ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 7, March 2018

FRUIT MATURITY DETECTION USING ARTIFICIAL NEURAL NETWORK TECHNIQUE

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Abstract— **Success of image processing and its expansion to numerous field of application like medical, engineering and remote sensing have paved its way to applications in agriculture. Machine vision based maturity detection system is aimed to replace manual based technique for sorting and grading of fruits as the manual inspection possess problem in maintaining consistency in grading and uniformity in sorting. We aim to develop an automated tool, which can be able to identify and classify the fruits based on its shape, size, color and other features by combining image processing, Discrete Wavelet Transform (DWT), Gray-Level Co-occurrence matrix (GLCM) and Artificial Neural Network (ANN) technique. This automatic vision based technology uses a Gabor filter for noise reduction , Canny edge detector for edge detection , GLCM matrix for feature extraction like contrast, correlation, energy, homogeneity, standard deviation, variance and mean, MATLAB software for image analysis and Artificial Neural Network (ANN) for modeling.**

Index Terms*— *Fruit sorting, machine vision, maturity detection, Discrete Wavelet Transform (DWT), Gray-Level Co-occurrence matrix (GLCM), Artificial Neural Network (ANN).

I. INTRODUCTION

In most of the developing nations, agriculture forms the major part of the country's economy and it plays the major role in economic development of India. Fruit detection system is primarily developed for robotic fruit harvesting. However, this technology can easily be tailored for other applications such as on tree yield monitoring, crop health status monitoring, disease detection, maturity detection and other operations which requires vision as a sensor. [1] For fruit harvesting system, it is very necessary to detect the fruit on the tree more efficiently. At present, most farms use manual experts for sorting the fruits, but most of the fruits are seasonal, so getting sufficient number of manual experts during that period is difficult. On the other hand, manual sorting is time consuming and suffers from the problem of inconsistency and inaccuracy in judgment by different human experts. Fruit categorizations in agriculture have changed from traditional grading by humans to automatic classification over the last few years. Classification of fruit is necessary in evaluating agricultural products, quality standards and increasing market values. It is also helpful in planning, packaging, marketing and transportation. [2]

An objective and accurate ripeness assessment of agricultural fruits is important in ensuring optimum yield of high quality products. Sorting according to the maturity level is necessary, as transportation time for fruits to different locations are different. Generally, most of the matured fruits must be sold to local markets and premature fruits can be shipped to customers over much longer distances. It is indispensable to have non-destructive automatic quality detection technology in order to improve fruits quality detection, the system should have grading efficiency and reduce labor requirement. [3]

Fruit non-destructive detection is the process of detecting fruits by each side without damaging the fruit by using some detecting technology to make evaluation according to some standard rules.

Determining ripeness stages is a very important issue in production (fruits) industry for getting high quality products. Product quality is one of the prime factors in ensuring consistent marketing of crops. [4] However, up to this day, optimal harvest dates and prediction of storage life are still mainly based on subjective interpretation and practical experience. In the proposed system we are going to implement Artificial Neural Network (ANN) algorithm along with MATLAB programming for final classification of ripeness stages and feature extraction of fruits, respectively. The color measuring technique in MATLAB has been used to provide a more versatile way to measure the color of many fruits more than the traditional expensive color measuring instruments.

II. METHODS

OBJECTIVES

The objective is to develop the fruit maturity assessment program based on specific characteristics extracted from photography. Hence, this presents an approach where the fruit is identified based on its features such as size, shape, texture, weight, volume, fractal analysis and classification. The main purpose of this program is to use MATLAB resources .Indeed, there are several advantages of combining MATLAB with the fruit maturity assessment program. The result proves this method to be a simple and an efficient attempt [1] . Future sections will discuss more on image preprocessing which includes image resizing, enhancement, color conversion and classification.

