A Diagnosis and Prescription System to Automatically Diagnose Pests

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ABSTRACT

Crop losses continue to increase due to climate change and the presence of foreign pests. However, it is difficult for farmers to reduce crop losses because they cannot diagnose and prescribe against pests quickly enough. Therefore, in order to resolve the issue, this paper describes a mobile-based, automatic system for pest diagnosis and prescription using a smart device with which to diagnose pests and obtain prescription information by taking photographs. In order to diagnose pests, image searches based on similarity are conducted. Due to the features of the image-similarity search, sufficient data sets must be obtained in order to increase search precision. In order to increase the pest-image data set, images of pests were collected using a focused web crawler on the Internet. However, because there are many images that do not pertain to the applicable pests, the precision of diagnosis is reduced. Therefore, image precision was increased through an inspection system that utilizes experts. The images obtained with the pest-image collection and search system is indexed using an image similarity-based search system. Next, the similarity of images of pests taken with the user's cell phone is compared, and information on diagnosis and prescription is shown to the user in real time. When the system-diagnosis performance was measured using three crops (pears, strawberries and grapes), a precision level of 83% was recorded. In the future, a video recognition-based system will be incorporated in order to enhance the precision and scope of application. It is expected that the system of mobile-based automatic pest diagnosis and prescription will provide quick, precise pest information to farmers and assist in the prompt prevention of disasters so as to minimize economic losses.

KEYWORDS

inspection system, pest diagnosis, searches based on similarity, web crawler

1 INTRODUCTION

Although various smartphone applications for the identification of crop pests are being developed amid the rising demand for diagnosis and prescription against loss-inducing crop pests, such apps remain incapable of analyzing images obtained using a smartphone in a program and autonomously diagnosing diseases. Therefore, in this project the images and information on pest diagnosis and prescription were saved in a database. Additionally, in order to collect only the most appropriate images, unnecessary images are eliminated through an image-inspection system in which experts participate, and clear images of pests are selected and saved in the "pest" database in order to provide precise images. Through a collection system that consumes just one-tenth of the time previously required, the applicable image-inspection

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system increases the precision and objectivity of pest-image data through means of an image-inspection system and the objective opinions of semi-experts and experts based on an image-inspection system. The images transmitted by the applicable image-inspection system are provided to the user real-time using a similarity-based search and machine running classification algorithm in order for the user to determine whether the images of suspected pests are actually so. With this system, if the user determines that the images depict such pests, the information on diagnosis and prescription will be indicated by means of an app in order to prevent any further crop losses the pests would cause.

2 RELATED WORK

In order to conduct automatic diagnosis in an automatic, mobile-based system for pest diagnosis and prescription, either the method using image similarity or the method using video recognition could be used. For these, videos with which to learn more about the images of pests are necessary. In order to configure image sets for use in study videos, it is necessary to collect data pertaining to images of pests. Currently, in order to configure databases of pest images, experts must visit web pages and collect images of pests one by one. Therefore, although the precision level is high, the collection of such images is time-consuming. A variety of data--including images, texts and SNS--is collected using an open API [1]. There are many kinds of open APIs to collect images. Among them, Google's Open API [2] and Microsoft's Open API are most popular.

Because experts must work concurrently with the collection of images for specific fields, there are instances in which errors occur due to judgments regarding ambiguous images. When such images are used, the expert's subjective judgment is reflected, so images are not objective. In order to resolve issues pertaining to subjective processing methods, many methods by which to obtain opinions objectively have been considered in the test-processing field [3].

Among inspection systems, product-inspection systems have been developed the most, and machine vision, contents-based image-inspection systems, etc., have been studied [4,5]. However, there has been no inspection system that uses or requires expert knowledge. Therefore, it is believed that, in certain areas, inspection systems that incorporate expert judgment will remain necessary.

Accordingly, for the purposes of mitigating the shortcomings of the existing systems for collection and inspection, systems in which semi-experts and experts collect various images through image-collection programs in a short period of time and to assist semi-experts and experts are necessary. Therefore, this paper describes a method in which precise images are collected with a supplementary system, pests are diagnosed automatically and prescriptions are provided based on an automatic mobile system.

