

A METHOD FOR DETERMINING SEEDLING QUALITY AND STRESS PROPERTIES

FIELD OF INVENTION

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The invention relates to a method of monitoring plantation. More particularly, the invention relates to a method for determining quality and stress properties of seedlings.

BACKGROUND OF THE INVENTION

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In the plantation industries, the demand for better and faster-growing trees has been ever-growing. High-quality trees have a higher survival rate and faster growth in the field, and only good-quality seedlings have the prerequisites to grow into high-quality trees. While seedlings are relatively pampered in the nursery, they must endure a
15 perilous journey from their safe growing environment to the plantation field. Any actions towards the seedlings during the transportation, such as lifting, grading, storing, handling, and planting, are opportunities for the seedlings to be subject to numerous stresses, including moisture stress, temperature stress, and physical stress. These stresses are cumulative and can lead to poor field performance. For this reason,
20 evaluating seedling quality is vital, especially for plants with long life cycles.

Over the years, various methods for evaluating seedling quality were developed. For instance, US Patent No. US20210345567A1 discloses a method for determining plant stress, including: using a computer-based camera system having thermal imaging and
25 visual imaging to capture foliage at close proximity of at least one plant to provide high resolution images/video thereof; analysing both thermal and visual images/video therefrom to form a composite image; determining the thermal activity of the composite image/video and photosynthesis state of the at least one plant; and deriving the plant stress from the determination. A handheld computer-based camera system is also

provided and includes a smartphone and thermal imaging device.

Another US Patent No. US10309896 B2 discloses a plant stress detection apparatus including a first light source that radiates a reference beam of a first wavelength that
5 has a characteristic of tending not to be absorbed in water toward a plant by optical scanning, a second light source that radiates a measuring beam of a second wavelength that has a characteristic of tending to be absorbed in water toward the plant by optical scanning, and a detector that detects presence or absence of water or undulation of the plant based on reflection light of the reference beam that is reflected at an irradiation
10 position of the plant that has a first irradiation area and reflection light of the measuring beam that is reflected at an irradiation position of the plant that has a second irradiation area that is different from the first irradiation area.

Nevertheless, these conventional methods failed to take into consideration that the
15 seedlings under stresses, which could be caused by external force or environment, would take significant amount of time to reflect the symptoms of stress. Accordingly, it would be desirable to provide a seedling evaluation method that overcomes the abovementioned drawback. This invention provides a solution to the problem.

20 SUMMARY OF INVENTION

One objective of the invention is to provide a method for determining seedling health quality and stress properties via soil and ambient environment conditions data and image processing techniques. Particularly, the method implemented a delay for the
25 image capturing as the current soil or ambient environment conditions would take significant amounts of time to affect the seedling and to reflect with the symptoms of stress.

In a first aspect of the invention, there is provided a method for determining seedling

- quality and stress properties, the method comprises the steps of: acquiring soil and ambient environment conditions data of a location, where the seedling is planted, from one or more sensor modules; generating a time sequence based on the soil and ambient environment conditions data for image capturing; triggering an image capturing device
- 5 to capture one or more images of the seedling based on the generated time sequence; processing the captured images to obtain parameter information of the seedling; applying a classification model to classify quality property of the seedling based on the parameter information; and applying a plant stress model to determine stress property of the seedling based on the classified quality property of the seedling; wherein the time
- 10 sequence is generated by the steps of: computing a time delay based on the soil and ambient environment conditions data; obtaining an averaged time delay by averaging the computed time delay with a pre-defined time delay; and generating the time sequence based on the averaged time delay.
- 15 Preferably, the captured images may be processed by the steps of: converting the captured images into an initial set of raw data; extracting predefined data from the initial set of raw data by one or more feature extraction techniques; measuring the parameters information of the seedling based on the extracted data; and isolating different organ parts of the seedling by an instance segmentation technique based on the measured
- 20 parameters information.

- Preferably, the classification model may comprise the steps of: comparing the measured parameters information of each organ part of the seedling with a trained data set to determine a health index of each organ part; determine an overall health index
- 25 representing an overall seedling quality based on the health index of each organ part; and updating the determined overall health index to a training database.

Preferably, the plant stress model may comprise the steps of: obtaining timeseries data of the soil and ambient environment conditions from the training database; splitting the

timeseries data of the soil and ambient environment conditions from an original data set; applying a non-linear regression technique to determine a data trend model which fits the timeseries data of the soil and ambient environment conditions; applying a pattern detection technique on the data trend model to determine a number of anomalies; and comparing the number of anomalies with a pre-determined threshold value to determine the stress property of the seedling.

