A METHOD FOR OIL PALM FRESH FRUIT BUNCH CLASSIFICATION

FIELD OF INVENTION

The invention relates to the field of properties classification. More particularly, the invention relates to a method for classifying properties of an oil palm fresh fruit bunch.

BACKGROUND OF THE INVENTION

Properties classification of an object refers to a process of systematic categorization of the properties of the object based on established criteria such as colour and size. This process can be performed with the aid of machine learning using a classification algorithm.. Such process can be employed in various fields such as agricultural and manufacturing fields to classify a desired object with minimal human input. This is because manual classification by human is time consuming and lacks accuracy, which may adversely affect outcome of the properties classification.

Over the years, various methods of classifying properties of an object were developed. For instance, China Patent Application Publication No. CN112800955A discloses a method for remote sensing a rotating target in an image based on a weighted bidirectional feature pyramid. The method performs feature extraction process on an image through a convolutional neural network to extract features from the image, whereby the weighted bidirectional feature pyramid is used. Particularly, the weighted bidirectional feature pyramid comprises a top-down convolution module and a bottom-up convolution module that performs an upsampling process and a downsampling process on the extracted features, respectively. However, the method generally involves a single stage algorithm that only extracts a single category of features from the image. As a result, the method is required to be reinitiated in order to extract subsequent categories of features from the image. Consequently, this increases processing time of

the method.

Accordingly, it would be desirable to provide a method for classifying properties of an oil palm fresh fruit bunch that overcomes the abovementioned drawbacks. This invention provides a solution to the problem.

SUMMARY OF INVENTION

One objective of the invention is to provide a method for classifying properties of an oil palm fresh fruit bunch with reduced processing time and enhanced accuracy.

In a first aspect of the invention, there is provided a method for classifying properties of an oil palm fresh fruit bunch comprising the steps of acquiring, via an image acquisition module, a plurality of images with different wavelength bands of the oil palm fresh fruit bunch; processing, via a plurality of feature extraction modules, the acquired images to extract features from different categories in a parallel operation, wherein each of the feature extraction modules applies a bidirectional feature extraction algorithm to extract a respective category of the features; merging, via a category awareness feature module, the extracted features to generate a feature map for each of the categories; and classifying, via a categorical classification module, the properties of the oil palm fresh fruit bunch based on the generated feature maps.

Preferably, the bidirectional feature extraction algorithm comprises a top-down feature extraction algorithm and a bottom-up feature extraction algorithm to extract the features based on relevance with respect to each of the categories.

Preferably, the category awareness feature module applies a global average pooling algorithm to merge the extracted features.

Preferably, the categorical classification module applies a multi-cross entropy loss function that classifies the properties of the oil palm fresh fruit bunch based on a predicted integer value.

Preferably, the method further comprises the step of normalizing, by a pre-processing module, the acquired images based on the respective wavelength bands to improve qualities of the acquired image.

In a second aspect of the invention, there is provided a system for classifying properties of an oil palm fresh fruit bunch comprising an image acquisition module for acquiring a plurality of images with different wavelength bands of the oil palm fresh fruit bunch; a plurality of feature extraction modules in communication with the image acquisition module for processing the acquired images to extract features from different categories in a parallel operation, wherein each of the feature extraction modules applies a bidirectional feature extraction algorithm to extract a respective category of the features; a category awareness feature module in communication with the plurality of feature extraction modules for merging the extracted features to generate a feature map for each of the categories; and a categorical classification module in communication with the category awareness feature module for classifying the properties of the oil palm fresh fruit bunch based on the generated feature maps.

Preferably, the bidirectional feature extraction algorithm comprises a top-down feature extraction algorithm and a bottom-up feature extraction algorithm to extract the features based on relevance with respect to each of the categories.

Preferably, the category awareness feature module applies a global average pooling algorithm to merge the extracted features.

Preferably, the categorical classification module applies a multi-cross entropy loss

function that classifies the oil palm fresh fruit bunch based on a predicted integer value.

