An approach based on deep learning that recommends fertilizers and pesticides for agriculture recommendation

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Article Info

ABSTRACT

With the advancement of the internet, individuals are becoming more reliant on online applications to meet most of their needs. In the meantime, they have very little spare time to devote to the selection and decision-making process. As a result, the need for recommender systems to help tackle this problem is expanding. Recommender systems successfully provide consumers with individualized recommendations on a variety of goods, simplifying their duties. The goal of this research is to create a recommender system for farmers based on tree data structures. Recommender system has become interesting research by simplifying and saving time in the decision-making process of users. We conducted although a lot of research in various fields, there are insufficient in the agriculture sector. This issue is more necessary for farmers in Quangnam-Danang or all Vietnam countries by severe climate features. Storm from that, this research designs a system based on tree data structures. The proposed model combines the you only look once (YOLO) algorithm in a convolutional neural network (CNN) model with a similarity tree in computing similarity. By experiments on 400 samples and evaluating precision, accuracy, and the value of the predictive test as determined by its positive predictive value (PPV), the research proves that the proposed model is feasible and gain better results compared with other state-of-the-art models.

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1. INTRODUCTION

We live in an age where the internet, intranets, and e-commerce platforms are widespread, there is an abundance of information available that we rarely use. People are increasingly turning to web applications to meet their needs since they provide more possibilities for selecting a certain product [1]. However, people may find it challenging to choose a suitable item from a huge pool of options that meets their needs. As a result, online apps must be accountable for providing strong recommender systems that can assist users. Recommender systems aid in product selection by identifying user interests and preferences [2]–[5]. e-commerce, health, agriculture, banking, social media, education, and sports all benefit from using buyer research. The agricultural sector is an important role for the economy ratio of developing countries. Although the sector seems to have plenty of advantages, it is plagued by issues such as climate change, rainy seasons

that are not as regular as they used to be, droughts, floods, and farmers leaving their homes for better-paying jobs in cities.

Hybrid recommender systems include both collaborative and content-based approaches. Hybrid recommender systems often perform better than standard collaborative and content-based systems, according to numerous studies [6]–[8]. When knowledge-based recommender systems are used, there is no need for rating data in order to obtain suggestions. Based on the knowledge base, the systems provide a list of suggestions. Both case-based and constraint-based systems employ knowledge-based. Knowledge is most useful when it is incorporated into constraint-based and case-based systems in diverse ways. Suggestions are provided based on user demographic information that may be obtained when the user's age, gender, nationality, and location are verified to be comparable [9]. The recommendation system is shown in general scheme Figure 1.
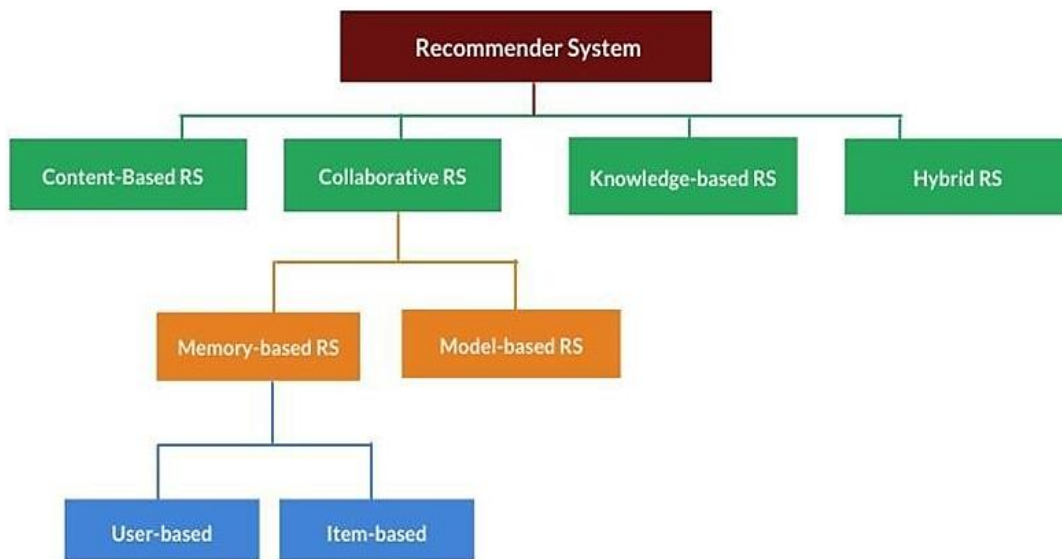

Figure 1. Types of recommender systems

Revolution 4.0 is a highly combined physical and digital hyper-connected systems with a focus on the internet, internet of things (IoT) and artificial intelligence (AI), which creates entirely new production possibilities and has a profound impact on the economic, political and social life around the world. This fourth industrial revolution has four major features, one of which is AI and cybernetics, which allows people to control remotely without regard for space or time constraints, as well as interact in a faster and more accurate manner [10]–[12]. An overview of the types of recommendation systems being implemented today can be found in Figure 1.

