Monitoring Oil Palm Tree Health– A Review

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Abstract. Oil palm is known as one of the most important resources in Malaysia which able to be exported to other countries. Oil palm, also known as “Elaeis guineensis”, has many usages and benefits. To ensure the productivity and quality of the oil palm, the health status of the tree needs to be monitored, as they can be prone to various diseases. This paper is going to discuss current methods other researchers have adapted that able to be used in monitoring oil palm trees health. In addition, some analyses and conclusion were drawn to address related issues in the area.

1. Introduction
The oil palm tree, scientifically known as “Elaeis guineensis”, are generally planted in the South-East Asia region, especially in Indonesia, Malaysia, and Thailand [1]. Malaysia is known as one of the world’s largest palm oil exporters among these countries and currently handles 39% of world palm oil production and 44% of world exports [2], which makes the oil palm tree plantation as one of the important business that is beneficial to other investor countries [3].

Commonly, the oil palm is mainly grown for the use of vegetable oil production, and it has been the most consumed vegetable oil in the world compared to other types of vegetable oil [1]. Figure 1 shows the worldwide consumption of vegetable oil, which includes palm oil, which has been used extensively, beating other well-known types like soybean and rapeseed oil.

![Figure 1. Consumption of vegetable oil throughout the world [1].](image-url)
1.1. Introduction to Oil Palm
Oil palm is a type of plant that able to adapt to the tropical humid climate, where it can be planted in a rainy and sunny environment, and with warm temperature. It contains some characteristics like a crown-shaped top and a single-stemmed stalk. The fronds are emerging from the stalk top and extending outward with eight fronds. It has a shape like an eight-pointed star from sky view. The oil palm is known as a perceptual plant, which is more similar to a forest tree than other agricultural crops [1].

1.2. Oil Palm Diseases
Due to a large amount of exportation of palm oil to all over the world, the producers have to ensure the good health level of oil palm and able to supply sustainably. Therefore, all oil palm planters and farmers have to be careful of any diseases that able to destroy their plantation. Generally, pest or plant disease will influence a large number of commercial crops and causes a large economy lost. Previous report has shown that more than 10% of food production of the world is lost due to plant diseases [4]. Many types of plant diseases can be found around oil palm, and one of the most famous plant diseases is basal stem rot disease or Ganoderma Boninense.

Ganoderma is a critical issue to all oil palm plantations in the South-East Asia region, especially in Malaysia and Indonesia. This disease is caused by a type of fungus that is known as Ganoderma Boninense. This is a dangerous disease for oil palms as it can causes at least 50% loss of the palm in a farm [5][6]. It is hard for oil palm farmers and planters to detect the disease at the early stage of infection on the basal stem and leaves by visual inspection, and when they are noticeable, it is too late to be cured [7]. The infection of Ganoderma disease between oil palm trees is spreading by root to root contact, where healthy roots will have the possibility to be infected if contacted with the infected roots. When infected, brown discolouration of oil palm occurred due to the formation of Ganoderma. There is also some noticeable early-stage infection visual symptom from oil palm trees which is the formation of fruiting bodies. At first, it shows white button emerging on the surface of the bark, and then developed into mature fruiting body. Then, the waxy brown will turn into dark brown in colour at the upper surface and then white to creamy white in colour of the bottom surface. For young oil palm trees, disease symptom is shown by observing the yellow and drying of the older leaf. It can start from a certain part of the palm where the infection of disease is started [8]. Figure 2 shows an example of Ganoderma that has affected an oil palm tree.

![Figure 2. Ganoderma Boninense][1]

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[1]: https://example.com/image2.png
Other than Ganoderma disease, oil palm plantations in Malaysia are also facing serious pest problem caused by bagworms, scientifically known as Psychidae which is a family of the Lepidoptera. It is known as leaf-eating caterpillars that have characteristics of possession of the bag and built from pieces of dried plant materials such as leaves and small twigs [10]. Consequently, yellow rust is also one of the plant diseases that have to be solved in the future to ensure the quality of oil palm exportation [4]. Figure 3 and 4 show the sample of bagworm and yellow rust.