Recently, several diagnostic systems that employ the IT fusing technology have been launched, and related technologies have been proposed.

First, with [6] it is possible for a farmer to know about the occurrence of pests on a real-time basis, and the system allows the farmer to contrast images to conduct diagnosis or to consult with an expert to prevent disasters.

Secondly, [7], [8] and [9] are systems that forecast the climate, predict the occurrence of pests, and provide pest management information. However, with the above systems the types of pests are limited. Moreover, the pest-diagnosis function is not provided automatically.

Thirdly, with the research described in citation [10], it is possible to diagnose pests in crops and search for prescription information with a smartphone-based pest-information search system. However, descriptions regarding the collection of images and recognized crops were insufficient, and LIRE (Lucene Image Retrieval) [11] which is similar to the image search library--was used. Consequently, the level of precision in diagnosing pests is not high.

Fourthly, in the research described in citation [12], special features of symptoms caused by eight pests were automatically extracted, and these features were studied and classified using a GG vector machine (SVM), which is a machine-learning classification algorithm, and it is said that the average level of precision was 84%. In the research described in citation [13], when the HOG features were studied using an SVM classifier following an image pre-processing process, the level of precision was 97%.

Finally, in the research described in citation [14], three cucumber diseases were classified using a probability-based neural network model (a type of artificial neural network), and the level of precision was 91%.

As described, there have been many studies on the recognition of crop pests. Although the level of precision decreases in the vent that a similarity-based image-search system is used, the level of coverage is very high because many types of pests can be handled. Although the level of recognition precision is high for crops of specific crops when machine learning algorithm is used, the scope of application is narrow due to such problems as the study time and large amount of training data required. In order to resolve such issues, we designed a quick but precise mobile-based automatic pest diagnosis and prescription system using a similarity image-based search method and SVM, which is a machine-learning classification method.

3 SYSTEM DESIGN

This paper describes the use of data-collection modules to collect images of pests, similarity-based image-search modules that support fast searches, video-recognition image processing modules that improve precision of pest recognition, and diagnosis and prescription modules that provide information on diagnosis and prescription. Figure 1 is our system structure.

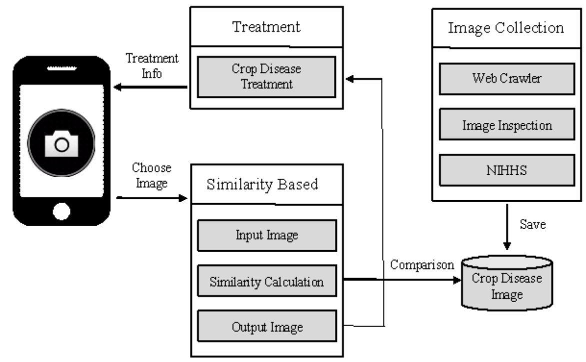

Figure 1. Overall system structure

3.1 Image Collection and Search-System Design

For this paper, an Image Search API using the Open API was used as an image-collection program. For this paper, images were collected using the Bing Image Search API [15] and a database was established through use of the image data collected through MySQL. Images collected on the World Wide Web and the existing images pertaining to pests were put into a pest-image collection system. An inspection system was used on images collected through an image collection system in order for semi-experts and experts to determine whether the images depict pests.

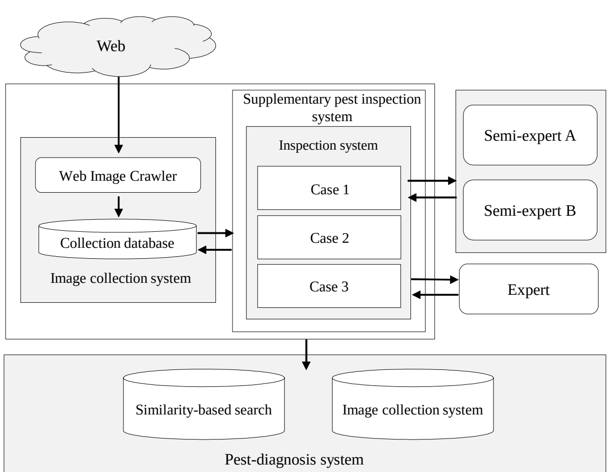

Figure 2. Image-search system configuration diagram

The overall system configuration diagram of the embodied pest image-search system is shown in Figure 2. The system acts as a supplementary system so that the pest-diagnosis system can provide experts and semi-experts with clear information regarding images of pests.