Preferably, the system further comprises a pre-processing module for normalizing the acquired images based on the respective wavelength bands to improve qualities of the acquired image.

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 classifying properties of an oil palm fresh fruit bunch.

Fig. 2 is a schematic diagram illustrating a plurality of feature extraction modules each applies a bidirectional feature extraction algorithm.

Fig. 3 is a schematic diagram illustrating a category awareness feature module and a categorical classification module.

DETAILED DESCRIPTION OF THE INVENTION

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

Fig. 1 illustrates an overview of a method (100) for classifying properties of an oil palm fresh fruit bunch. The properties can include but not limited to physical condition of the oil palm fresh fruit bunch, maturity of the oil palm fresh fruit bunch, or any combination thereof. Preferably, the method (100) is used in agricultural industries to classify maturity of the oil palm fresh fruit bunches for upstream processing thereof. Preferably, the method (100) employs a convolutional neural network (CNN) to classify the properties of the oil palm fresh fruit bunch.

In a preferred embodiment of the invention, the method (100) begins by acquiring a plurality of images (101) with different wavelength bands of the oil palm fresh fruit bunch via an image acquisition module. Preferably, the wavelength bands of the acquired image can include but not limited to Near-infrared (NIR) and Red, Green, and Blue (RGB). Preferably, the images are acquired at an isometric angle such that essential characteristics of the oil palm fresh fruit bunch is captured clearly. The essential characteristics may be physical appearance of the oil palm fresh fruit bunch such as colour and size. Advantageously, this minimizes the reliance on the use of an image enhancement software to sharpen the acquired images. Additionally, the images of the oil palm fresh fruit bunch are acquired at multiple instances at a time for comparison purpose to identify an acceptable range of image values such as pixel intensity value of the images.

In the preferred embodiment of the invention as illustrated in Fig. 1, the method (100) then processes the acquired images (103) to extract features from different categories via a plurality of feature extraction modules in a parallel operation. The parallel operation of the feature extraction modules allows simultaneous processing of the

acquired images to extract the features from different categories without reinitiating the method (100). Advantageously, this reduces processing time and enhances accuracy of the classification of properties obtained from the method (100). Preferably, each of the feature extraction modules applies a bidirectional feature extraction algorithm to extract a respective category of the features. The categories of the features to be extracted are defined by a user prior to the processing of the acquired images (103). Referring to Fig. 2, the categories of the features can include but not limited to object class such as types of the oil palm fresh fruit bunch, object category such as parts of the oil palm fresh fruit bunch, and other object attributes such as colour, size, and shape of the oil palm fresh fruit bunch. By way of example, each of the categories of the features are extracted from the acquired images with a respective wavelength band. For example, the acquired images with RGB wavelength bands are used in extracting the features of the object class category.

Referring to Fig. 2, the bidirectional feature extraction algorithm preferably comprises a top-down feature extraction algorithm and a bottom-up feature extraction algorithm to extract the features based on relevance with respect to each of the categories. Preferably, the top-down feature extraction algorithm and the bottom-up feature extraction algorithm are performed in a parallel operation. Preferably, the top-down feature extraction algorithm prioritizes the extraction of the features that are more relevant to the categories whereas the bottom-up feature extraction algorithm prioritizes the extraction of the features that are less relevant to the categories. Additionally, the features with a higher priority are set for prioritized processing whereas the features with a lower priority are set for later processing. Difference in the priorities of feature extraction between the top-down feature extraction algorithm and the bottom-up feature extraction algorithm leads to distinction in the extracted features, thereby further improving the accuracy of the classification of properties.

Subsequently, the method merges the extracted features (104) to generate a feature map

for each of the categories via a category awareness feature module, as illustrated in Fig. 1. Referring to Fig. 3, the category awareness feature module aims to establish a multi object classification CNN that classifies the oil palm fresh fruit bunch into a specific class based on the extracted features from the top-down feature extraction module and the bottom-up feature extraction module. The merging of the extracted features (104) via the category awareness feature module is according to Equation 1, where C refers to the classification of the properties, MOC - CNN refers to the multi object classification CNN, and input1 and input2 refers to the extracted features from the top-down feature extraction module and the bottom-up feature extraction module.

