A METHOD FOR ANALYSING PLANTATION HEALTH

FIELD OF INVENTION

The invention relates to a method for analysing plantation health. More particularly, the invention relates to a method for analysing plantation health by generating nearby plantation health indices.

BACKGROUND OF THE INVENTION

Plantations contribute to over 80% of foods consumed by humans and feedstock for domestic animals. Therefore, plantations in their healthy state are essential. A plantation in a healthy state is capable of carrying out its physiological function to the best of its genetic potential. Plantation health may be affected by moisture and nutrient contents in the soil medium, ambient temperature, and presence of diseases or pests. Plantation health affects the yield of the plantation in a plantation field. For example, unhealthy plantation generally results in a reduced yield, whereas unattended unhealthy plantation arose from disease and pest infestation can easily infect nearby plantations in a wide area due to presence of carriers such as wind and water, thereby further reducing the yield and increasing the cost of treatment.

Over the years, various methods for analysing plantation health were developed. For instance, US Patent No. US11003908B2 discloses a method of determining soybean aphids in soybean canopy based on spectral reflectance data of the soybean canopy in a captured image. The method generally comprises the steps of collecting at least one image of a soybean canopy, processing the image into spectral reflectance data, classifying the spectral reflectance data, and determining whether to treat the soybean for soybean aphids based on the classification of the spectral reflectance data.

Conventional methods may not be capable of determining individual plantations with adverse plantation health. For example, the aforementioned method determines whether a soybean canopy requires treatment for soybean aphids instead of individual soybean plants. Consequently, soybean plants infested by soybean aphids within a soybean canopy that is generally healthy may be overlooked, thereby resulting in a delay in treatment. Accordingly, it would be desirable to provide a method for analysing plantation health that overcomes the abovementioned drawback. This invention provides a solution to the problem.

SUMMARY OF INVENTION

One objective of the invention is to provide a method for analysing plantation health that is capable of generating nearby plantation health indices of nearby plantations with respect to a targeted plantation. Particularly, the nearby plantation health indices allows the user to monitor health conditions of the nearby plantations that change based on health conditions of the targeted plantations rather than individual plant health indices that only represent their own health conditions.

In a first aspect of the invention, there is provided a method for analysing plantation health in a plantation field comprising the steps of acquiring a plurality of multispectral images, of the plantation field, each with different wavelength bands; converting the multispectral images of each wavelength band into a plurality of vegetation index images that carry a set of features; and computing nearby plantation health indices using the features via a first processing model, wherein the nearby plantation health indices computation comprises the steps of selecting a targeted plantation; determining nearby plantations that are within a predetermined distance from the targeted plantation; and performing a correlation analysis between the targeted plantation and the nearby plantations to generate the nearby plantation health indices of the nearby plantations with respect to the targeted plantation.

Preferably, the wavelength bands include Red, Green, and Blue (RGB), Near-infrared (NIR), Red Edge or any combinations thereof.

Preferably, the method further comprising a step of stitching the multispectral images of each wavelength bands into a stitched multispectral image of each wavelength bands that substantially represents entirety of the plantation field.

Preferably, the method further comprising a step of acquiring coordinate information of each of the plantations in the plantation field that corresponds to the multispectral images, whereby each of the plantations in the multispectral images is linked to the coordinate information.

Preferably, the set of features comprises indices of mean, median, minimum, maximum, or any combinations thereof.

Preferably, the method further comprising a step of normalizing each of the vegetation index images into a normalized vegetation index image prior to the step of computing nearby plantation health indices.

Preferably, the method comprising a step of determining deviations between the normalized vegetation index images and their respective vegetation index images to determine if subsequent vegetation index images of that kind are required to be normalized prior to the step of computing nearby plantation health indices.

Preferably, the multispectral images are converted based on vegetation indices including Ratio Vegetation Index (RVI), Difference Vegetation Index (DVI), Normalized Difference Vegetation Index (NDVI), Atmospheric Resistant Vegetation Index (ARVI), Renormalized Difference Vegetation Index (RDVI), Enhanced Vegetation Index (EVI), Chlorophyll Index – Red edge (CI_RE), Normalized

Difference Red-Edge Index (NDRE), Infrared Percentage Vegetation Index (IPVI), Structure Insensitive Pigment (SIPI), or any combinations thereof.

Preferably, the method further comprising a step of removing outliers from the vegetation index images to improve accuracy of analysing plantation health prior to the step of computing nearby plantation health indices.

Preferably, the method further comprising a step of filtering the features in each vegetation index images via a second processing model prior to the step of computing nearby plantation health indices.

Preferably, the second processing model applies SelectKBest algorithm.