Table 1. Saved results, as obtained from semi-experts and experts

Configuration	Semi-expert Bxpert A	Semi-expert B	Expert	Result
Case 1	O	O	—	Save
Case 2	X	X	—	Delete
Case 3	O	X	X	Delete
	X	O	O	Save

The search system is saved as shown in Table 1. After semi-experts and experts in the field of pests determine with a search system whether the images depict pests, the results are either saved or deleted depending on the results shown in Table 1. In order to determine objectively and precisely about images of pests, two semi-experts and an expert in the field of pests determine whether the images depict pests. Whether the images are to be saved depends on the results shown in Table 1.

As can be seen in Table 1, cases are classified into three types. Case 1 is the one in which two semi-experts determine that the collected images depict pests. In this case, because two semi-experts distinguished clear images pertaining to pests, the images are saved in the pest collection database without any separate measures taken. Case 2 is the situation in which two semi-experts determine that it is not clear whether the collected images depict pests. This is the one in which the images are deleted due to the fact that the semi-experts believe that the images are not pertaining to pests. Case 3 is the situation in which two semi-experts determine it is difficult to decide whether the collected images of pests are those of pests. Among the images, it is difficult even for experts to distinguish images of such diseases as pear fire blight and pear leaf spot. Therefore, whether the images should be saved or deleted will be determined through one other pest expert's decision for accuracy. Table 2 is an example of the tables that are saved in the image collection system. This allows semi-experts and experts pertaining to pests to confirm and determine images based on the images saved in the collection system. The ID on Table 2 is an index that indicates the number of image data, and the types of crops number approximately five, including pears. Diseases were classified according to the scientific names of pests in citation [16]. The image address indicates the address of the images according to the scientific names of pests, and the web address indicates the address displayed on the

Table 2. Image Table structure

ID	Crop type	Disease	Image address	Web address	Semi-expert A	Semi-expert B	Expert
1	Pear	Fire blight	https://en.wikipedia.org/wiki/File:Fire_blight_(Erwinia_amylovora)_of_pear.png	https://en.wikipedia.org/wiki/File:Fire_blight	O	O	X
2	Pear	Fire blight	http://www.starkbros.com/blog/wp-content/uploads/2010/09/Fire-Blight-Pear-Tree_LG.jpg	http://www.starkbros.com/growing-guide/article/got-fire-blight/	O	X	O
…	…	…	…	…	…	…	…
N	Grape	Leaf spot	http://www3.syngenta.com/country/kr/kr/vermin/PublishingImages/ver_sick/image/pest14.gif	http://www3.syngenta.com/country/kr/kr/Vermin/ver_sick/Pages/info14.aspx	O	O	—

corresponding website. Semi-expert A and Semi-expert B check the images of the pests collected with a collection system in order to determine whether the images depict pests. The expert then checks the images in order to determine whether the decision of the two semi-experts is correct.

3.2 Design the Pest-Image Data Model

To efficiently save images of pests as well as applicable pest information and prescription information, the research for this paper made use of a relational database model. Figure 3 is an ER diagram for the saving of data. With our proposed system, three tables were used in order to save image information and prescription information. The basic information and prescription information regarding the applicable disease are produced through a query based on the name of the disease pertaining to the candidate pest image selected by the user.

