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A Conceptual Model of Mobile Expert System for Integrated Pest and Disease Control: The Case of MyCorn

A Conceptual Model of Mobile Expert System for Integrated Pest and Disease Control: The Case of MyCorn

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Abstract. The study of plant disease detection systems development has become very popular especially after the introduction of precision agriculture and the widespread use of mobile computing in almost all area including agriculture. While there exist an abundance of frameworks or models, however, given the unique nature of pest and disease management influenced by the different types of cultivation setting such as location, history, soil and the threat's, research in this area is still needed. In addition, crop disease and pest detection is a complex task requiring accumulated knowledge and expertise as well as collecting detailed information very often manually. Therefore, on the basis of generic expert system model, this research aims to develop a conceptual model of mobile expert system for pest and disease management. Drawing from the case study of MyCorn development project, this study specifically offers a conceptual model of mobile application which offers a collaborative platform for integrated corn crop disease and pest diagnosis, treatment, and protection. The findings also offer useful practical insights for those who are seeking to build similar expert system for agriculture crops other than corn.

1. Introduction

Agriculture and farming activities play a pivotal role in providing food supply to all over the world. For many agriculture countries, it is responsible not only as a source of livelihood but also the main contributor of their GDP or even the back bone of the national development [1]. Nevertheless, the agricultural and more specifically farming is challenged by damaging crops caused by pest and disease attacks. Especially in recent decades, serious problems with pesticides, such as the rapid development of pest resistance and the emergence of climate-driven disease could affect harvest quality and the overall productivity.

This challenge could threaten agricultural productivity since there are a limited number of field staffs who could tickle down the knowledge regarding pest and disease occurrences. Even if the staffs are available, they may sometimes face difficulties in getting detailed data on different types of cultivation (e.g. location, history, soil, and the threat's characteristics) on hand for providing a thorough consultation to farmers or directing them the next action plans about the appropriate control solutions. At the same time, field staffs also need to do the tough agricultural field-works such as manual crop tracking, log keeping using pen and paper with the limiting use of technology or no integrated tool to help reduce the administrative burden and make the process free from errors.

In the last few decades, great efforts have been made by both academia and practitioners in the area of agriculture as well as computer science to study development of expert system for use in pest and disease management. Early examples of studies found in the literature that proposed architecture and models of expert systems in the agriculture [2, 3]. Much of the works at this time generally develop models which captured the crop pathologist knowledge and expertise into the form of IF-THEN rule-based or knowledge-based used for diagnosing pest and disease attacks. Some popular methodologies used for pest and disease identification included Fuzzy inferences, forward-reasoning as well as back propagation. Furthermore, the expert system models that developed earlier mostly were command line based and can be used only for stand-alone.

Moving to 2000s, much more studies providing models or architectures have become available in the literature. Review on the literature showed researchers have made attempt to employ different methodologies such as neural network, case based reasoning, object oriented method, ontology based method, and intelligent agent systems [4-6]. In addition, during this period, web-based expert system models in disease and pest detection picked up due to the availability of Internet [7, 8]. This internet-based approach to develop expert system is an attempt to provide real time diagnosis and to help farmers obtain more personalized information directly from the paddock. In the same vein, researches into image based disease expert system are also gaining popularity due to development of high capacity computers along with the emerging of digital/video cameras technologies [9-11]. The image-based model are generally proposed to offer a practical way especially for farmers who seek to diagnose pest or disease attacks on their crops immediately without supports from field officers.

Now-a-days, a large and growing body of literature has made attempt to offer different models and architectures of expert systems for crop disease detection utilizing more recent and advanced approaches. For instance, a number of researchers used machine learning as knowledge based of the expert system which can provide an adaptive thinking when identifying disease symptoms or pest threats in all stages [12-14]. Other researchers have begun working on how to use Internet of Things (IOT) to create more sensible and autonomous expert system diagnosing and recognizing plant disease and insect attacks [15, 16]. In addition, IOT along with its sensors devices has offered researchers to expert systems for remote crop disease and pest surveillance. Finally, with the proliferation of smart phones and the high speed of internet access, many researchers have also developed models of mobile expert systems aimed at easing the difficult task of plant disease identification at the paddocks [17, 18].