Preferably, the first processing model is an ensemble model that applies a plurality of algorithms including Logistic Regression, Random Forest, Bagging, K-Nearest Neighbour, Ridge Regression, Naïve Bayes, Support Vector Machine, or any combinations thereof.

One skilled in the art will readily appreciate that the invention is well adapted to carry out the objects and obtain the ends and advantages mentioned, as well as those inherent therein. The embodiments described herein are not intended as limitations on the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

For the purpose of facilitating an understanding of the invention, there is illustrated in the accompanying drawing the preferred embodiments from an inspection of which when considered in connection with the following description, the invention, its construction and operation and many of its advantages would be readily understood and

appreciated.

Fig. 1 is a schematic diagram illustrating an overview of a method for analysing plantation health.

Fig. 2 is a schematic diagram illustrating a method for a first feature manipulation process in model development stage.

Fig. 3 is a schematic diagram illustrating a method for second feature manipulation process in deployment stage

Fig. 4 is a schematic diagram illustrating the steps of computing nearby plantation health indices.

Fig. 5 is a schematic diagram illustrating an ensemble model.

DETAILED DESCRIPTION OF THE INVENTION

The invention will now be described in greater detail, by way of example, with reference to the drawings.

Referring to Fig. 1, an overview of a method (100) for analysing plantation health in a plantation field is illustrated therein. Plantation health refers to a health condition of a plantation. A plantation can be considered healthy when it is able to carry out its physiological function to the best of its genetic potential. An unhealthy plant tends to possess symptoms such as wilting, yellowish and/or brownish leaves, spotted leaves, increased in temperature due to reduced evapotranspiration activity, or any combinations thereof. The plantation field refers to a land where plantations are cultivated for agricultural or aesthetic purposes, wherein the plantation field can include

but not limited to farmland, cultivated field, and garden. The plantation can include but not limited to *Eucalyptus*, *Acacia*, and oil palm.

The invention generally comprises three stages, namely data collection and preparation stage (110), model development stage (120), and deployment stage (130). During the data collection and preparation stage (110), multispectral images of the plantation field are acquired (111) and stitched into a stitched multispectral image (112) that substantially represents entirety of the plantation field. Next, coordinate information is acquired (113) and linked to the plantations in the stitched multispectral image. Subsequently, the stitched multispectral image with the coordinate information is converted into shapefile (SHP) format (114).

During the model development stage (120), the stitched multispectral image in SHP format is digitized (121) and subjected to a first feature manipulation process (122). Referring to Fig. 2, the first feature manipulation (122) process generally comprises the steps of converting the digitized image into a plurality of vegetation index images (201) that carry a set of features, normalizing the vegetation index images (202), comparing deviations between the normalized vegetation index images and their respective vegetation index images (203), removing outliers (204), filtering the features (205), and computing nearby plantation health indices (206). Two sets of outputs are obtained from the first feature manipulation process, namely train set (123) and test set (124). Then, the train set is used in model training (125). Subsequently, the test set and output from the model training are used in model evaluation (126). Next, output from the model evaluation is used in model selection (127) to select a suitable model for the analysis of plantation health.

Upon completion of the model development stage (120), the invention is ready for deployment. In the deployment stage, the method (100) generally comprises the steps of acquiring a plurality of multispectral images (131), converting the multispectral

images into a plurality of vegetation index images (301), and computing nearby plantation health indices (305) via a first processing model (500).

In a preferred embodiment of the invention, the multispectral image of the plantation field are acquired (131), wherein each multispectral image has different wavelength bands. Preferably, the wavelength bands include Red, Green, and Blue (RGB), Near-infrared (NIR), Red Edge, or any combinations thereof. More preferably, each multispectral image is acquired in RGB, NIR, and Red Edge wavelength bands. Advantageously, the multispectral images in different wavelength bands allow the method (100) to analyse a more diversified unhealthy conditions or diseases of the plantation as each of the wavelength bands is more sensitive to a different unhealthy conditions or diseases of the plantation relative to other wavelength bands.

In the present invention, the method (100) may include a step of stitching the multispectral images of each wavelength bands into a stitched multispectral image of each wavelength bands (132) that substantially represents entirety of the plantation field. By way of example, each of the multispectral images in the NIR wavelength bands are stitched to form a stitched multispectral image in the NIR wavelength bands that substantially represents entirety of the plantation field.

Additionally, the method (100) may include a step of acquiring coordinate information of each of the plantations in the plantation field that corresponds to the multispectral images (133), whereby each of the plantations in the multispectral images is linked to the coordinate information. The coordinate information of the plantations allows a user to determine location of the plantation in the plantation field from the multispectral images.