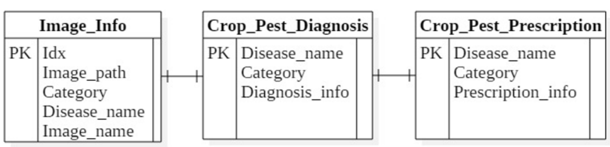

Figure 3. ER diagram

3.3 Design of a Similarity-Based Image-Search System

In this stage, if the user inputs images that are believed to depict pests, similar images are produced. In this system, LIRE (Lucene Image Retrieval), which is an image index library will be used to obtain image similarity.

Based on this library, the features of the images entered are first extracted. Subsequently, the images in the pest DB for which indexing was completed are compared in order to produce images with high levels of similarity. This method is advantageous in that the speed is conducted at a high speed, but the disadvantage is that indexing must be conducted again when new images are entered in the DB.

Figure 4 is a sequence diagram regarding a similarity-based image-search system.

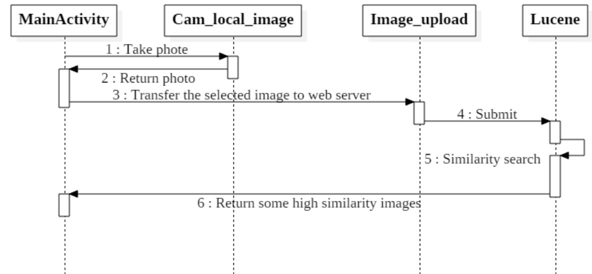

Figure 4. Similarity-based search sequence diagram

The user may, with his or her smartphone, capture images of crops that are suspected of being infected by pests, or may select images from a local file system. After images are selected, the transmission button is clicked for transmission and uploading to a web server.

Then, with the images uploaded in the server, the degree of similarity is calculated using the LIRE (Lucene Image Retrieval) library, and the similarity of the many images existing in the pest DB is calculated in order to generate six candidate images in the order of similarity to be shown to the user through the UI.

4 SYSTEM IMPLEMENT

In this paper, we embody a pest-image collection-and-inspection system whereby images are collected, identified and saved so as to provide the applicable images for an automatic, mobile-based pest diagnosis and prescription system in order to select images from the World Wide Web, particularly those that depict suspected pests, and to produce pest-diagnosis information and prescription information.

4.1 Implement of the Pest-Image Collection-and-Inspection system

Three people two semi-experts and one expert, determine the precision level of images through a web page. In the event the decisions of the two semi-experts are different, the images are checked by the expert.

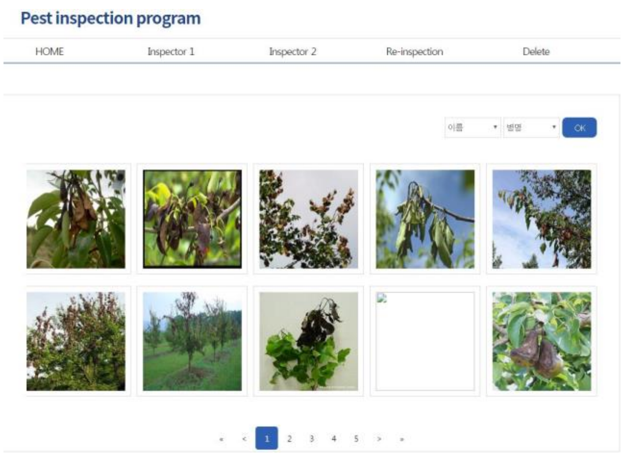

Figure 5. Main screen of the pest-collection/inspection system

Figure 5 is the main screen of the inspection system. On the main screen, those images that are confirmed by the two experts and one expert as depicting pests are shown on the main screen.

Based on the images displayed on the main screen, the images that are used on mobile-based automatic pest diagnosis and prescription systems are obtained.

Figure 6 illustrates the work of the two semi-experts as they employ the pest-inspection system. On that screen, the two semi-experts determine through an inspection system whether the images pertaining to pests could be used. Thus the decision is based on the assessment of the images as correct or incorrect. Additionally, additional texts could be added for images.

The question of whether images can be used is determined by the two semi-experts, as shown in Table 1. Figure 7 is the screen on which inspection is being conducted by the expert due to the fact that the decisions of the two semi-experts were different. Figure 8 shows a page that was deleted after the two semi-experts and one expert determined that the images did not depict pests.