PRE-PROCESSING

Preprocessing is the common name for operations with image at lowest level of abstraction (i.e.) both input and output are intensity images. The aim of pre-processing is an improvement of the image data that suppresses unwanted distortions or enhances some image features important for future processing. [1]

IMAGE ACQUISITION

Digital imaging or digital image acquisition is the creation of photographic images, such as of a physical scene or of the interior structure of an object. The term is often assumed to imply or include the processing, compression, storage, printing and display of such images. In all classes of digital imaging, the information is converted by image sensors into digital signals that are processed by a computer and made output as a visible-light image. [2]

IMAGE RESIZING

In computer and digital imaging, image scaling refers to the resizing of a digital image. In video technology, the magnification of digital material is known as up scaling or resolution enhancement. Image interpolation occurs when resizing or distorting image from one pixel grid to another. Image resizing is necessary when there is a need to increase or decrease the total number of pixels, whereas remapping can occur when correcting for lens distortion or rotating an image [2]. Zooming refers to increase the quantity of pixels, so that while zooming an image, more details will appear.

FILTERING

Filtering is a technique for modifying or enhancing an image. For example, an image is filtered to emphasize certain features or remove other feature image processing operations implemented with filtering include smoothing, sharpening, removing noise, edge detection and edge enhancement. Filtering is a neighborhood operation, *in* which the value of any given pixel in the output image is determined by applying some algorithm to the values of the pixels in the neighborhood of the corresponding input pixel. A pixel's neighborhood is some set of pixels, defined by their locations relative to that pixel. A filter is defined by a kernel, which is a small array applied to each pixel and its neighbors within an image. In most applications, the center of the kernel is aligned with the current pixel, and is a square with an odd number (3, 5, 7, etc.) of elements in each dimension [2]. The process used to apply filters to an image is known as convolution, and may be applied in either the spatial or frequency domain. In the assessment of fruit maturity, two filters are used: Gabor filter and Gaussian filter. [3]

EDGE DETECTION

Edge detection is a fundamental tool in image processing, machine vision and computer vision, particularly in the areas of feature detection and feature extraction Edge detection is a technique for finding the boundaries of objects within images. It works by detecting discontinuities in brightness. Edge detection is used for image segmentation and data extraction in areas such as image processing, computer vision, and machine vision. It includes a variety of mathematical methods that aim at identifying points in a digital image at which the image brightness changes sharply or more formally, has discontinuities. The points at which image brightness changes sharply are typically organized into a set of curved line segments termed edges. [3] The same problem of finding discontinuities in one-dimensional signals is known as step detection and the problem of finding signal discontinuities over time is known as change detection. In the detection of fruit maturity, canny edge detection technique is used.

RGB to YCbCr CONVERSION

Color space conversion has become an integral part of image processing and transmission. Real time images and video are stored in RGB color space. [4] Transmitting images in RGB color space is not practical as their bandwidth requirement is very high.

To overcome this problem and minimize the bandwidth requirement images in RGB color space are converted into other color space such as YUV, YIQ and YCbCr and then transmitted. The choice of the color space is dependent on the application and their requirement such as less storage, bandwidth or computation in analog or digital domains. [6]

DISCRETE WAVELET TRANSFORM (DWT) ALGORITHM

In numerical analysis and functional analysis, a discrete wavelet transform (DWT) is any wavelet transform for which the wavelets are discretely sampled. As with other wavelet transforms, a key advantage of DWT over Fourier transforms is temporal resolution. It captures both frequency and location information (location in time). [3] This transform decomposes the signal into mutually orthogonal set of wavelets, which is the main difference from the continuous wavelet transform (CWT), or its implementation for the discrete time series sometimes called discrete-time continuous wavelet transform (DT-CWT).