The rest of this paper is organized: the related works are listed in section 2. The problem definition, system architecture and method experiment are declared in sections 3. The authors discuss about results in section 4 and provide a brief conclusion in section 5.

Recommender systems assist users in selecting products based on their particular preferences. Machine learning approaches using tree-based and fuzzy logic, as well as other recommender systems for the agricultural industry, are all reviewed in the literature study [5], [8], [9]. Agro consultant is a comprehensive intelligence system developed to assist Vietnam and countries in Asia zone farmers make intelligent planting selections that are dependent on such weather and environmental aspects as soil quality, farm location, and sowing season. Distributed computing is used to assess customer behavioral data, uncover their preferences, and provide personalized suggestions to them. The technique developed to predict crop yield and price a farmer may make from his property uses a sliding window non-linear regression approach to evaluate rainfall, weather, market prices, land acreage, and the yield of previous crops. By using a collaborative recommender system that employs fuzzy logic, farmers may gain an early jump in crop production prediction [13], [14].

AI in general, and computer vision in particular, is one of the key technologies of the fourth industrial revolution that scientists are particularly interested in researching. Some of the most well-known applications of computer vision are: utilizing large data sets accumulated over time to train recognition

models; using machine learning, deep learning techniques to assist in object detection and recognition; developing image classification systems [15]–[17]. The proposals and projects listed above demonstrate that, in the current agricultural industry, scientists and researchers are very interested in researching and applying AI in general and computer vision in particular, especially in the field of using algorithms such as CNN to extract image features and attribute descriptors of fruits [4].

2. SYSTEM ARCHITECTURE

Agriculture is critical to the economies of developing countries, as it provides the key foundation of food, profits, and employment for rural populations. Agriculture in Vietnam has progressed dramatically during the last few decades. Agriculture supports more than 70% of rural households. QuangNam, being solitary of India's states, has an agricultural sector that produces over 30% of the country's national summary data page (NSDP) and employs 73% of the country's agricultural labour. However, most farmers in Quang Nam continue to cultivate in the old manner, oblivious of new herbicides, fertilizers, and instruments available for a particular crop. They may have to suffer losses in their farming as a result of these factors, which has a significant impact on our society. The results of this study suggest that the authors developed a recommender system that suggests pesticides and crop-specific equipment for a farmer who is active in a certain crop. This tip also offers viable seeds for other crops depending on soil test findings [4], [10].

This system, which is based on the use of computer vision technology, is designed to determine the ripening stage of pineapple fruit. The system analyzes data, extracts images and attribute descriptors of pineapples using CNN algorithm. In this article, the authors use the YOLOv4 model to improve training speed and performance. The system's architecture is depicted [18]–[21].

The system's input is a dataset of images collected by the authors at various pineapple gardens. After an image has been fed into the system using the absolute path, it will be labeled and the features' coordinates will be determined. User will receive the input image as well as information about the growth stage as output.

2.1. Input data

In this paper, the authors perform pineapple's growth stages detection, from bud emergence stage to senescence stage. Data which is used was collected during the research process. This study has surveyed and took pictures at some pineapple gardens. Each data element contains images divided into two sets: one training dataset and one validation dataset. It also contains labels that assign location to each photo. The datasets are updated attributes such as image name, growth stage, and the pineapple position in the image ($x\_min, y\_min, x\_max, y\_max$). Whole dataset includes 36,000 photos about five growth stages of pineapple taken at various local pineapple gardens. The model will be trained with 30,000 independently-labeled images and evaluated on a testing set of 6,000 images left.

2.2. Annotate images

Following the collection of input images, the authors proceed to label each image in order to extract the characteristic regions of pineapple. Labeling is done with the LabelImg software. LabelImg is a tool for annotating images written in Python and using Qr as its interface. The information is saved as text files (.txt). Each file will be named after the image and saved in you only look once (YOLO) format in the specified folder. It contains parameters such as class code, x-coordinate, y-coordinate, x'-coordinate, y'-coordinate.