While there exist an abundance of frameworks or models, however, given the unique nature of pest and disease management influenced by the different types of cultivation setting such as location, history, soil and the threat’s, research in this area is still needed. In addition, crop disease and pest detection is a complex task requiring accumulated knowledge and expertise in the area of pathology, entomology, horticulture and agricultural meteorology [19]. In view of all that has been discussed above, it is suggest that more and more research providing models for crop disease and pest detection are needed. Therefore, this research aims to develop a model of mobile expert system for pest and disease management. Drawing from the case study of MyCorn development project, this study specifically offers a conceptual model of mobile application which offers a collaborative platform for integrated pests and diseases management

2. Research Methods

To address the research objective stated above, this study needs to propose a model that shows the generic structure of the system. For this purpose, we identify various models existed in the literature that have been introduced and used to develop an expert system in agriculture [20-22]. We then examined those generic models and made several adaptations to come up with the proposed model suitable for addressing the unique nature of integrated pest and disease management, especially in the context of MyCorn. Fig 1 shows the proposed model that is used to guide the development of MyCorn's conceptual model. As can be seen in Fig 1, the proposed model of mobile expert system consists of four main components including:

1. Expert Interface. Graphical user interface representations (e.g. menu, dialog box, and forms, or other input/output methods) which enable the experts interact with users and the system

2. Knowledge base. Collection of rules as representation of knowledg. This element is built upon collection of disease or pest along with the set of symptoms and the imagery of suspected pathologies.
3. Inference Engine. The processing element which aims to provide solution based on data from users using the existing knowledge base.
4. User interface. Graphical user interface representations provided for users

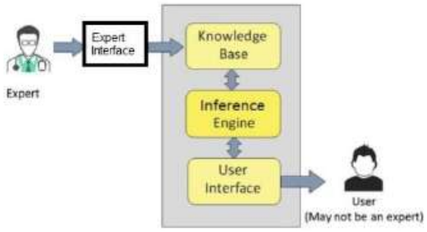

Fig 1. Conceptual Framework

3. Results

In this section, we present our proposed concept model of a mobile expert system for integrated pest and disease control. Taking the actual case of MyCorn development project, the findings of this paper, while preliminary, is expected to offer a model for guiding a similar expert system for integrated agricultural crop disease and pest management. Therefore, prior to present our results, it is important to briefly describe the case study of MyCorn development project to provide an account on why such project is important and how the model is proposed as discussed next.

3.1. MyCorn development project

MyCorn stands for Mobile Crop Advisory Application for Assisting Corn Farmers in Madura Island, to Monitor and Mitigate Pests and Diseases Attacks. This project is timely given corn is the second most important food crop in Indonesia especially in Madura Island, nevertheless; farmers often encounter problems dealing with disease and pest control. The problem is likely to multiply due to the limited number of field staffs who could assist them. Even if the staffs are available, they sometimes lack of data to support farmers in suggesting a possible control solution. Therefore, the project aimed to design, develop, and deploy an easy-to-use mobile application that allows corn farmers and field staffs in four regencies of Madura Island taking collaborative and holistic actions for pest and disease management including diagnosis, treatment, and protection.

To address the problem described above we needed to define functional and non-functional requirements. First, MyCorn application is envisaged to enable farmers use the application freely and start to identify pests or diseases using the camera on their smart-phones. Second, the application should be also able to provide the steps to mitigate the attacks and information about preventing the possible attacks in the next season. Further, the application presents both biological and conventional treatment options for pest and disease control. Another expected feature is that the application has library and database of crop pests and diseases which updatable every time field staffs or farmers upload pictures with time marked and geo-referenced for diagnosis. This feature is aimed at facilitating pest and disease outbreak monitoring and can send early warning messages for specific locations. In case there is no available information supports from field staffs, the application provides an online forum where farmers could post their questions or pictures to get feedback and learn best practices from their peers, gardeners, plant pathologists and related experts immediately. For this purpose, the application will be made free for interested people about corn farming.