In image processing, wavelets are often used to denoise two dimensional signals, such as images. [8] Wavelet analysis is similar to Fourier analysis but the Fourier transform breaks signal into a series of sine waves of different frequencies. The wavelet transform breaks the signal into its "wavelets", scaled and shifted versions of the "mother wavelet". The wavelet is irregular in shape and compactly supported which makes the wavelets an ideal tool for analyzing signals of a non-stationary nature. The DWT of a signal is calculated by passing it through a series of filters. First the samples are passed through a low pass filter with impulse response .The signal is also decomposed simultaneously using a high pass filter. The outputs giving the detail coefficients (from the high-pass filter) and approximation coefficients (from the low-pass). [4] The two filters are related to each other and they are known as a quadrature mirror filter. The discrete wavelet transform (DWT) gives information about the frequency components as well as being able to indicate what time these components occur at. It becomes much easier to filter in or filter out a given non-stationary waveform. A lot of signals are found to be sparse in an appropriate DWT basis. This makes it easy to, for instance, filter noise out of a phoneme (small units in the sound system) by using a simple binary mask in the DWT domain. [10]

FEATURE EXTRACTION

Feature extraction involves reducing the amount of resources required to describe a large set of data. When performing analysis of complex data one of the major problems are the number of variables involved. Analysis with a large

number of variables generally requires a large amount of memory and computation power. Feature extraction is a general term for methods of constructing combinations of the variables to get around these problems while still describing the data with sufficient accuracy. [5] The transformed attributes, or features, are linear combinations of the original attributes. Models built on extracted features may be of higher quality, because the data is described by fewer, more meaningful attributes. Feature extraction is related to dimensionality reduction.

Common numerical programming environments such as MATLAB, SciLab, NumPy and the R language provide some of the simpler feature extraction techniques (e.g. principal component analysis) via built-in commands. [9]

GRAY-LEVEL CO-OCCURRENCE MATRIX (GLCM)

In statistical texture analysis, texture features are computed from the statistical distribution of observed combinations of intensities at specified positions relative to each other in the image. According to the number of intensity points (pixels) in each combination, statistics are classified into first-order, second order and higher-order statistics. The Gray Level Co-occurrence Matrix (GLCM) method is a way of extracting second order statistical texture features. [5] A statistical method of examining texture that considers the spatial relationship of pixels is the gray-level co-occurrence matrix (GLCM), also known as the gray-level spatial dependence matrix. (The texture filter functions, described in Texture Analysis cannot provide information about shape, that is, the spatial relationships of pixels in an image.)The GLCM functions characterize the texture of an image by calculating how often pairs of pixel with specific values and in a specified spatial relationship occur in an image, creating a GLCM, and then extracting statistical measures from this matrix. [5] To create a GLCM, use the graycomatrix function. The function creates a gray-level co-occurrence matrix (GLCM) by calculating how often a pixel with the intensity (gray-level) value i occurs in a specific spatial relationship to a pixel with the value j. By default, the spatial relationship is defined as the pixel of interest and the pixel to its immediate right (horizontally adjacent), but you can specify other spatial relationships between the two pixels. If most of the entries in the GLCM are concentrated along the diagonal, the texture is coarse with respect to the specified offset.

Each element (i, j) in the resultant GLCM is simply the sum of the number of times that the pixel with value i occurred in the specified spatial relationship to a pixel with value j in the input image. The number of gray levels in the image determines the size of the GLCM. By default, graycomatrix uses scaling to reduce the number of intensity values in an image to eight, but you can use the NumLevels and the Gray Limits parameters to control this scaling of gray levels. [6] The gray-level co-occurrence matrix can reveal certain properties about the spatial distribution of the gray levels in the texture image. After you create the GLCMs, using graycomatrix, you can derive several statistics from them using graycoprops.These statistics provide information about the texture of an image.