In the preferred embodiment of the invention, the multispectral images, stitched multispectral images, or any of these with the coordinate information are subjected to

a second feature manipulation process (134) as illustrated in Fig. 3. The multispectral images, stitched multispectral images, or any of these with the coordinate information are converted into the vegetation index images that carry a set of features (301). Preferably, the multispectral images are converted based on vegetation indices including Ratio Vegetation Index (RVI), Difference Vegetation Index (DVI), Normalized Difference Vegetation Index (NDVI), Atmospheric Resistant Vegetation Index (ARVI), Renormalized Difference Vegetation Index (RDVI), Enhanced Vegetation Index (EVI), Chlorophyll Index – Red edge (CI_RE), Normalized Difference Red-Edge Index (NDRE), Infrared Percentage Vegetation Index (IPVI), Structure Insensitive Pigment (SIPI), or any combinations thereof. More preferably, the multispectral images are converted based on RVI, DVI, NDVI, ARVI, RDVI, EVI, CI_RE, NDRE, IPVI, and SIPI. Preferably, the set of features comprises indices of mean, median, minimum, maximum, or any combinations thereof. More preferably, the set of features comprises indices of mean, median, minimum, and maximum. By way of example, the set of features of the RVI vegetation index image includes RVI_mean, RVI_median, RVI_minimum, and RVI_maximum.

In the present invention, the method (100) may include a step of normalizing each of the vegetation index images into a normalized vegetation index images (302) prior to the step of computing nearby plantation health indices (305). The vegetation index images are normalized to adjust the range of pixel intensity values due to difference in lighting conditions caused by weather conditions and/or daytime cycle. Subsequently, deviations between the normalized vegetation index images and their respective vegetation index images are compared (303) to determine if subsequent vegetation index images of that kind are required to be normalized prior to the step of computing nearby plantation health indices. Preferably, the step of normalizing the vegetation index images can be bypassed if the deviations between a normalized vegetation index image and its respective vegetation index image are insignificant. Advantageously, this improves efficiency by shortening overall computation time of nearby plantation health

indices.

Additionally, the method (100) may include a step of removing outliers from the vegetation index images or the normalized vegetation index images (204) prior to the step of computing nearby plantation health indices (305), wherein plantations at a completely healthy condition will be removed and excluded from the computation of nearby plantation health indices. Advantageously, the step of removing outliers reduces variability in data to be analysed, thereby improving accuracy of analysing plantation health.

Furthermore, the method (100) may include a step of filtering the features in each vegetation index images or normalized vegetation index images (304) via a second processing model prior to the step of computing nearby plantation health indices (305). The second processing model applies an algorithm that ranks the features according to their impact to the computation of nearby plantation health indices. Subsequently, the second processing model filters top n features in the ranking to be used in the computation of nearby plantation health indices. Preferably, the second processing model filters top 30 features in the ranking. The features at higher rankings are features that are more relevant to the computation of nearby plantation health indices, whereas features at lower rankings are features that are less relevant and redundant to the computation of nearby plantation health indices Preferably, the second processing model applies SelectKBest algorithm, wherein the algorithm filters the features according to their respective k highest scores. Advantageously, the step of filtering the features in each vegetation index images further shortens the overall computation time of nearby plantation health indices.

In the preferred embodiment of the invention, nearby plantation health indices are computed (305) using the features of the vegetation index images via the first processing model (200). Referring to Fig. 4, a targeted plantation is selected from the

vegetation index images, whereby the targeted plantation serves as origin which the nearby plantation health indices computed are with respect to the targeted plantation.

Then, nearby plantations that are within a predetermined distance from the targeted plantation are determined (401). Preferably, a circle is applied to the target plantation as a computational area, wherein a radius of the circle is specified by the user as the predetermined distance from the target plantation such that the nearby plantation within the circle are selected for the computation of nearby plantation health indices.

Subsequently, a correlation analysis between the target plantation and the nearby plantations is performed (402) to generate the nearby plantation health indices of the nearby plantation with respect to the targeted plantation (403). Thereafter, a second targeted plantation is selected for computation of the nearby plantation health indices with respect to the second targeted plantation (404). Referring to Fig. 5, the first processing model (200) is preferably an ensemble model that applies a plurality of algorithms including Logistic Regression, Random Forest, Bagging, K-Nearest Neighbour, Ridge Regression, Naïve Bayes, Support Vector Machine, or any combinations thereof. More preferably, the ensemble model applies Logistic Regression, Random Forest, Bagging, K-Nearest Neighbour, Ridge Regression, Naïve Bayes, and Support Vector Machine algorithms. Preferably, the features or the filtered features are fed into a level 0 of the first processing model (200) comprising the algorithms as abovementioned for computation process. Next, the outputs of each of the algorithms as abovementioned from the computation process in the level 0 are fed into a level 1 of the first processing model (200) for unequal weight stacking process. Preferably, the level 1 of the first processing model (200) applies two or more algorithms. More preferably, the level 1 of the first processing model (200) applies any two of Logistic Regression, Random Forest, Bagging, K-Nearest Neighbour, Ridge Regression, Naïve Bayes, and Support Vector Machine algorithms. Most preferably, the level 1 of the first processing model (200) applies Logistic Regression and Random