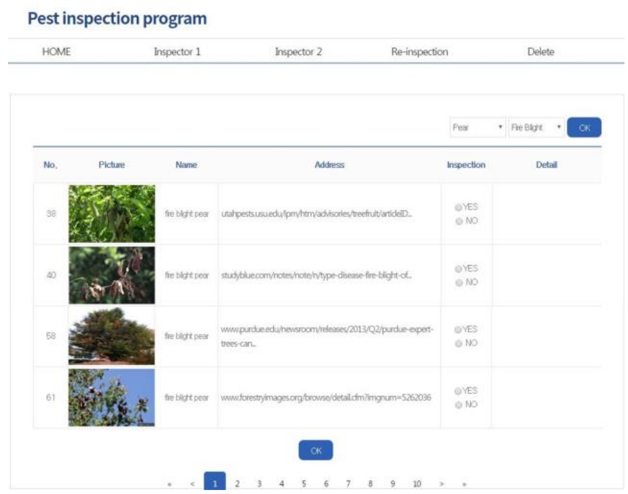

Figure 6. The pest-inspection system's inspection page

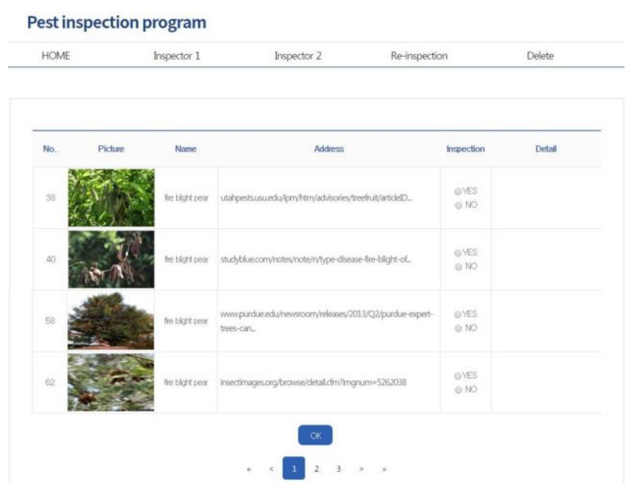

Figure 7. Page on which pests are inspected again

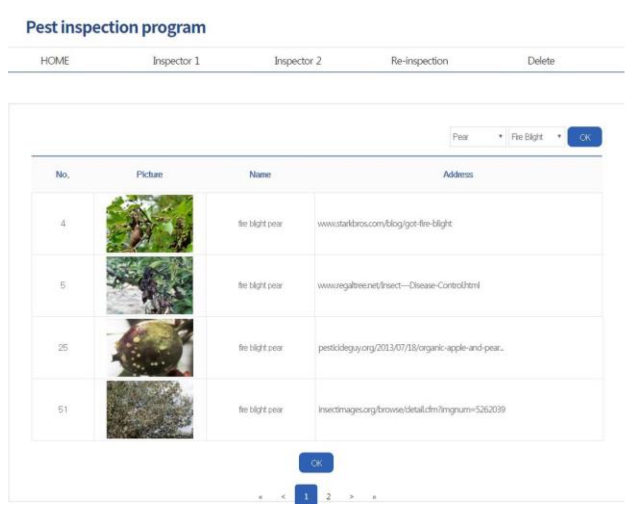

Figure 8. Page being deleted by the pest-inspection system

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4.2 Implement of an Automatic, Mobile-Based Pest Diagnosis and Prescription System

The mobile-based automatic pest diagnosis and prescription system may be used with an app or on the World Wide Web. Figure 9 is the initial screen of our system. The screen is the screen UI (User Interface) on which the user directly selects images of suspected pests. The screen is also the one on which types of crops are selected. There are two methods for the selection of images: One is to obtain images with a camera, and the other is to obtain them from a local file system.

After selecting images of pests through the process shown on Figure 9, when the "Search" button is clicked the screen (UI) as shown in Figure 10 is displayed.

