Conceptual Modeling for Intelligent Knowledge-Based System in Agriculture: Case Study of Indonesia

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***Abstract* – Agriculture is a pillar for economic growth in Indonesia. It drives the needs of agricultural information and knowledge increase. In order to provide information for farmers and knowledge to support the decision-making process in strategic level, the conceptual modeling for the intelligent knowledge-based system in agriculture is proposed. The conceptual model combines the geo-fencing technique to ensure the availability of information for farmers and machine learning to provide the knowledge for the strategic decision-making process in order to improve agricultural sector performance.**

Keywords--Agriculture, intelligent knowledge-based system, machine learning, strategic decision-making

I. INTRODUCTION

The agriculture is one of sectors that brings the increase towards economic growth in Indonesia and also acts as an important source of income for local people and has also contributed to export revenue. Indonesia is the only one Association of Southeast Asian Nations (ASEAN) countries to get surveyed by the Economist Intelligent Unit (EIU) and Barilla Center for Food and Nutrition (BCFN) Foundation. According to EIU and BCFN, Indonesia is ranked 24th in sustainable agriculture category [1]. It means that Indonesia is on the right path to implementing a sustainable agriculture system.

Nowadays, Indonesian government has been massively utilizing Information Technology (IT) in all fields[2] since IT innovations are constantly emerging and leading to the development of new products and innovative applications which can bring the benefits and values to Indonesian people and government. The use of IT in Indonesia can be seen from any aspects such as for the security, Indonesia government set up the closed-circuit television (CCTV) to monitor the city in real time. Indonesian government has also install the Automatic Water Level Recorder (AWLR) which aims to monitor the water level in Jakarta in order to manage and direct the flood disaster preparation.

In the agriculture field, Balai Penelitian Tanaman dan Sayuran (BALITSA) or Indonesian Vegetables Research Institute has developed the mobile-based learning application to spread the information and knowledge to the farmers in Indonesia. This application provides the information about the agriculture products sell and buy, seeds, feltilizers, and also enables the farmers communicate to agriculture instructor. Unfortunately, according to the observation, the most difficult part of this innovation is the process of adoption-diffussion. The farmers tend to find easier to understand and use the simpler technology [3]. Besides, the other problem comes from IT infrastructure in Indonesia. According to the observation, which was done along the Sumatra road, from Palembang, South Sumatra, Indonesia to Bengkulu City, Bengkulu Province, Indonesia, the internet network is unstable. Even at the small villages, the available communication network is the Global System for Mobile Communication (GSM) first generation and second generation which can not fully support the internet-based information dissemination application. Whereas on every IT adoption-diffusion process, the strategic level needs to accommodate the slow adopters needs [4]. By means, Indonesian government needs to accomodate the farmers who are not familliar to the used of advanced IT innovation and also in an area with unstable internet network.

Hence, to accommodate the requirement towards the effective and efficient information dissemination, the technology which can be supported by communication network in remote areas of Indonesia and easy to use by slow adopters. The technology is a short message service (SMS) technology and supported by geo-fencing technique.

Geo-fencing technique is a virtual fence which is used as a technique to monitor the geographic areas[5]. It has been used in disaster management[6][7][8][9], medical science[10][11], human security[12], and also logistics management[13][5][14]. By engaging geo-fencing technique in this model, the government can put the virtual-fence to spesific producing areas of agricultural products. It enables government to send information to farmers about agriculture such as seeds and fertilizer products, forum group discussion invitation, the agricultural commodity prices, market system, etc. In this paper, proposed model does not only provides information for the remote areas farmers but also from strategic level perspective, model aims to generate knowledge to support decision-making.

The knowledge can be generated using machine learning technique. Machine learning is commonly used to enable the human behaviour in solving the problem and completing the automation. The characteristics of machine learning are the process of learning or training. These process is required data which is referred to as training data.

The main features of machine learning are classification and regression. Classification is a machine learning method which aims to sort or classify objects based on certain

characteristics as humans try to distinguish objects from one another. Meanwhile regression is a predictive method to predict the output of input data based on the trained data.

There are widely used techniques in machine learning such as support machine vector, K-means, Gaussian Mixture, neural networks (NN), etc. The selection of methods are done by considering the type of learning, supervised learning or unsupervised learning.

Finally, this paper proposed an intelligent knowledge-based model which can support the current IT-based agricultural information dissemination in Indonesia. The proposed model embeded the machine learning technique to support inference engine. It aims to improve the decision-making process in strategic level that deals with agricultural policy, regulations, practices, and economic growth.

II. RELATED THEORIES

A. *IT-Based Agricultutal Information Dissemination in Indonesia*

Agriculture is defined as set of activities in utilization of biological resources that aims to produce industrial materials, food, and also aims for environmental management of these resources [15]. In Indonesia, agriculture sector plays the important role towards the economy growth. By means, the need for knowledge and information about agriculture is increasing.