Forest algorithms. Lastly, the outputs of each of the algorithms in the level 1 of the first processing model (200) in the form of probability then undergo a weight stacking process in level 2 of the first processing model (200), wherein the probabilities obtained from the level 1 of the first processing model (200) are summed up, thereby generating the nearby plantation health indices.

The nearby plantation health indices allows the user to monitor health conditions of the nearby plantations that change based on health conditions of the targeted plantations rather than individual plant health indices that only represent their own health conditions. Advantageously, the nearby plantation health indices provide awareness to the user regarding unhealthy plantations such as diseased plantations that may infect the nearby plantations in the predetermined distance from the targeted plantation such that the user can provide treatment to the unhealthy plantation and the nearby plantations that may be potentially infected.

The present disclosure includes as contained in the appended claims, as well as that of the foregoing description. Although this invention has been described in its preferred form with a degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangements of parts may be resorted to without departing from the scope of the invention.

CLAIMS

1. A method (100) for analysing plantation health in a plantation field comprising the steps of:

acquiring a plurality of multispectral images (131), of the plantation field, each with different wavelength bands;

converting the multispectral images of each wavelength band into a plurality of vegetation index images that carry a set of features (301); and

computing nearby plantation health indices using the features (305) via a first processing model (500),

wherein the nearby plantation health indices computation comprises the steps of:

selecting a targeted plantation;

determining nearby plantations that are within a predetermined distance from the targeted plantation (401); and

performing a correlation analysis between the targeted plantation and the nearby plantations (402) to generate the nearby plantation health indices of the nearby plantations with respect to the targeted plantation (403).

2. The method (100) according to claim 1, wherein the wavelength bands include Red, Green, and Blue (RGB), Near-infrared (NIR), Red Edge or any combinations thereof.

3. The method (100) according to claim 1, further comprising a step of stitching the multispectral images of each wavelength bands into a stitched multispectral image of each wavelength bands (132) that substantially represents entirety of the plantation field.

4. The method (100) according to claim 1, further comprising a step of acquiring coordinate information of each of the plantations in the plantation field (133) that corresponds to the multispectral images, whereby each of the plantations in the

multispectral images is linked to the coordinate information.

5. The method (100) according to claim 1, wherein the set of features comprises indices of mean, median, minimum, maximum, or any combinations thereof.

6. The method (100) according to claim 1, further comprising a step of normalizing each of the vegetation index images into a normalized vegetation index image (302) prior to the step of computing nearby plantation health indices.

7. The method (100) according to claim 6 comprising a step of determining deviations between the normalized vegetation index images and their respective vegetation index images (303) to determine if subsequent vegetation index images of that kind are required to be normalized prior to the step of computing nearby plantation health indices.

8. The method (100) according to claim 1, wherein the multispectral images are converted based on vegetation indices including Ratio Vegetation Index (RVI), Difference Vegetation Index (DVI), Normalized Difference Vegetation Index (NDVI), Atmospheric Resistant Vegetation Index (ARVI), Renormalized Difference Vegetation Index (RDVI), Enhanced Vegetation Index (EVI), Chlorophyll Index – Red edge (CI_RE), Normalized Difference Red-Edge Index (NDRE), Infrared Percentage Vegetation Index (IPVI), Structure Insensitive Pigment (SIPI), or any combinations thereof.

9. The method (100) according to claim 1, further comprising a step of removing outliers from the vegetation index images (204) to improve accuracy of analysing plantation health prior to the step of computing nearby plantation health indices.

10. The method (100) according to claim 1, further comprising a step of filtering the

features in each vegetation index images (304) via a second processing model prior to the step of computing nearby plantation health indices.

11. The method (100) according to claim 10, wherein the second processing model applies SelectKBest algorithm.

12. The method (100) according to claim 1, wherein the first processing model (500) is an ensemble model that applies a plurality of algorithms including Logistic Regression, Random Forest, Bagging, K-Nearest Neighbour, Ridge Regression, Naïve Bayes, Support Vector Machine, or any combinations thereof.