Preferably, the quality and stress properties of the seedling may be compared with pre-defined references to determine whether to dispose the seedling or to continue for cultivation in a plantation.

Preferably, the captured images may be displayed with a bounding box generated for each organ part of the seedling, whereby each bounding box comprises a float representation of the quality and stress properties of the respective organ part of the seedling.

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 block diagram illustrating an overview of a method for determining seedling quality and stress properties.

Fig. 2 is a block diagram illustrating a process flow of generating a time sequence for image capturing.

Fig. 3 is a block diagram illustrating a process flow of determining stress property of the seedling.

10 DETAILED DESCRIPTION OF THE INVENTION

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

15 Fig. 1 illustrates an overview of a method (100) for determining seedling quality and stress properties. The quality and the stress properties of the seedling can be defined by several parameters such as seedling health, seedling height, root collar diameter, presence of white root damage, stem erection, position of the seedling in a tube, or any combination thereof. The seedling can include but not limited to seedling of *Eucalyptus*,
20 *Acacia*, and oil palm.

In a preferred embodiment of the invention, the method (100) begins by acquiring soil (101) and ambient environment conditions (102) data of a location where the seedling is planted from one or more sensor modules. Preferably, the soil condition (101) data
25 include soil moisture, pH value of soil, nitrogen content in soil, phosphorus content in soil, potassium content in soil, or any combination thereof. Preferably, the ambient environment condition (102) data include temperature, humidity, rainfall, or any combination thereof. The soil (101) and ambient environment conditions (102) data are preferably acquired periodically based on a predefined time delay from a user's input,

resulting in a timeseries data represented in plurality of series of soil (101) and ambient conditions (102) data with respect to time.

- Next, the method (100) generates a time sequence (110) based on the soil (101) and ambient environment conditions (102) data for image capturing of the seedling. Referring to Fig. 2, the time sequence is preferably generated (110) by computing a time delay (112) based on the soil (101) and ambient environment conditions (102) data obtained by the sensor modules (111). Then, the computed time delay and the predefined time delay (113) are used to obtain an averaged time delay (114) in capturing the image of the seedlings. Preferably, the predefined time delay (113) is based on the user's input. Subsequently, the time sequence is generated (110) based on the averaged time delay obtained (114) from the soil (101) and ambient environment condition (102) data. The seedling that experiences stress due to various soil and ambient environment properties does not immediately reflect a visible symptom. Therefore, the method in the present invention provides the averaged time delay for capturing the image of the seedlings such that such visible symptom can be reflected therein. Preferably, the average time delay can vary with species of the seedling as different species may require different duration for the symptom to become visible.
- Referring back to Fig. 1, the method (100) then triggers an image capturing device to capture one or more images of the seedling (120) based on the generated time sequence. By way of example, when the average time delay of 2 hours is obtained, the time sequence is generated (110) such that the image capturing device continuously captures the image of the seedling in an interval of 2 hours. Preferably, the images are taken within a close proximity of the seedling at a suitable angle such that characteristics of the seedlings are clearly captured.

Subsequently, the method (100) processes the captured images (130) to obtain parameters information of the seedling. Preferably, the step of processing the captured

- image (130) begins by converting the captured images into an initial set of raw data. Next, parameters information of the seedling is measured (131) based on the initial set of raw data.. Then, the measured parameters information of the seedling is extracted (132) by one or more feature extraction techniques.. Subsequently, different organ parts
- 5 of the seedling are isolated (133) by using an instance segmentation technique based on the extracted parameters information of the seedling. Preferably, a bounding box that captures and encloses each of the organ parts of the seedling is generated as an output of the instance segmentation technique.
- 10 Then, the method (100) applies a classification model to classify the quality property of the seedling (140) based on the parameters information. Preferably, the step of classifying the quality property of the seedling (140) begins by comparing the measured parameters information of each organ parts of the seedling with a trained data set to determine a health index of each organ part. Then, an overall health index that
- 15 represents an overall seedling quality is determined based on the health index of each organ part. Lastly, the determined overall health index is updated to a training database. Preferably, the health index of the organ part of the seedling is determined by a similarity in percentage between a first index and a second index of the organ part of the seedling, wherein the first index and the second index are obtained from the trained
- 20 data set during training phase and the measured parameters information, respectively. Preferably, the bounding box that captures and encloses the organ parts of the seedling is generated as an output of the classification model, whereby each bounding box comprises a float representation of the quality and stress properties of the respective organ part of the seedling. The float representation is preferably a float number that
- 25 indicates the health index in percentage.