ARTIFICIAL NEURAL NETWORK

NNs (NEURAL NETWORK) consist of ten billions of densely interconnected nerve cells (neurons). Neurons essentially behave as microprocessors. Each neuron receives the combined output of many other neurons through input paths called dendrites (Figure).These dendrites receives signs from other neurons. If this signal is strong enough, the neuron is activated and produces an output, which is transmitted through output structures called axons. [6] The receiving ends of these junctions on other cells can be found both on the dendrites and on the cell bodies itself. The axon of a typical neuron leads to a few thousand synapse associated with other neuron.
The axon splits up and connects to the dendrites of many other neurons via junctions called synapses. A neural network is a collection of "neurons" with "synapses" connecting them. The strength of the synapses is modified as the brain learns. Artificial are statistical learning models, inspired by biological neural networks (central nervous systems, such as the brain), that are used in machine learning. These networks are represented as systems of interconnected "neurons", which send messages to each other. ANNs are loosely based on the structure of NNs but exhibit only a small portion of their capabilities. [7] ANNs are similar to NNs in that they consist of interconnected PEs (Processing Elements) and are only allowed to receive information supplied locally. ANNs are a type of parallel computer, which differ from conventional computers in the way they process information.

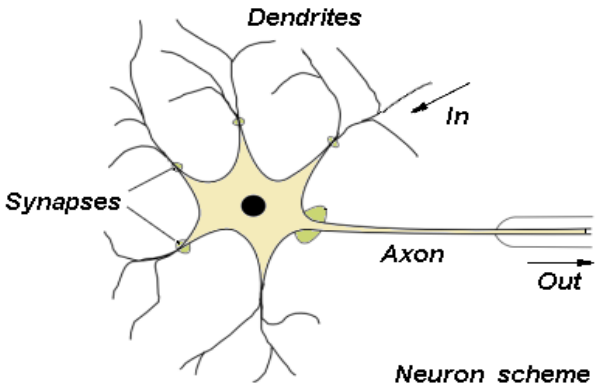

Fig: NEURON IMAGE

The operation of conventional computers is controlled by a single central processing unit (CPU), which holds the computer's memory and processes information in a sequential manner. Parallel computers, on the other hand, consist of a number of smaller processing elements (PEs), that are linked together. As a result, the computer's memory is distributed and information is processed in a parallel manner. [7] These layers are known as "hidden", since they are not visible as a network output.

The PEs in the various layers are either fully or partially interconnected. The connections between the PEs are weighted. The strength of each connection weight can be adjusted; a zero weight represents the absence of a connection, and a negative weight represents an inhibitory relationship between two PEs. The propagation of data through the network starts with the presentation of an input stimulus at the input layer. [8] The data then flow through, and are operated on by, the network until an output stimulus is produced at the output layer. In operation each

unit of an ANN receives input from other connected unit a weighted sum of the input is computed at a given instance of time. The activation value determines the actual output from the output function unit. [11] When the weights are changing, then the synaptic dynamics of the network determines the weight vector as a function of time. Synaptic dynamics is followed to adjust the weights in order to store the given patterns in the network .the process of adjusting the weights is known as learning. Once the learning process is completed, the final set of weight values corresponds to the long term memory function of the network.

The procedure to incrementally update each of the weights is called a learning law or learning algorithm. In particular, the updating of the output states of all the units could be performed synchronously.[10] ANNs are trained computer programs, which works similar to our brains. An extension of many classification techniques can be regarded as artificial neural networks [9]. ANNs are robust in dealing with the ambiguous data and the kind of problems that require the interpolation of large amounts of data. The network performs routinely many operations in parallel and also a given task in distributed manner. User friendliness and can handle noisy data. Well suited to analyze complex problem. Comparable classification accuracy with other methods.

III.CONCLUSION

The results presented in this paper contain detailed analysis with the randomly selected samples from different regions and in different times. In this paper the identification of good and bad fruits based on quality in image processing using MATLAB is done successfully with 94% accuracy. The use of image processing for identifying the quality can be applied not only to any particular fruit, we can also apply this method to identify quality of vegetables with more accuracy. Thus, this will enable the technology to be applied in many products.

The performance also found to be reasonable good in comparison with human experts and other work.

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