Equation 1:

$$C \leftarrow MOC - CNN(\{input1, input2, \dots, inputN\}) \; with \; C \in \{Class1, Class2, \dots, ClassN\}$$

Preferably, the category awareness feature module applies a global average pooling algorithm to merge the extracted features (104) and to generate the feature map based on the merged features. This is because the extracted features of the top-down feature extraction module and the bottom-up feature extraction module are not spatially correlated due to the parallel operation. Additionally, the global average pooling algorithm removes spatial information of the extracted features by averaging the generated feature maps into a single value. Furthermore, the global average pooling algorithm does not involve optimizing of parameters during the merging of the extracted features. Advantageously, this minimizes the risk of overfitting which reduces accuracy and reliability of the method.

In the preferred embodiment of the invention as illustrated in Fig. 1, the method (100) then classifies the properties of the oil palm fresh fruit bunch based on the generated feature maps (105) via a categorical classification module. Preferably, the categorical classification module applies a multi-cross entropy loss function that classifies the properties of the oil palm fresh fruit bunch based on a predicted integer value. The

integer value is predicted based on total loss according to Equation 2, where x refers to one of the classification in the user's target, p(x) refers to a probability of x being classified into the user's target, and q(x) refers to a probability of x being classified into other targets. Preferably, each of the integer values represents a classification that ranges between 0 to n, where n equals to total number of classifications minus 1.

Equation 2

$$Total\ Loss = \sum_{x} \big(p(x).\log\ q(x) + \big(1 - p(x)\big).\log(1 - q(x))\ \big)$$

Preferably, the categorical classification module further applies a cross-entropy function to determine an average difference between an actual probability of classification and the predicted probability of classification, wherein the actual probability of classification is based on a ground truth data, which can be obtained via equipment and calibration technique. The average difference is calculated using the cross entropy function based on Equation 3, wherein CE refers to the average difference based on cross entropy loss, t_i refers to the ground truth data, and s_i refers to the total loss obtain from the categorical classification module. Preferably, the average difference that is closer to 0 represents that the classification is accurate. On the other hand, the method (100) repeats from the step of processing the acquired images (103) via the plurality of feature extraction modules if the average difference is greater than a predetermined threshold value. By way of example, the predetermined threshold value is 0.1.

Equation 3:

$$CE = -\sum_{i}^{C} t_i \log\,(s_i)$$

In a second embodiment of the invention, the method (100) further comprises the step of normalizing the acquired images (102) based on the respective wavelength bands by

a pre-processing module to improve qualities of the acquired image. The acquired images are normalized to adjust the range of pixel intensity values due to difference in lighting conditions in a surrounding. Preferably, the step of normalizing the acquired image (102) is performed prior to the step of processing the acquired images (103). Advantageously, this improves the accuracy of the classification.

In a third embodiment of the invention, there is provided a system for classifying properties of the oil palm fresh fruit bunch. The system comprises an image acquisition module, a plurality of feature extraction modules in communication with the image acquisition module, a category awareness feature module in communication with the plurality of feature extraction modules, and a categorical classification module in communication with the category awareness feature module. Firstly, the image acquisition module acquires a plurality of images (101) with different wavelength bands of the oil palm fresh fruit bunch. Then, the feature extraction modules process the acquired images (103) to extract features from different categories in a parallel operation, wherein each of the feature extraction modules applies a bidirectional feature extraction algorithm to extract a respective category of the features. Preferably, the bidirectional feature extraction algorithm comprises a top-down feature extraction algorithm and a bottom-up feature extraction algorithm to extract the features based on relevance with respect to each of the categories. Subsequently, the category awareness feature module merges the extracted features (104) to generate a feature map for each of the categories. Finally, the categorical classification module classifies the properties of the oil palm fresh fruit bunch based on the generated feature maps (105). Preferably, the system further comprises a pre-processing module for normalizing the acquired images (102) based on the respective wavelength bands to improve qualities of the acquired image.