Subsequently, the method (100) applies a plant stress model to determine stress property of the seedling (150) based on classified quality property of the seedling. Referring to Fig. 3, the plant stress model firstly obtains the timeseries data (151) of the soil (101)

and ambient environment conditions (102) from the training database. Secondly, the timeseries data of the soil and ambient environment conditions is split from an original data set from the training database. By way of example, the original data set from the training database may contain an abundance of data across a period of time. Therefore, a set of desired timeseries data of the soil and ambient environment conditions, preferably the most recent data is split from the original data set such that the plant stress model can perform an analysis according to recent conditions. Then, a non-linear regression technique is applied (152) to determine a data trend model (153) which fits the split timeseries data of the soil (101) and ambient environment conditions (102). By way of example, the data trend model can include but not limited to a logarithmic regression model and a polynomial regression model. Subsequently, a pattern detection technique is applied (154) on the data trend model to determine a number of anomalies. The anomaly refers to a discontinuous part of the timeseries data that is distinctive from normal data, in which the anomaly deviates from the data trend model. Subsequently, the number of anomalies determined is compared (155) with a predetermined threshold value to determine the stress property of the seedling (156, 157). Preferably, the predetermined threshold value refers to a number of anomalies that the seedling will experience over its growing phase, whereby the predetermined threshold can vary based on the species of the seedlings. Despite being classified as the seedling with good quality defined by the float representation on the bounding box, the seedling is likely to be under stressed condition if the determined number of anomalies is greater than the predetermined threshold value (156). Referring back to Fig. 1, the quality and stress properties of the seedling are preferably compared with predefined references (160) to determine whether to dispose (170) the seedling or to continue for cultivation in a plantation (180). The predefined references are preferably the first index and the predetermined threshold value.

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 determining seedling quality and stress properties, the method (100) comprising the steps of:
 - 5 acquiring soil (101) and ambient environment conditions (102) data of a location, where the seedling is planted, from one or more sensor modules;
 - generating a time sequence (110) based on the soil (101) and ambient environment conditions (102) data for image capturing;
 - triggering an image capturing device to capture one or more images of the seedling(120)
 - 10 based on the generated time sequence;
 - processing the captured images (130) to obtain parameters information of the seedling;
 - applying a classification model to classify quality property of the seedling (140) based on the parameters information; and
 - applying a plant stress model to determine stress property of the seedling (150) based
 - 15 on the classified quality property of the seedling;
 - wherein the time sequence is generated (110) by the steps of:
 - computing a time delay (112) based on the soil (101) and ambient environment conditions (102) data;
 - obtaining an averaged time delay (114) by averaging the computed time delay with
 - 20 a pre-defined time delay (113); and
 - generating the time sequence (110) based on the averaged time delay.

2. The method (100) according to claim 1, wherein the captured images are processed (130) by the steps of:
 - 25 converting the captured images into an initial set of raw data;
 - measuring parameters information of the seedling (131) based on the initial set of raw data;
 - extracting the measured parameters information (132) by one or more feature extraction techniques; and

isolating different organ parts of the seedling (133) by an instance segmentation technique based on the extracted parameters information.

- 5 3. The method (100) according to claim 1, wherein the classification model comprises the steps of:
comparing the measured parameters information of each organ part of the seedling with
a trained data set to determine a health index of each organ part;
determine an overall health index representing an overall seedling quality based on the
10 health index of each organ part; and
updating the determined overall health index to a training database.
4. The method (100) according to claim 3, wherein the plant stress model comprises the steps of:
15 obtaining timeseries data (151) of the soil (101) and ambient environment conditions (102) from the training database;
splitting the timeseries data of the soil (101) and ambient environment conditions (102) from an original data set;
applying a non-linear regression technique (152) to determine a data trend model (153)
20 which fits the timeseries data of the soil (101) and ambient environment conditions (102);
applying a pattern detection technique (154) on the data trend model to determine a number of anomalies; and
comparing the number of anomalies with a pre-determined threshold value (155) to
25 determine the stress property of the seedling.
5. The method (100) according to claim 1, wherein the quality and stress properties of the seedling are compared with pre-defined references (160) to determine whether to dispose (170) the seedling or to continue for cultivation in a plantation (180).

6. The method (100) according to any one of claims 1 to 5, wherein the captured images are displayed with a bounding box generated for each organ part of the seedling, whereby each bounding box comprises a float representation of the quality and stress
- 5 properties of the respective organ part of the seedling.