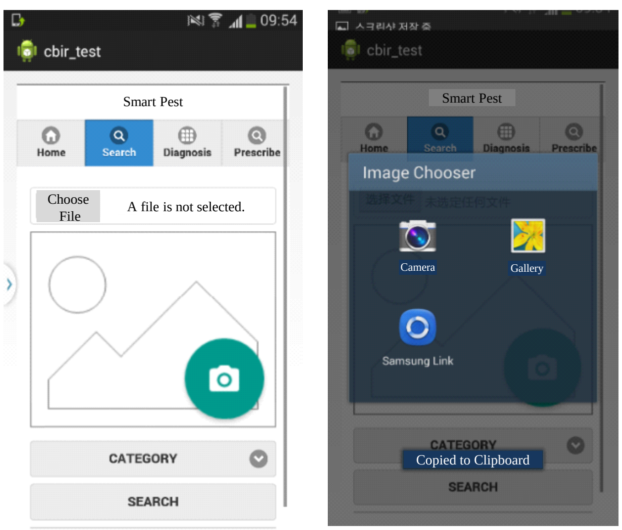

Figure 9. Selecting images of pests

In Figure 10, the features of the images selected by the highest level of similarity are produced. Among the six images of pests, the user selects the image that is most similar in terms of symptoms.

When the user selects an image, the pest-diagnosis information and prescription information applicable to the image are produced.

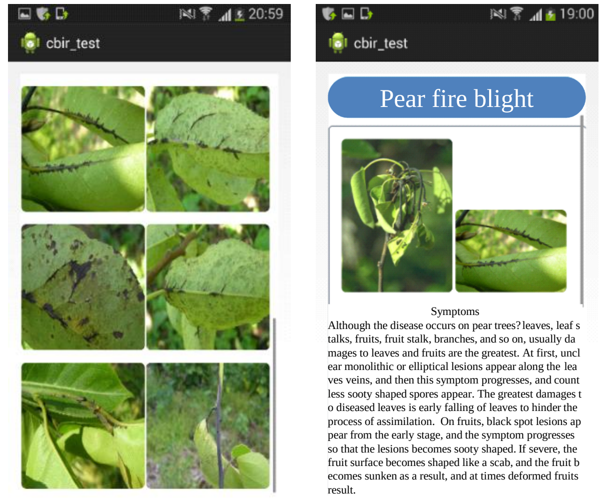

Figure 10. Selecting images of similar pests

5 PERFORMANCE COMPARISON

To measure the performance of the pest-collection/inspection system, we compared the number of images collected by using the inspection system and the number of images inspected without using the search system during a given period of time. Additionally, the level of precision was measured in order to assess the performance of a similarity-based search system on mobile-based automatic pest diagnosis and prescription systems.

5.1 Performance of the System for Pest Collection and Inspection

Figure 11 shows the results of the difference in speed when two semi-experts and one expert searched images pertaining to pests manually and when the search system proposed in this paper was used to search images.

We could thus confirm that the speed at which images were searched using the collection-and-inspection system proposed in this paper was 10 times the speed at which two semi-experts and one expert in the field of pests collected images of pests.

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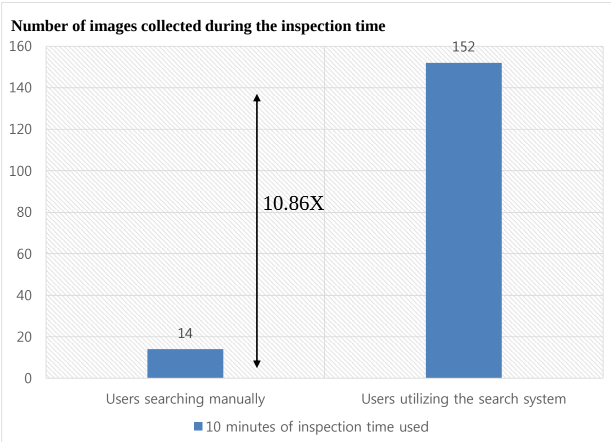

Figure 11. Comparison of the number of images found when images were searched manually and when images were searched using the search system

The speed at which images were collected was improved through the collection-and-inspection system proposed in this paper, and the level of precision for the images was improved through the opinions of the two semi-experts and one expert in the field of pests.

