for farming, it is evident that there still is lack of timely, relevant and accurate knowledge and information especially when it comes to the youthful farmers who have no prior knowledge in farming and agriculture. The old extension service delivery system that was meant to pass on research outputs to farmers in Africa has proved inefficient and most of the institutions have inadequate machinery and capacity to share and disseminate outputs to small scale farmers and other actors [4]. The hope for revitalising this sector is now on ICT which over the years has developed and changed to allow people to think more and do more. The machine learning and image analysis sector of artificial intelligence promises some benefits to the agriculture community especially when it comes to using mobile devices which are capable of running some artificial intelligence applications both online and offline. When paired with image analysis and deep neural networks, there is promise especially in detection of plant diseases by using leaves and stems and

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also detecting insects well before damage is done to crops.
Crops diseases are a major threat to food security but their rapid identification remains difficult in many parts of the world due to lack of necessary infrastructure. This is equally a problem for the young farmers in Botswana who tends to depend on the Extension workers for identification and management of some of the common plant diseases. It is a challenge even with the help of extension farmers as they have to cover a wide geographical area to deliver the service. Even on days that the service is delivered on time, the diagnosis is done using naked eye and therefore there are high chances of wrong diagnosis. Verbal information is usually not scientific and not accurate leading to treating a wrong disease with wrong chemicals and eventually harming the environment. Relying on pure naked eye observation by experts to detect plant diseases can be prohibitively expensive especially in developing countries. The farming community in Botswana still depends on traditional means to access information as found in the preliminary study conducted, refer to .The combination of increased mobile penetration and internet use in Botswana and the world over together with recent advances in computer vision through deep learning has made opportunities to exist for Smartphone based disease detection and phenotyping.

Research Aims and Objectives

The aim of the research was to provide a fountain of relevant knowledge and information that will better the farming practices of young small scale farmers with a focus on plant disease management. The main objective of the study is to design and develop plant disease detection system that uses plant images as input.

1. To design an accurate image classifier for plant disease detection.
2. To compare the performance of the classifier with results of expert knowledge.
3. To explore transfer learning and machine learning frameworks in plant disease detection.
4. To find out if it is technically feasible to diagnose diseases based on automated image recognition.
5. To design and agro-advisory system that offers information dissemination capabilities

Justification of the Proposed Solution

The availability of ICT resources in Botswana accommodates the implementation of the proposed system. Given that the mobile penetration is Botswana is high and most youthful farmers owns a smartphone phone capable of taking pictures in colour and capable of connecting to the internet it means the system stands a high chance of acceptance than traditional means. Technology development especially in the field of artificial intelligence and the power of mobile phones is well documented in the literature. To further argument this, a preliminary survey was conducted to understand the views of young farmers. The result of the study shows dependency on traditional means of information access, that the market is ripe for ICT enhanced agriculture information. This is shown in Figure 1 and Figure 2.

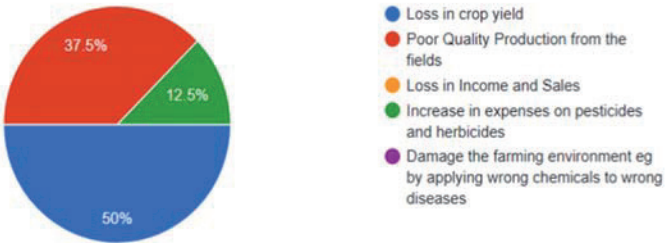

Figure 1 How Plant Diseases Affect Farming

Figure 2 Sources of Farming Information

Brief Literature and Related Works

Madibela [5], states that farming has the potential to help create wealth, improve farmers' livelihoods as well as reducing poverty especially for rural farmers. The author continues to elaborate that animal products are first-rate sources of high quality protein. They help improve the quality of life and food security. Farming in Botswana and in the region is challenged by presence of diseases and parasites, drought and shortage of feeds and lack of markets. As of now foot and mouth disease has made some farmers poor as their cattle were killed during the eradication control policy employed by the Ministry of Agriculture, leaving farmers unemployed. This shows the importance of livestock in the livelihoods of communities. Not only would disease pose a risk to marketing of farm produce to the EU, but lack of hygiene and sanitation at farms may lead to spread of zoonotic diseases to humans [5].
There is evidence that the government of Botswana spent millions of pula's to ensure the nation is provided with cheaper and faster Internet [6]. The widespread of Internet connectivity and phone line network coverage allows the instant access of the proposed dissemination system. It will allow small scale farmers to access the information, anytime, anyhow and anywhere (if and only if the location of the farmer(s) allows). The Botswana farming community are still to enjoy the use of ICT in their profession. The growth in mobile apps has seen a development of farming apps like MODISAR which is said to be a unique farm management app that helps with livestock management problem, it is a desktop and web productivity software that can be installed on farmers computer or laptop and allows the farmer to capture information about the farm before and after [7].
In their study Kulkani and Patil [8] proposed a methodology for detecting plant diseases early and accurately using diverse image processing techniques and artificial neural networks. Their experiment showed classification accuracy of 91%. The detection of plant diseases by analysing the texture, colour and structure of the leaf is promising accurate results as is captured in the literature. The leaves of a plant provides the most important information of data which can allow people to know

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which type of plant it is and which type of disease is affecting the leaf [9]. Different approaches are reported in the literature for analysing images for disease detection. Some researchers uses classification with K-NN classifiers [10], in some studies images in RGB form and segmentation and feature extraction are used for the disease detection [11]. In their work Badai and Suchitra [12], used spatial filter, k-means clustering, GLCM and Support Vector Machine (SVM) to detect pomegranate plant diseases and their results presented 90% accuracy in disease detection.