2.3. Pineapple's growth stage detection model

The model is built in the following steps:
a. Data preprocessing: Annotate images. In order for our detector to learn to detect objects in images, it needs to be fed with labeled training data. After finishing the labeling, files are saved in the 'data' folder for training.
b. Training: Images are still being collected and labeled automatically in order to improve training coverage and scale via reinforcement. Image resolution is increased for greater accuracy. The higher the pixel resolution, the more detailed features the model can detect and the more easily image borders, image styles, colors can be extracted. The patterns are determined by the outer skin of pineapple and its defects. The image features are extracted using the CNN algorithm in the YOLOv4 training model [22].
c. Testing: The system will be tested and evaluated after the training phase. The system will take input images from the testing set, compare with the extracted characteristic attributes, and then return prediction results that include input images and their labels for different pineapple cultivars. Figure 2 shows that the training set includes images of semi-ripe pineapples and ripe pineapples.
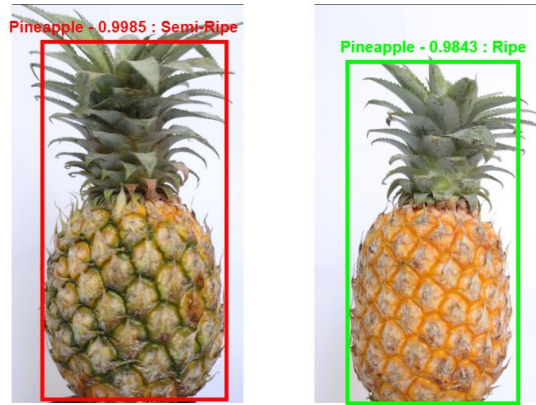
Figure 2. Pineapple images used for detection

3.   METHOD

The system is expected to take an input list of farmers on farms in the Quang Nam Da Nang region, Vietnam. There is a list of plant tools and pesticides that we recommend. Depending on the area, growing soil, we recommend people to experiment on pineapple. Additionally, we recommend pineapple varieties suitable for this area [4], [10]: i) this study employed a questionnaire method in this investigation. The questionnaire is initially distributed to the respondents. A total of 400 people took part in the research. This study included 310 males and 90 females with an average age of 25.4 years (M_{age}=30 years, F_{age}=32.5 years). All of the respondents are from Da Nang, Vietnam, in Quang Nam's west area. The proposed method uses the user's location and crop preferences as input to construct a skewed binary tree. Because it was used to compute similarity, this skewed tree is referred to as a similarity tree. The projected model is depicted in Figure 3 and ii) a similarity tree is utilized to locate active query farmers comparable to the farmers who have comparable characteristics. Figure 1 depicts the topology of the similarity tree and its probable nodes. The first branch of the similarity tree is the farmer's country of origin. Seeds (S1, S2, ..., Sp) are places that are immediately adjacent to each other. Pesticides (P1) and instruments (I1) are those used in the treatment of seeds. States (ST1, ST2, ST3, ..., STn) are the countries that are immediately adjacent to each other. Seeds (S1, S2, ..., Sp) are the places that are immediately adjacent to each other. Pesticides (P1) and instruments (I1) are the treatment methods used on seeds. States (ST1, ST2, ST3, ..., STn) are the countries that are immediately adjacent to each other.
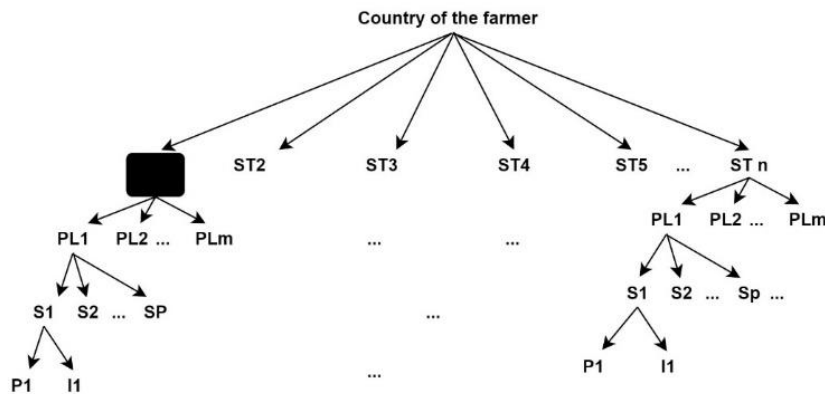