3.2. Architecture/technological representation Design

Following the requirement elicitation process as described above, we then composed architecture of the system which depicts the technological representation of MyCorn application. In addition, the architecture also can be used to show how the proposed MyCorn application may look like. Drawing from the overarching framework (see Fig.1) and the requirements, this study was able to develop the architecture of MyCorn application as illustrated in Figure 2. As can be seen in Figure 2, MyCorn was designed using n-tier architecture and has four essential components as followings:

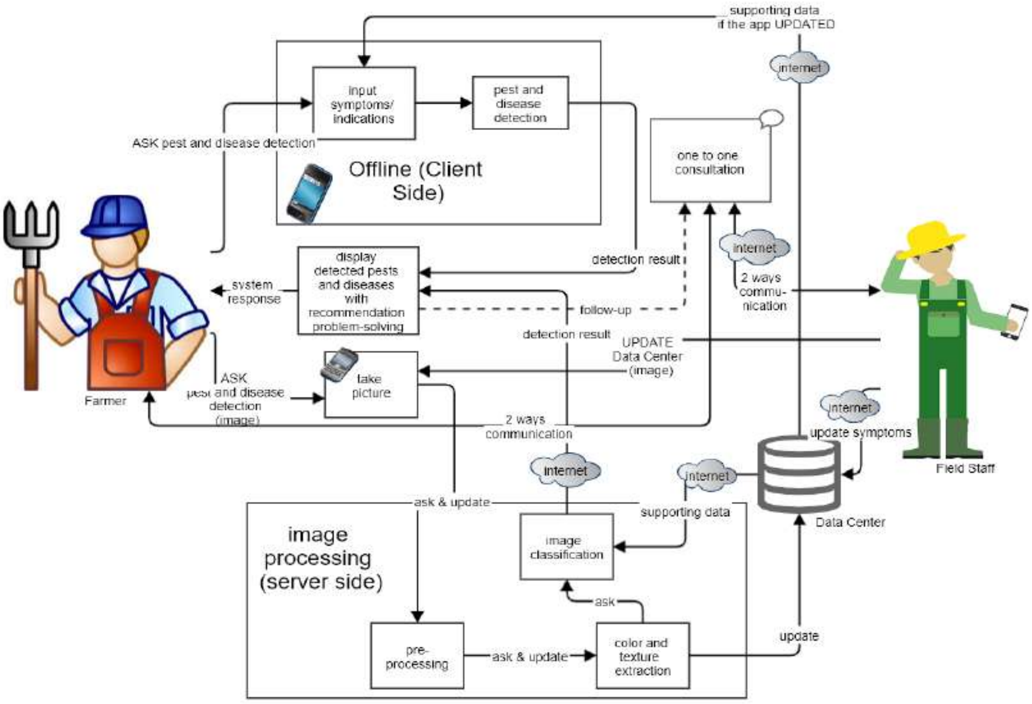

Fig 2. MyCorn Architecture

1. Expert Interface for Field Staffs

This component was designed specifically for expert users (field staffs) to interact with MyCorn application and to receive information from it. As can be seen in Figure 2, field staff can use a part of this feature called knowledge base editor to update (create, update and delete) or refining knowledge based of the MyCorn that was acquired previously including new symptoms or diseases using input form as well as imagery suspected pathologies captured by phone camera. Using this feature, field staff will also be able to interact with the other users such as providing one to one consultation to farmers and responding discussion in the forum with other field staff or farmers. The expert interface feature in particular was designed into two platforms: native mobile application interface and web-based platform to provide a better overall user experience. This means field staffs can use and access this feature either from their mobile device or PC.

2. Knowledge Base of Corn Disease and Pest

This feature was developed using relational database management system and provided to store the whole data about corn disease and pest along with the associated symptoms as well as the recommended action solutions. The information in this database can be categorized as factual knowledge and heuristic knowledge. The factual knowledge representation contains of information about pest and disease diagnosis, treatment, and protection that was typically prescribed in the manual, paper, journal, internet sources and other publication. While the heuristic knowledge is tacit knowledge that is rarely published or formally discussed and largely derived from personal experiences, reasoning or best practices. We derived this knowledge based on the information provided by field staffs and discussion with other expert in pest and disease control for corn crop. All the information was then coded for diagnosis domain in the form of IF (G)…THEN (P)…where (G) is for the combination of symptoms and (P) is the suspected pest or disease along with the treatment actions. At the time of this paper writing, we have identified and verified with the field staffs about 48 symptoms and its combination resulting 7 types of diseases as illustrated in Table 1. As mentioned previously, these rules can be later updated using expert interface