Research Methods and Approach

This study follows the Design Science Research Methodology (DSRM). This approach is of importance in a discipline oriented towards creation of artefacts [8]. The methodology incorporates principles, practices and procedures required to carry out such research and meet objectives. Design experiment will be developed as a way to carry out a formative research to test and refine the solution by prototyping. In design science paradigm knowledge and understanding of a problem domain and its solutions are achieved in the building of a problem domain and its solutions are achieved in the building and application of the designed artefact [9].
The study seeks to use Transfer Learning technique of machine learning. In this regards the Googlenet or Inception V3 will be retrained on a publicly available dataset. The publicly available PlantVillage dataset that consist of 54306 images will be used to retrain Inception using Tensorflow. Inception and Tensorflow are openly available resources provided by Google. Transfer learning has been selected as an approach because it allows for better results as reported by [15]. The machine learning model will be used for classification of the plant disease.

Proposed Solution

This research proposes an Android based disease detection and classification system. The proposed system will be called Makgonatsothe which is a Setswana word for certain herb that heals all ailments and diseases. Makgonatsothe will allow young farmers who are in possession of a smartphone to take pictures of diseased plants leaves. The image will be submitted to the application where the classification will be performed. Based on the results of the classification, the app will give the farmer some management tips for the identified disease. The control measures will include both the chemical and the biological controls for the identified disease and how to prevent the disease in the future. The app should be accessible offline too with an option to update the system when internet connection is established.
The overview of the proposed Makgonatsothe system is shown in Figure 3. The system consists of the client side and the server side operations. Given the high computational needs of the classification, no inference will be done on the mobile application. All machine learning operations will be handled separately by dedicated servers.

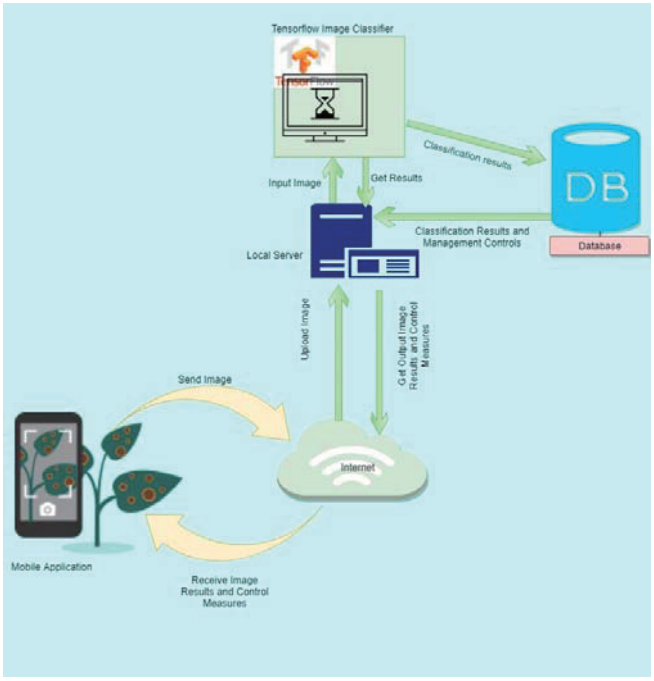

Figure 3 Proposed System Architecture

The client side will be an Android mobile app designed with JAVA. The mobile app will allow the user to take pictures using their smartphone or upload pictures which already exist in their phone gallery. The user interface has to be friendly enough with little navigation and allow the user to perform the tasks with much difficulty. The mobile app will also have a library of common diseases to allow the user to search and view the information about the management of the disease.

The system will have a MYSQL database server for storing the disease information. This server will be queried using the classification result to provide the management information that matches the identified disease. The other server will be a machine learning server Tensorflow Serving. This server will handle the Tensorflow model and algorithms which will be used for running the inference.

Conclusions and Way Forward

Along with incredible opportunities, implementation of mobile applications also poses a lot of challenges in Botswana due to lack of mobile friendly and locally relevant digital content, rural mobile infrastructure limitations, illiteracy among the old farmers and large number of local languages. Sustainability is also a major hurdle. Instead of stand-alone projects, mobile based applications needs to be integrated with on-going agricultural extension programs and methods. Private and public partnerships for project implementation and web to mobile, voice, image and text integrated applications needs to be developed to cater for the farmer specific information and knowledge. Systematic studies on farmers mobile use behaviour and impact of on-going projects to be carried out to understand the real benefits of mobile based agricultural advisory services. The contribution of ICT in agriculture knowledge management, gathering, storing, retrieving, adopting, localizing and disseminating innovations are needed by the young farmers to enhance productivity.

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