The Indonesian Vegetables Research Institute or BALITSA has developed the mobile-based learning application to spread the information and knowledge to the farmers in Indonesia which is named MyAgri. This mobile-based application is free download in Google Playstore. This application aims to provide the agricultural information to farmers such as information about trading, new agricultural innovation, fertilizer, and it also provides the real time communication between agriculture consultant and farmers. Unfortunately, this application can not run properly in the remote areas because its operation requires internet connection. Figures 1, 2, 3 reveal the distribution map of three largest mobile internet providers in Indonesia, Telkomsel, XL Axiata, and Indosat [16][17].

Fig.1 The distribution map of internet connection provided by Telkomsel [18]

Fig.2 The distribution map of internet connection provided by Indosat [18]

Fig.3 The distribution map of internet connection provided by XL Axiata [18]

As shown in figures 1, 2, and 3, the three internet providers have the uneven distribution especially in middle Indonesia and eastern Indonesia. Besides, as new innovation, the current mobile-based information dissemination system aims to support the smartphone friendly users. In fact, farmers tend to more engage with the simple and appropriate technology [3]. Considering the mentioned disadvantages of existing agricultural information dissemination in Indonesia, a conceptual model of intelligent knowledge-based system is proposed in order to serve the adopters in all levels.

B. *Geo-Fencing*

Practically, geo-fencing technique is accomplished by setting up the virtual boundaries in specified geographic areas and connecting mobile devices to the system. It is supported by a group of subsystems based on Global Navigation Satellite System (GNSS) services and communication and information technology, especially wireless technology. Figure 4 shows the geo-fenced area of child abuse prevention system[12], as long as the mobile devices are in the virtual fence, the mobile devices will be monitored by the system. It also enables the system administrator to send the notification. The virtual fence ensures that information conveyed meets the information criteria of being on target and on time. Geofencing is widely used in the agriculture field such as for machine tracking [19] , animal tracking [20] and monitoring, and agricultural logistics and invoice system [21].

Fig. 4 The geo-fenced area[12]

In this research, the geo-fence technique enable the administrator to send the message using the short message service to farmers. The message contains the information or knowledge which can be applied in agricultural activities. In the proposed model, farmers can send feedback by sending a specific code and then the system will send more detailed information.

C. Machine Learning as Inference and Learning Engine

Machine learning is a branch of artificial intelegence (AI) which contains development of algorithm that enables computer to learn behaviour of data. Machine learning is often used in decision-making process and automation such as forecasting, classifying the data, etc. Recently, machine learning-based systems utilize various techniques such as SVM, Naive bayes, Discriminant Analysis, Apriori, FP-Growth, Decision Tree, and Neural Networks. Machine learning techniques are selected based on the cases, supervised or unsupervised. The supervised learning aims to model a prediction on the input and output. In other hand, the unsupervised learning recognizes the data from input data and the results are unknown.

For classification and prediction, the machine learning technique which successfully applied in different areas is neural networks [22]. The neural network technique works based on the functions and structure of human nerves as a part of human brain. Neural network has layers; input, hidden, and of unit. The problem solving using neural network can be done by the algorithm such as radial basis function neural networks (RBFNN), multi-layer perceptron (MLP), deep neural network (DNN), so on. output layer. The layers consists of one or more neuron units that have activation function which aims to determine output

The radial basis function neural network (RBFNN) model consists of three layers, the input layer, hidden layer and output layer. The input layer receives an input which is then taken to the hidden layer that will process input data using the activation function. Then, output of the hidden layer is processed in the output layer. Since RBFNN is non-linear and the output of the network is linear when it concerns to adjustable weights by means it has better learning perfomance [23][24].

While the RBFNN has only one hidden layer, MLP has one or more than one hidden layer and the final layer of MLP utilizes the activation function. In the previous research, the MLP and RBFNN has their own advantages and disadvantages, the MLP has better performance than RBFNN but it outperformed MLP for data training process[25]. The RBFNN data training uses clustering method, K-Means, to construct the neural networks.

As the neural networks can learn using training data, their performance of neural networks depends on number of training data. The more training data, the better performance of neural network. Unfortunately, the ability of neural network is limited to the number of layers, by means the neural network capacity is higher and it requires more iteration and training. To solve this problem, deep learning is developed.

Deep learning as a class of machine learning techniques was developed in 2006 [26]. It exploits layers of non-linear information processing stages. To implement the deep learning, we can implement the available deep learning frameworks such as TensorFlow, Theano, Torch7, Caffe, and Nervana, Cuda, Chainer, cuDNN.

There are techniques which can be embeded to the intelligent knowledge-based system. It depends on the cases and resources. As the data is now an organizational asset that can be used to construct knowledge, the proposed model utilized the machine learning to support the inference engine.

III. CONCEPTUAL MODELING

In this section, the conceptual modeling of intelligent knowledge-based system in agriculture is discussed. The conceptual modeling contains the geo-fencing technique, short message service (SMS), current IT-based information dissemination, the machine learning as an approach to generate trained model to support inference engine. Figure 5 shows the proposed conceptual model.

