INTELLIGENT NON-DESTRUCTIVE CLASSIFICATION OF JOSAPINE PINEAPPLE MATURITY USING ARTIFICIAL NEURAL NETWORK

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SEPTEMBER 2016

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ANN	Artificial Neural Network
CCV	Color Coherence Vector
CM	Color Moments
ECER	East Coast Economic Region
EMM	Edge Mismatch
FAMA	Federal Agriculture Marketing Agency (Malaysia)
FAOSTAT	Food and Agriculture Organization of The United Nations
GLCM	Grey Level Co-occurrence Matrix
LPNM	Lembaga Perindustrian Nanas Malaysia
MARDI	Malaysia Agricultural Research and Development Institute
MHD	Modified Hausdorff Distance
MLP	Multi Layer Perceptron
MPIB	Malaysia Pineapple Industrial Board
ME	Misclassification Error
NU	Non-uniformity
RAE	Relative Foreground Area Error
RBF	Radial Basis Function
ROI	Region of Interest

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ABSTRACT

The pineapple maturity level also referred as pineapple maturity index is based on the percentage of yellowish that appears on the pineapple's skin. In pineapple industry to determine the level of maturity, human experts adopt methods based on their subjective assessment of skin color. To this day, the pineapple maturity sorting process is still performed manually by expert human grader. So in order to reduce errors caused by human factors, there is a need to automate this process to an automated inspection system. The matured fruit harvested for the purposes of local sale or export is complete fruit with crown, fruit body and stump. However, in determining the pineapple maturity index, the main thing to be considered is only the pineapple fruit without crown. Fruit without crown also represents the actual size of the pineapple. Therefore the percentage of yellowish must be proportional to the size of the pineapple. Having extensive search of literatures found that studies of the size of the fruit, especially pineapple are very limited and only been started in recent years. To obtain the actual size of the fruit, the detection Region of Interest (ROI) is using segmentation method called minimum symmetrical edge distance. This minimum symmetrical edge distance algorithm wills geometrical rotated the pineapple images which to align with horizontal axis. Then the shortest vertical distances of the edge is calculated and converted to a background pixel, the largest region (fruit body) is maintained and the small region (crown) was abolished. The performance of segmentation algorithms are calculated using misclassification error that provides the rate of image pixels are incorrectly misclassified into the wrong segment. The results reveal that the algorithm used to achieve overall accuracy up to 99.05%. *ROI* that has been identified lengthened for feature extraction on the skin color of pineapple. Statistical based features namely minimum, maximum, arithmetic average and standard deviation were extracted from each image channels within detected ROI to represent pineapple skin color's tendency and dispersion. Next, classification index to determine the pineapple maturity level has been applied which are linear classification using thresholding value and artificial neural network adopting pattern recognition method. The results show that the classification using artificial neural network (pattern recognition) involving feature vectors arithmetic average and standard deviation for all channels R, G and B give the average correct classification rate of 88.89%.

ABSTRAK

Tahap kematangan nanas juga dirujuk sebagai indeks kematangan nanas adalah berdasarkan peratusan kekuningan yang kelihatan pada kulit nanas tersebut. Dalam industri nanas bagi menentukan tahap kematangannya, pakar-pakar menggunapakai kaedah berdasarkan penilaian subjektif mereka terhadap warna kulit buah. Sehingga ke hari ini proses mengenalpasti dan mengasingkan buah nanas mengikut tahap kematangannya masih dilakukan secara manual oleh pakar. Maka bagi mengurangkan kesilapan yang disebabkan oleh faktor manusia, adalah menjadi keperluan untuk mengautomasi proses ini kepada satu sistem pemeriksaan automatik. Buah nanas matang yang dipetik bagi tujuan jualan ataupun eksport adalah buah yang lengkap terdiri daripada jambul, badan buah dan tunggul. Namun begitu, dalam menentukan indek kematangan nanas, perkara utama yang perlu dipertimbangkan hanyalah badan buah tanpa jambul. Buah tanpa jambul adalah mewakili saiz sebenar buah nenas. Oleh yang demikian peratusan kekuningan buah mestilah berkadar terus dengan saiz buah nanas. Setelah meneliti secara mendalam terhadap litaratur yang ada, didapati kajian terhadap saiz buah-buahan terutamanya nanas adalah sangat terhad dan hanya dimulakan beberapa tahun terakhir. Maka dalam mendapatkan saiz sebenar buah nanas, pengesanan rantau berkepentingan (*Region of Interest-ROI*) adalah dengan menggunakan kaedah segmentasi jarak simetri minimum. Algoritma segmentasi jarak simetri minimum ini akan memutarkan imej nanas secara geometrikal selaras dengan paksi mendatar. Kemudian jarak terpendek menegak dikira dan ditukarkan kepada piksel latar belakang, rantau terbesar (badan buah) dikekalkan dan rantau kecil (jambul) dihapuskan. Prestasi algoritma segmentasi ini dikira menggunakan *misclassification error*, yang memberikan kadar piksel yang tersalah dikelaskan kepada bukan segmen yang sebenar. Keputusan menunjukkan algoritma yang digunapakai mencapai keseluruhan ketepatan menghampiri 99.05%. *ROI* yang telah dikenalpasti dipanjangkan lagi bagi mendapatkan pengekstrakan ciri yang terdapat pada warna kulit nanas. Sifat-sifat berdasarkan statistik yang dikenali sebagai nilai minimum, nilai maksimum, purata aritmetik dan sisihan piawai diekstrak dari setiap saluran imej pada lokasi *ROI* bagi mewakili kecenderungan dan penyerakan warna kulit nanas. Seterusnya pengkelasan indeks nanas bagi menentukan tahap kematangannya dilakukan dengan menggunakan dua kaedah iaitu klasifikasi linear menggunakan nilai pengambangan dan pengkelasan *artificial neural network* menggunapakai kaedah pengiktirafan corak (*pattern recognition*). Hasil menunjukkan bahawa pengkelasan artificial neural network menggunapakai kaedah pengiktirafan corak yang melibatkan pengekstrakan ciri purata aritmetik dan sisihan piawai bagi kesemua saluran R,G & B memberikan purata kadar pengkelasan betul 88.89%.

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