Figure 3. Structure of the similarity tree

Using the aforementioned structure, a similarity tree will be generated for every provided input active query farmer. It is revealed that the farmer has a matching preorder traversal. Related preorder traversal is also studied in the context of database users. Comparing the active query farmers' preorder traversals to the database users' preorder traversals yields the database users' comparable users. Users in the database with preorder traversals that match the active user's are thought to be comparable. The database user's similarity value is set to 1 if the database user's preorder matches that of the active query farmer

[19]–[21]. For example, if an active inquiry farmer specifies rice as his preferred crop and is from Vietnam, the state of Da Nang, and the province of Quang Nam, a similarity tree is generated for that user.

Figure 3 shows similar tree structures in all pineapple-growing areas of Quang Nam-Danang. The figure on the right shows the similarity tree for this current query user. A skewed binary search tree is used to build the similarity tree. The preorder traversal of the similarity tree is found. These two preorder traversals connect to each other in the sense that one happens before to the next preorder traversal. The system assigns the similarity value to either 1 or 0, depending on the total number of preorder traversals. This sentence means that, given two users with similarity values of 1 in the database, they are seen to be as similar to the nth query user [23], [24]. This process groups customers who have provided rating values for previously bought seeds in the order in which they are provided. in order to suggest individuals, the top users will be utilized whose total number of recommendations is n (N).

4. RESULTS AND DISCUSSION
4.1. Performance assessment

The suggested system's performance is assessed using measures such as precision, accuracy, and positive predictive values (PPV). Precision can be defined as the percentage of correctly classified positive instances among those that are projected to be positive. Predictive positive is another name for precision. The proportion of correct classifications out of the total number of cases is called accuracy.

$$Precision = \frac{TP}{TP+FP} \tag{1}$$

Where, TP is true positive, FP is false positive, TN is true negative, and FN is false negative. A good rule of thumb for identifying true positives is to consider the proportion of positives that have been detected correctly. A tree that grows pineapples is similar to the tree pictured in Figure 4.
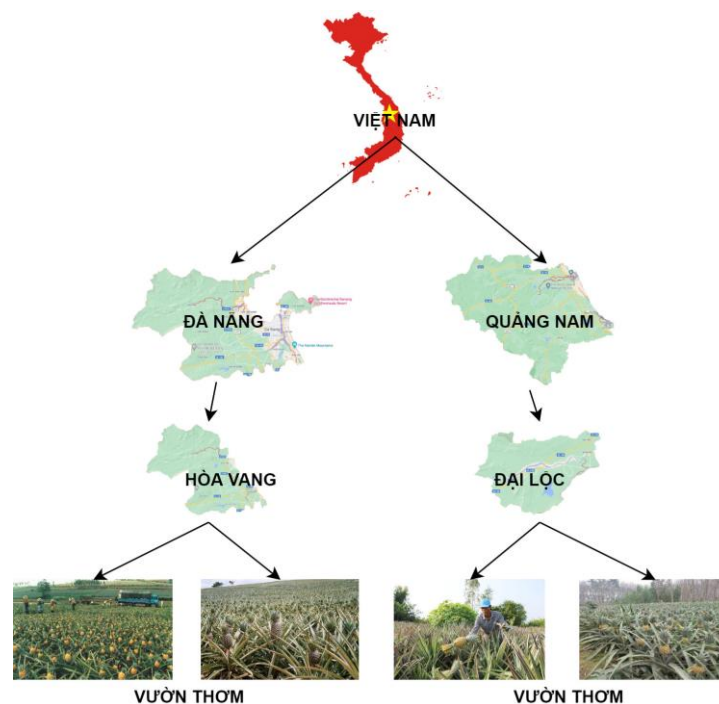

Figure 4. Active query farmer similarity tree

A false negative is said to occur when a symptom occurs when it is not existent. An FP is a case in which an attribute or condition is stated improperly. A genuine negative result, which indicates that the condition is not present when it is not present, is indicated by a TN result. True positive test findings make up the total proportion of true positives (PPV). The PPV shows the diagnostic statistical measure's performance.