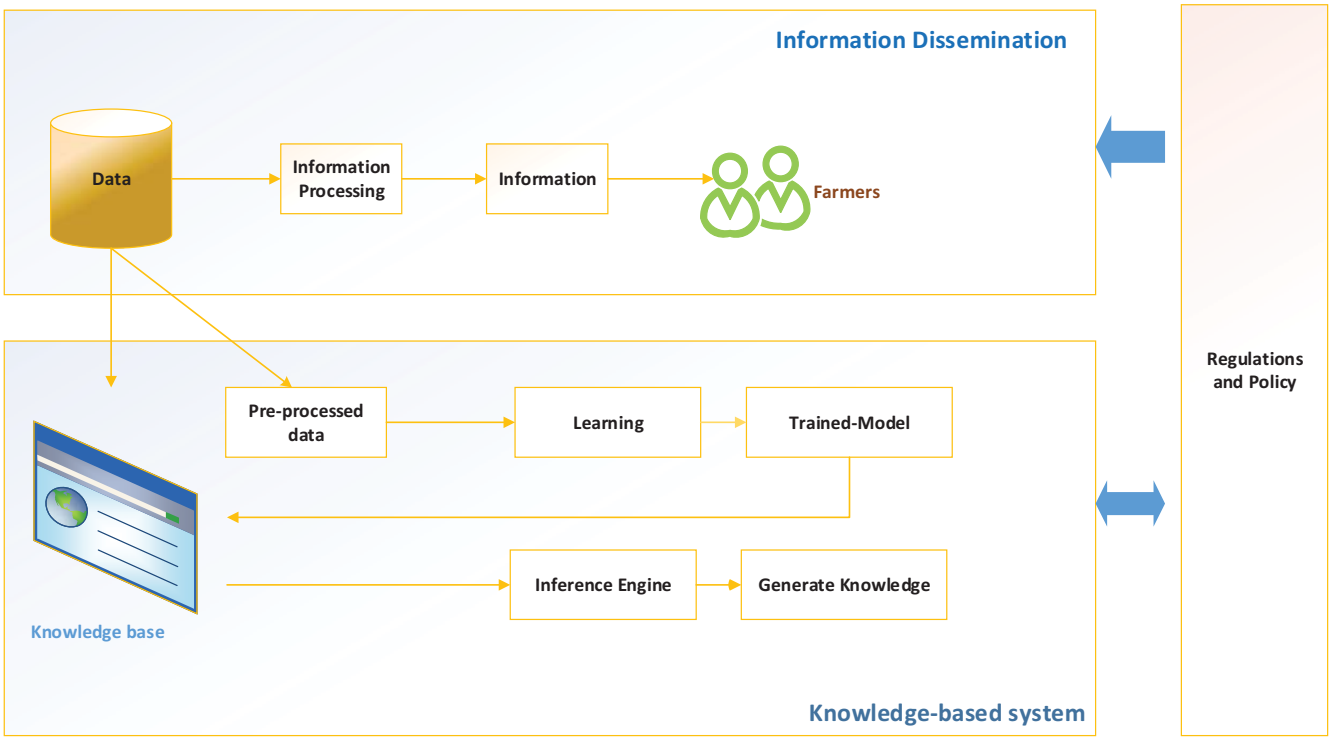

Fig 5. The proposed conceptual modelling for intelligent knowledge-based system

The conceptual model contains 3 blocks of concepts, information dissemination block, knowledge-based system block, and regulations and policy block. The objective of the information dissemination block is to gather the agricultural data from source of data such as from market, agricultural industry, etc.

The gathered data is then processed as information and disseminate to the farmers. The information dissemination can be done by current IT-based agricultural learning system in Indonesia and also can be done using geo-fencing technique. The geo-fencing technique enables the government to send the information to the farmers in the remote areas. The mechanism of information dissemination using SMS and supported by geo-fencing technique considers the type of agricultural comodity from the targeted areas by means the farmers will recieve the useful information.

The second block is the knowledge-based system block which aims to provide the knowledge for strategic decision-making process. It contains knowledge base and the process of generating the model using machine learning which needs the data. The data is firstly pre-processed and trained by a machine learning technique. The selection of machine learning technique considers cases and resource.

Once the trained-model is generated, it is stored to knowledge base. When strategic level needs an outcome by giving input to the system, the inference engine processes the input, model, and knowledge stored in knowledge base.

The third block, the regulations and policy block, described about the contribution of knowledge to the improvement of agricultural sector performance. It supports the decision-making process in the strategic level to evaluate, direct, and monitor the agricultural sector regulations and policy.

IV. CONCLUSION

The conceptual model of intelligent knowledge-based system in agriculture has been generated. It contains 3 blocks of concepts, information dissemination block, knowledge-based system block, and regulations and policy blocks. In further research, the conceptual model will be proven by developing prototype and performing the gap analysis.

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