![Figure 3. Bagworm, also known as Psychidae [11].](image1)

![Figure 4. Yellow rust, known as Phragmidium spp. [12].](image2)

2. Methods Used in Monitoring Oil Palm Tree Health

In oil palm plantation monitoring, there are many ways that have been suggested by researchers and scientists. A combination of hardware and sensors like the Unmanned Aerial Vehicles (UAV), remote sensing imaging and spectrometer with respective processes involving Artificial Neural Network (ANN) and Deep Learning (DL) algorithm were preferred. In the following sub-section, every method is discussed in sections of hardware and algorithm. Then, their advantages and limitations are observed and discussed in monitoring oil palm diseases.
2.1. Hardware

2.1.1. Remote Sensing Imaging
Remote sensing is known as a technique to deliver temporal and multimodal data representing the Earth’s surface. As more sensors and advanced image fusion techniques can be implemented together, it will create the opportunities to process and extract complementary information even better. For example, optical and microwave remote sensing image fusion is a valuable tool to optimize multi-sensor image exploitation [13][14]. Remote sensing imaging techniques are very useful for oil palm studies and many applications can be applied by using it apart for pest and disease detection, such as land cover classification, tree counting, as well as for tree age, carbon production and yield estimation [15]. This method has brought a lot of advantages in monitoring Ganoderma disease because of its ability to obtain accurate information, preventing the spreading of disease and nutrient deficiency sufficiently from a satellite image. Figure 5 shows an example of a satellite image.

![Satellite Image Example](image)

**Figure 5.** An example of satellite image [15].

2.1.2. Unmanned Aerial Vehicles (UAV)
UAV is a type of aircraft that can operate without human pilot control and is used for various purposes. It can perform multi-spectral and multimodal data acquisition by taking orthophotos. In [16], UAV is used in assisting the monitoring of oil palm trees growth and identifying the condition of the trees. It has the advantages of providing low cost and quickly response information that suits for smallholders. Apart from that, it has a much better resolution up to several centimeters and also has greater flexibility in selecting suitable payloads with appropriate time and spatial resolutions [16].

2.1.3. Spectrometer
A spectrometer is a common tool used by various scientists to obtain information about an object or substance through the analysis of its light properties. In oil palm tree health monitoring, by observing the ultraviolet (UV), visible (blue, green and red bands) and near-infrared (NIR) wavelengths with certain range, it can be used to identify contaminants or levels of various substances in the leaves to detect possible diseases or unwanted toxin [17][18][19][20]. Figure 6 shows an example of the widely-used spectrometer.
Figure 6. GER 1500 field spectrometer [10].

2.2. Algorithm

2.2.1. Vegetation Index Algorithm
To determine the health status of the oil palm tree, it is important for the researcher to understand the green substance in a plant which is chlorophyll. The chlorophyll content is a significant biochemical parameter for testing crop status. It can be used to identify crop growing conditions, their physiological status, and health [21]. By investigating the chlorophyll pigment in the plant, researchers can perform image processing to detect vegetation area and then observe the health status of plants from the satellite image [22]. Apart for tree health status, users can also perform a count of oil palm trees at the plantation area automatically from this method [23][24][25].

In summary, four basics steps can be performed to detect vegetation area and then check the health status of oil palm trees. Firstly, a satellite image is needed as the input into the software. Secondly, the image will undergo pre-processing such as noise or disturbance removal from the image. Thirdly, the clean satellite image will be segmented to extract necessary data that will be used in the research. Fourthly, an output graph or result data is produced. For example, the estimated vegetation area and chlorophyll of oil palm trees which can be used to monitor their health status.

2.2.2. Artificial Neural Network (ANN) Algorithm
ANN can be applied in the oil palm tree health monitoring to let the computer systems able to perform tasks normally requiring human intelligence, such as infected oil palm tree recognition. By applying the ANN analysis technique, the system can perform discriminating and classifying fungal infections in oil palm trees automatically at an early stage using raw, first, and second derivative spectroradiometer datasets. Besides that, ANN is also able to model the relationship between variables derived from different collected data [26]. An example of the algorithm structure representing ANN can be seen in Figure 7.
2.2.3. Deep Learning (DL) Algorithm
The idea of the DL algorithm is simple – to allow machine in understanding elements by learning the features and it is usually will be very good at decision making. To understand it easily, DL is about a machine using neural networks with more neurons and layers compared to the ANN, and is having interconnectivity with each other to calculate for the result. In other words, DL is a subset of machine learning that enables computers to solve more complex problems depending on different conditions and reasons [27]. By applying DL theory, the system can be designed to check the oil palm tree health. Figure 8 shows a sample of DL model [28].

Figure 7. The structure of the artificial neural network (ANN) [7].