Table 1. Knowledge base rules of pest and disease diagnosis

Rule	Disease	Combination of Symptoms
R1	P1	G2,G4,G5,G6,G7,G8,G11,G13,G35
R2	P2	G16,G17,G18,G36,G40,G46
R3	P3	G3,G19,G20,G21,G22,G30
R4	P4	G11,G12,G23,G24,G25,G26,G27,G46,G47,G48
R5	P5	G12,G13,G27,G28,G46
R6	P6	G29,G30,G31,G32
R7	P7	G10,G16,G36,G37,G38,G40

Since the proposed application was envisaged to enable users identify disease and pest using their phone camera, this knowledge base also contained infected images captured from corn leaves, stem and fruit. All the images were then organized processed into several steps including image segmentation, feature extraction and classification to produce rules-based for crop pest and disease detection. Figure 3 shows image retrieval process employed in this study generate knowledge-based rules used for the examination of imagery suspected disease or pest attacks.

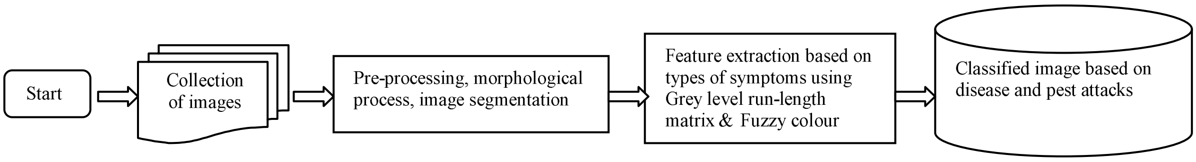

Figure 3. Image retrieval process

3. Inference Engine

This component is considered as the central processing unit where the process identification, interpretation and diagnosis of disease and pest take place. In doing so, firstly, the inference engine collects the information about the symptoms using user interface or imagery suspected pathologies captured by phone camera. Secondly, the inference engine makes reasoning and performs matching of facts or information provided by users and rules stored in the knowledge-based. For diagnosis disease and pest based symptoms, we employed probabilistic classifier method called Naïve Bayes to rank and sort what diseases are most likely based on the selected symptoms. Whereas for suspected image diagnosis, we used using K-nearest neighbours to classify and analyze images based on features that have been previously extracted using FCH and GLRLM and stored in the knowledge base. Finally, the recommendation was then stored into the working memory before transferred to the users.

4. User Interface

This feature is similar to Expert Interface that was proposed to enable farmers as the main users interact with the system as well as obtain information from the system. Unlike, the expert interface, this feature was designed only in mobile interface platform. In addition, this feature was designed in accordance with the user experience principles that were practical, user-friendly with little or no training required. It also aimed to reduce the administrative burden and tough agricultural field works where previously they have had to collect detailed information using pen and paper, manual crop tracking, log keeping, limiting use of data and scalability.

4. Conclusion and further work

As stated above, this study sought to propose a conceptual model applied to develop a mobile expert system for diagnosing pest and disease. Taking a specific case study of MyCorn project, this study was undertaken to present a conceptual model for guiding the development of a mobile-based expert system for assisting corn farmers mitigating disease and pest attacks. Our proposed model offers a practical way that brings down crop disease monitoring to the paddock using both the inference of visible symptoms and the examination of imagery suspected pathologies captured by phone camera. This feature is no comparable to any existing expert system developed previously for pest and disease diagnosis in Indonesia. Moreover, the feature is proposed to address the difficulties in pest and disease monitoring activities which involve great amount of manual works, time consuming, requiring particular knowledge and expertise in observing visual symptoms and eventually is uneasy especially for farmers. In particular, the proposed feature will enable farmers to perform diagnosis and then get the first-hand information about the possible control solution easier without waiting support from the experts or field staffs. Finally, the model provides communication media, discussion forum, sharing information and one-to-one consultation to allow both farmers and field officers taking collaborative and holistic actions for pest and disease management including diagnosis, treatment, and protection. All the above features are proposed to develop a mobile expert system for integrated pest and disease diagnosis, containment, and treatment.

Summing up from the results above, this paper offers a framework that can be readily used for guiding the development of a mobile-based expert system. Therefore, it would be interesting to assess whether the model demonstrate the aim of integrated pest and disease management. the Although the current study is mainly based on a specific case study of MyCorn project, our analysis suggests that the proposed model also has great potential for guiding the development of similar expert systems for pest and disease monitoring. Accordingly, it is recommended that further work be undertaken in agriculture crops other than maize.

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