If the system is very accurate, then the PPV will be too. Obtaining a false positive is a type one mistake, and the false discovery rate (FDR) expresses the likelihood of this happening. Connecting the PPV and FDR is done using (1) [20], [22], [25].

$$PPV = FDR = 1 \qquad (2)$$

Before determining whether the suggested method is suitable, 20 crop kinds are tested to find out their quality. The database contains 150 user opinions. The seeds for different crops have been rated on a 1-5 scale. For the five most often selected items from Table 1, the authors computed the precision, accuracy, PPV, and FDR values for five distinct users. PPV and FDR as seen in Figure 5 while Figure 6 show the precision and accuracy graphs, respectively.

Table 1. Precision, accuracy, PPV and FDR values of five users

User ID	Precision	Accuracy	PPV	FDR
1	0.57	0.62	0.75	0.55
2	0.34	0.75	0.5	0.56
3	1.21	0.9	1.25	0.6
4	0.78	0.74	0.9	0.73
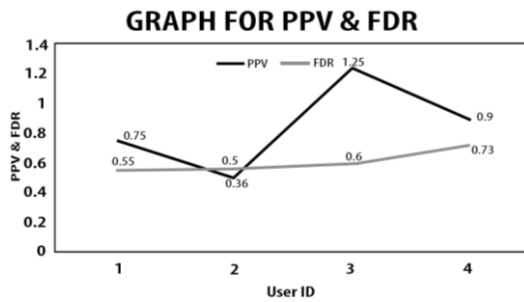
Figure 5. Graph for PPV and FDR
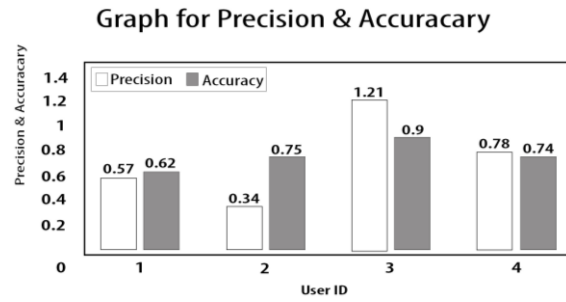
Figure 6. Graph for precision and accuracary

4.2. Time complexity analysis

Traditional approaches such as cosine similarity, pearson correlation coefficient, and Jacard's similarity may be proved to be less time efficient than the suggested technique. The amount of time required to find the cosine similarity between two vectors is O(n2), while recommendation of a skewed binary tree is O(n), where n is the size of the input. After successfully training, the study used the trained data to perform detection on the images that were collected. The study used the data from the 6,000[th] loop to make the comparison. The training result is shown in the diagram in Figure 5.

$$Accuracy = \ TP + TN$$
$$TP + TN + FP + FN \qquad (3)$$

Through the evaluation diagram, the authors found that the training model achieved good results to be able to perform the pineapple's growth stage detection. The training model correctly identified the pineapples and detected their growth stages with an accuracy of more than 95%.

This study used deep learning techniques, specifically the neuron network model, with the purpose is to identify the pineapple and determine its ripening stage, in order to propose optimal care and harvesting solutions [24], [25]. As a result, farmers can save time, money, and human resources, while also increasing system flexibility. In this article, the authors used YOLOv4 model. The experimental results show that the YOLOv4 model achieved high accuracy in determining pineapple ripeness, reaching approximately 95% after 6,000 epochs.

5.   CONCLUSION AND FUTURE WORK

Based on previous choices, a recommendation system predicts a user's preferences. This technology has proven successful across virtually every domain. It is essential to implement effective recommender systems in countries like Vietnam, where agriculture comprises a large part of the economy, for farmers to

adapt to environmental change and learn about new pesticides and instruments for boosting crop yields. To make the right choice of insecticides and equipment for a particular crop, we should look at the farmer's needs, says this paper. It also suggests some other crops that may be suitable for the farmer's area. A tree-based similarity strategy is used to find users or farmers related to a query user. Compared to other similarity metrics, this method is more time-efficient. Accuracy, precision, and positive predictive values were used to assess the effectiveness of the suggested systems. In this study, we took only Quang Nam and Da Nang into account as geographical locations. Future studies may examine technology adaptation for agricultural production and other geographical regions. Using deep neural networks, a machine learning technology that is most suitable for large data-sets, can also improve the capability of agricultural recommender systems. The stacking of auto-encoders with a short dataset is an effective method to retrain deep neural networks. When it comes to generalization, deep neural networks outperform shallow neural networks and support vector machines (SVM). Finally, future research the authors conduct is a hybrid recommender system. According to that, a system is designed by using various input data. The robust features in both collaborative filtering and content-based are combined in a unity system.

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