Figure 8. Feedforward deep learning models [28].
3. Discussions
In this section, previously mentioned methods will be discussed and compared to and the best way to monitoring oil palm tree disease can be observed. Comparison is carried out into two groups respectively, which are hardware and data processing or also known as an algorithm.

In here, a scoring system is introduced to compare them. Three levels are assigned to observe the effectiveness of every medium which is 1 represents weak tool, 2 represents moderate tool and 3 represents best tool. By comparing differences of hardware and software and then accumulate all the scores, method with highest score is assumed to be the best tool to be used. Table 1 compares the related hardware used while Table 2 summarizes the algorithm.

| Differences       | Remote sensing imaging | Unmanned Aerial Vehicles (UAV) | Spectrometer |
|-------------------|------------------------|-------------------------------|--------------|
| Availability      | Easy and free to get (3)| Need special tool (1)         | Need special tool (1) |
| Accuracy          | High (3)               | High (3)                      | Moderate (2)  |
| Consistency       | High (3)               | Moderate (2)                  | Moderate (2)  |
| Sensitivity       | High (3)               | High (3)                      | High (3)      |
| Timeliness        | Short time (3)         | Short time (3)                | Long time (1) |
| Costing           | Low (3)                | High (1)                      | High (1)      |
| SCORE             | 18                     | 13                            | 10            |

Table 1. Comparison of different hardware.

| Differences       | Artificial Neural Network (ANN) Algorithm | Vegetation Index Algorithm | Deep Learning (DL) Algorithm |
|-------------------|-------------------------------------------|----------------------------|------------------------------|
| Completeness      | Good (3)                                  | Moderate (2)               | Good (3)                     |
| Accuracy          | Moderate (2)                              | High (3)                   | Moderate (2)                 |
| Consistency       | Moderate (2)                              | High (1)                   | Moderate (2)                 |
| Sensitivity       | High (3)                                  | High (3)                   | High (3)                     |
| SCORE             | 10                                        | 9                          | 10                           |

Table 2. Comparison of different algorithm.

From Table 1, it can be seen that remote sensing imaging is the best choice. This is because it has the highest score of 18 among all of the hardware. For the availability, remote sensing imaging can provide an easy and free platform for users to download from the internet directly without any costing. For example, Google Maps is one of the platforms that frequently used by researchers to get satellite images immediately. Because of that, remote sensing imaging has involved low expenses in researches from the consideration of costing and also it just takes a short time for researchers to get climate data or geographical images from satellite compared to other hardware. Remote sensing imaging and UAV are mostly used to collect the image of an oil palm farm from Earth’s surface, the only difference between them is one is for wider coverage and the other one is for the smallholder. Thus, remote sensing imaging will be the best tool to be used in the system of monitoring the oil palm tree health especially for large scale plantation.

Table 2 has shown three types of the algorithm that are possible to be used. From here, ANN and DL have the same score of 10, whereas the vegetation index algorithm has a score of 9. The operation model of DL is the upgrading version of the ANN algorithm, the difference between them is DL has enabled many practical applications of machine learning and by extension the overall field of artificial intelligence. Moreover, the vegetation index algorithm can be run manually by just inserting data into the software but with the aid of the ANN algorithm and DL algorithm, it is possible to let the monitoring oil palm tree health system to run automatically. This is said to be a contribution to the current research for oil palm disease.

The current program for the vegetation index algorithm that has been used to check the health status of oil palm is suggested to be upgraded which able to show the different healthy levels of oil.
palms by using percentage, instead of the conventional way of calculating the vegetation index. With this function, users can understand how the infection level of the tree is immediately.

Also, it is good for future research to try to combine the ANN / DL algorithm with the vegetation index into a complete system. This idea can let the monitoring Ganoderma disease system to check for any infection of the oil palm tree automatically and also able the system to self-learning from the experience for upgrading the system to be more complete. It is also suggested to set in the detection system so that it can run automatically to check the damage level of the oil palm and also it can inform the owner immediately by using a message.

4. Conclusion

Oil palm products have become more and more important in our daily lives, especially to the exporter. Due to the high economic potential of oil palm in the future, Malaysia should find out the most effective way to prevent disease attack for the purpose to ensure the good quality of palm oil production. To monitor oil palm tree health, remote sensing imaging can be further applied due to its low costing, short timing to get satellite image, high accuracy, high consistency, high sensitivity, and easy to handle. To process the data, it will be a good idea to combine the ANN / DL and the vegetation index algorithm to build an artificial intelligence monitoring system.

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