5.2 Measurement of the Precision of the Similarity-Based Search System

In this section, the level of precision of a similarity-based image-search system was measured. The types of crops measured were pears, strawberries and grapes, and performances were measured in two cases. Figure 12 measures the level of precision of similarity-based search systems.

In Figure 12, there are two bar graphs for the parameter crops. When the image with the highest level of similarity is entered, if the applicable image corresponds to the applicable pest, "1" is indicated, but "0" is indicated if the image does not correspond to the applicable pest. "Voting" is the proportion of the applicable images among the six that have been produced. If the proportion is over 50%, "1" is entered, but otherwise "0" is indicated. For example, the user enters a query regarding an image of fire blight. If there are five images of the fire blight out of the six images produced, "1" is indicated

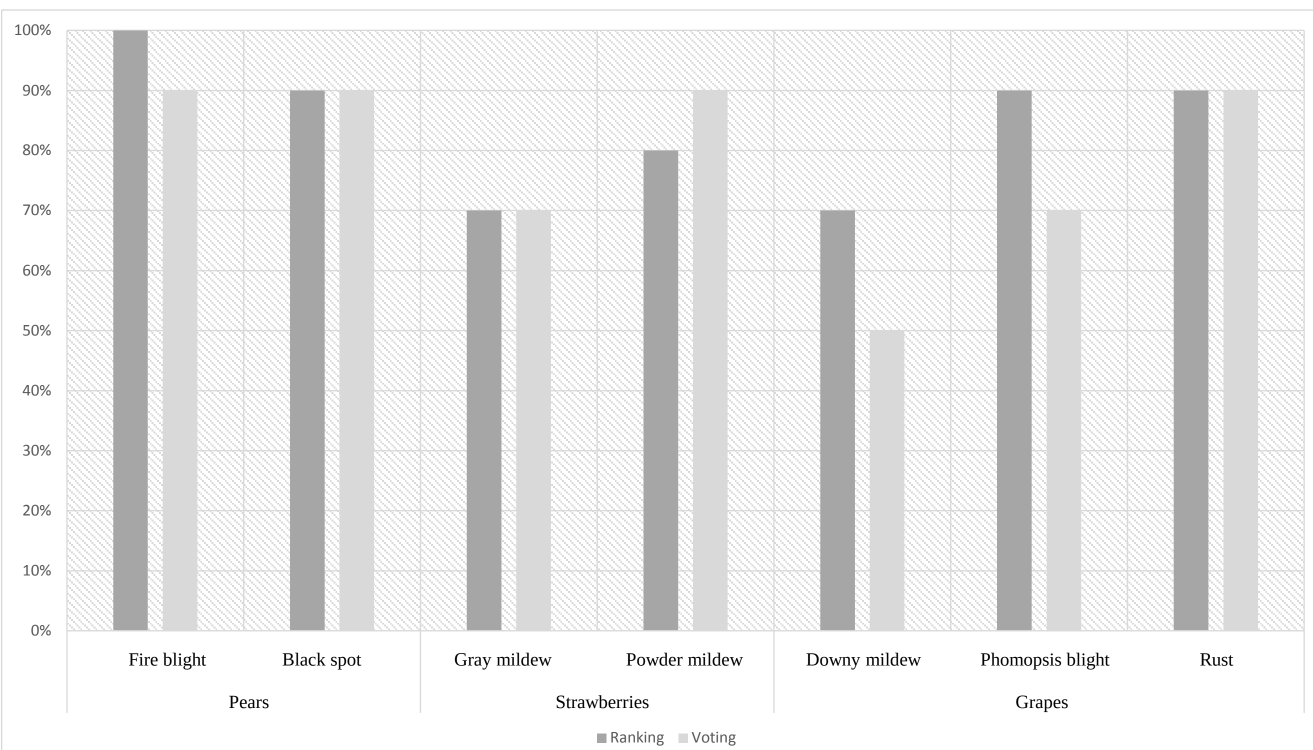

Figure 12. Precision level of similarity-based images

because the number of fire blight images is greater than three, meaning it exceeds 50% of the images.