A comparative analysis was conducted in which images of the oil palm fresh fruit bunches are acquired, processed, merged, and classified. The step of processing was

carried out either with the plurality of feature extraction modules in parallel operation or a single stage feature extraction module. It was found that the classification with the plurality of feature extraction modules in parallel operation achieved a classification accuracy of 97% whereas the classification with the single stage feature extraction module achieved a classification accuracy of 82%.

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 classifying properties of an oil palm fresh fruit bunch comprising the steps of:

acquiring, via an image acquisition module, a plurality of images (101) with different wavelength bands of the oil palm fresh fruit bunch;

processing, via a plurality of feature extraction modules, the acquired images (103) to extract features from different categories in a parallel operation, wherein each of the feature extraction modules applies a bidirectional feature extraction algorithm to extract a respective category of the features;

merging, via a category awareness feature module, the extracted features (104) to generate a feature map for each of the categories; and

classifying, via a categorical classification module, the properties of the oil palm fresh fruit bunch based on the generated feature maps (105).

2. The method (100) according to claim 1, wherein the bidirectional feature extraction algorithm comprises a top-down feature extraction algorithm and a bottom-up feature extraction algorithm to extract the features based on relevance with respect to each of the categories.

3. The method (100) according to claim 1, wherein the category awareness feature module applies a global average pooling algorithm to merge the extracted features.

4. The method (100) according to claim 1, wherein the categorical classification module applies a multi-cross entropy loss function that classifies the properties of the oil palm fresh fruit bunch based on a predicted integer value.

5. The method (100) according to claim 1, further comprising the step of normalizing, by a pre-processing module, the acquired images (102) based on the respective

wavelength bands to improve qualities of the acquired image.

6. A system for classifying properties of an oil palm fresh fruit bunch comprising:

an image acquisition module for acquiring a plurality of images (101) with different wavelength bands of the oil palm fresh fruit bunch;

a plurality of feature extraction modules in communication with the image acquisition module for processing the acquired images (103) to extract features from different categories in a parallel operation, wherein each of the feature extraction modules applies a bidirectional feature extraction algorithm to extract a respective category of the features;

a category awareness feature module in communication with the plurality of feature extraction modules for merging the extracted features (104) to generate a feature map for each of the categories; and

a categorical classification module in communication with the category awareness feature module for classifying the properties of the oil palm fresh fruit bunch based on the generated feature maps (105).

7. The system according to claim 6, wherein the bidirectional feature extraction algorithm comprises a top-down feature extraction algorithm and a bottom-up feature extraction algorithm to extract the features based on relevance with respect to each of the categories.

8. The system according to claim 6, wherein the category awareness feature module applies a global average pooling algorithm to merge the extracted features.

9. The system according to claim 6, wherein the categorical classification module applies a multi-cross entropy loss function that classifies the oil palm fresh fruit bunch based on a predicted integer value.

10. The system according to claim 6, further comprising a pre-processing module for normalizing the acquired images (102) based on the respective wavelength bands to improve qualities of the acquired image.

ABSTRACT

A METHOD FOR OIL PALM FRESH FRUIT BUNCH CLASSIFICATION

The present invention discloses a method (100) for classifying properties of an oil palm fresh fruit bunch comprising the steps of acquiring, via an image acquisition module, a plurality of images (101) with different wavelength bands of the oil palm fresh fruit bunch; processing, via a plurality of feature extraction modules, the acquired images (103) to extract features from different categories in a parallel operation, wherein each of the feature extraction modules applies a bidirectional feature extraction algorithm to extract a respective category of the features; merging, via a category awareness feature module, the extracted features (104) to generate a feature map for each of the categories; and classifying, via a categorical classification module, the properties of the oil palm fresh fruit bunch based on the generated feature maps (105). The parallel operation of the feature extraction modules allows simultaneous processing of the acquired images to extract the features from different categories, thereby reducing processing time and improving accuracy of the classification of properties obtained from the method (100).

(The most illustrative figure: Fig. 1)