In this paper, performance measurements were made for three types of crops: pears, strawberries and grapes. In Figure 12, the averages of the "ranking" and "voting" for each crop were calculated. The level of precision for "ranking" was 83%, and the level of precision for "voting" was 78.5%.

6 CONCLUSION

Based on the above process, we designed an embodied an automatic, mobile-based pest diagnosis and prescription system that can be used in crop production sites.

Images of crop pests and pest management information were provided by the National Institute of Horticultural and Herbal Science for use in the proposed system. Additionally, through the pest-image collection-and-inspection system, it was possible to resolve the issue of insufficient numbers of images to a certain extent, and it was possible to improve the reliability and precision of the images used for analysis.

The proposed system made it possible to handle more types of pests through the similarity-based image-search system, and it was possible to search more quickly. However, this system did not achieve a high level of precision in the identification of pests. Consequently, in the future a video recognition-based system will be incorporated for greater precision and coverage.

Additionally, the system we propose will be linked with the NCPMS (National Crop Pest Management System)[17] and provide farmers with prompt, precise pest information, thereby assisting them with timely pest management in order to minimize the economic losses caused by pests.

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REFERENCES

[1] J.I.Kim, K.H.Lee, “A Study of Contents Service System Using Open API”,International Conference on Multimedia Information Technology and Applications(MITA), 342-345, 2009.

[2] https://developers.google.com/products/?hl=ko.

[3] T.Brants, “Inter-Annotator Agreement for a German Newspaper Corpus”, In Second International Conference on Language Resources and Evaluation LREC-2000.

[4] U.S.Khan, J.Iqbal, M.A.Khan, “Automatic Inspection System Using Machine Vision“, 34th Applied Imagery and Pattern Recognition Workshop (AIPR’05), pp.210-217, 2005.

[5] J.Iivarinen, J.Pakkanen, J.Rauhamaa “Content-Based Image Retrieval in Surface Inspection”.

[6] http://ncpms.rda.go.kr/npms/FoodImageListR.np, National Crop Pest Management System(NCPMS).

[7] http://nongup.gg.go.kr/works/27,Gyeonggido Agricultural Research& Extension Service.

[8] http://www.cnnongup.net/html/kr/tech/tech_04_03.html, CHUNGCHEONGNAM-DO Agricultural Research & Extension Services.

[9] http://www.agri.jeju.kr/, JEJU Agricultural Research & Extension Services.

[10] K.JAGAN, M.Balasubramanian. Recognition of Paddy Plant Diseases Based on Histogram Oriented Gradient Features. International Journal of Advanced

Research in Computer and Communication Engineering, 2016; 5(3), pp.1071-1074.

[11] S.Yun, X.F.Wang, S.W.Zhang, C.L.Zhang. PNN based crop disease recognition with leaf image features and meteorological data. Int J Agric & Biol Eng, 2015: 8(4), pp.60-68.

[12] Jagadeesh D, Rajesh and Abdulmunaf S. Classification of Fungal Disease Symptoms affected on Cereals using Color Texture Features. International Journal of Signal Processing, 2013; 6(6): pp.321-330.

[13] J.H.Kang, S.H.Jung, S.S.Nor, W.H.So, C.B.Sim. Design and Implementation of Produce Farming Field-Oriented Smart Pest Information Retrieval System based on Mobile for u-Farm. 2015, pp.1145-1156.

[14] M.Lux and Savvas A. LIRe: Lucene Image Retrieval - An Extensible Java CBIR Library. Proceeding MM '08 Proceedings of the 16th ACM international conference on Multimedia. 2008, pp.1085-1088.

[15] https://www.bing.com/dev.

[16] https://ko.wikipedia.org/wiki/ Scientific.

[17] http://www.nihhs.go.kr/english/index.asp, National Institute of Horticultural and Herbal Science.