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Artificial Neural Network and Particle Swarm Optimization in Orange Identification

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Abstract - *Advancement in technology has lead to the use of computer science and it's associated technology in agriculture and food science. Fruit industry contributes a major part in the growth of a nation. Identifying foods that looks similar is of major concern. And also, the rise in labour costs, shortage of efficient labourers and the need to improve the processes at the production side have all put pressure on producers and processors to demand for a time-saving, economic, consistent and non-destructive inspection method. In such scenarios, automation can reduce the costs while increasing the production efficiency. Automatic fruit grading and sorting requires the implementation of computer vision systems. Hybrid approaches that consists of artificial neural networks and meta-heuristic algorithms can provide satisfying solutions to these problems. This can provide fast and accurate ways in classifying fruits. This paper deals with the use of artificial neural networks and Particle Swarm Optimization (ANN-PSO) in identifying orange varieties.*

***Key Words*:** Artificial Neural Network (ANN), Metaheuristics, Artificial Neurons, Particle Swarm Optimization, Nature inspired metaheuristics.

1. INTRODUCTION

Fruits play vital part in a balanced diet. They are said to be good sources of minerals and vitamins and for their role in preventing related deficiencies. People those who have the habit of eating fruits as part of their daily diet are generally less prone to chronic diseases. Fruits provide many essential nutrients including fibre, potassium, folate and vitamin C. The nutrients in fruit are vital for maintaining the health of one's body. Oranges are relatively hard to classify when compared with other fruit varieties. Here, we mainly consider three types of oranges namely Bam, Pavyandi and Thomson.

The use of Computer Vision Systems in the field of agriculture has increased substantially in the recent years for the substantial information it provides about the nature and attributes of the produce while reducing costs and guaranteeing the maintenance of quality standards in real time. Computer vision is a new technology which acquires an image of a scene and analyses it using computers in order to control machines or to process it. It makes use of the chromatic (colour) and geometric (shape, size, texture) attributes that are present on the image to predict the outcome.

The tasks involved in Computer vision are the methods to acquire, process, analyze and understand the digital images, and to extract high-dimensional data from those images so as to produce the decision in either numerical or symbolic forms. Artificial systems have been designed to act based on the science of computer vision which extracts information from images. The image data that can be used to extract the necessary information can be of many forms, such as sequence of video, multiple camera views from various angles or data from medical scanners that are usually multi-dimensional.

Computer vision along with artificial neural networks is used to identify the type or category to which the given image of orange belongs to.

2. LITERATURE SURVEY

Yudong Zhang and his associates have combined fitness-scaled chaotic artificial bee colony (FSCABC) algorithm[7] and feed forward neural network (FNN) which is a hybrid method to classify objects. The acquired images were processed for background removal and to obtain various features to create feature space. Since, the obtained feature space is large principal component analysis was performed to reduce the dimensions of the feature space. And then, these were fed to the FNN. The FSCABC algorithm was used to train the weights of the neural network. This method proved to acquire higher classification efficiency than other genetic algorithms.

Yudong Zhang and his associates proposed another novel fruit-classification system, with the goal of recognizing fruits in a more efficient way. It employs four-step pre-processing before the extraction of various geometric and chromatic attributes. Principal component analysis was utilized in the decrease of the quantity of features. Feed-forward neural network (FNN) and Biogeography-based optimization (BBO) [8] had been utilized to group the fruits from the diminished features. This technique had higher productivity in both precision and calculation time.

Wang S and his associates in their work proposed two novel machine-learning based classification methods. Their work involved the utilization of wavelet entropy (WE), principal component analysis (PCA). And mainly, the two machine-learning based classification methods namely feed-forward neural network (FNN) along with fitness-scaled chaotic artificial bee colony (FSCABC) and biogeography-based optimization (BBO) were employed. This required the utilization of considerably less features in expectation when contrasted and different techniques.

Nasirahmadi and his associate Ashtiani S in their paper have grouped fruits and classified them using Image processing combined with pattern recognition. They classified 20 varieties almonds which are of sweet and bitter taste utilizing Bag-of-Feature (BOF) model. Harris, Harrise Laplace, Hessian, Hessiane Laplace and Maximally Stable Extremely Regions (MSER) key point indicators along with a Scale Invariant Feature Transform (SIFT) descriptor were utilized. The execution of Chi-SVM classifier was found be exceptional than the k-NN and L-SVM classifiers.

Sofu MM, Erb O, Kayacan MC, Cetissli B. The paper proposed real-time processing system that consequently sorts apples and assesses it's quality. The apples were arranged dependent on various characteristics, for example, colour, size and weight into different classes. It was likewise ready to recognize the apples that were influenced by scab and stain and furthermore the one's that were spoiled. The proposed framework had the capacity to sort 15 apples in a normal for each second. It had a arranging precision rate of 73– 96%.

3. ARTIFICIAL NEURAL NETWORKS

Artificial neural network (ANN) has also been known as connectionist system. Normally, artificial neurons are collected into layers. It is essentially a registering framework that was motivated by the working of the natural neural systems of creature minds [1]. The neural network is essentially not an algorithm. It is a system for the AI calculations to chip away at to process complex information inputs [2]. They figure out how to play out the assignments while handling the issue by considering the precedents as the procedure proceeds onward with no errand explicit tenets. The process takes place without any prior knowledge. They do so by generating characteristics that identify the object at the time of processing.

An artificial neural network is basically a system that consists of components called artificial neurons, which get input, change their inward state (initiation) as indicated by that input, and produce the necessary output upon the information on the input and activation.

As in general, in an ANN the signs between artificial neurons are genuine numbers, and the yield of each neuron is figured by some non-direct capacity of the entirety of its sources of info. The associations between neurons are called 'edges'. Artificial neurons and edges commonly have a weight that alters as learning continues. The weight increments or diminishes the quality of the flag at an association. The flag might contain a threshold such that the signals are sent only if the total of the flag crosses that threshold.

Typically, artificial neurons are accumulated into layers. Distinctive layers may perform various types of changes on their data sources. Signs travel from the primary layer (the information/input layer), to the last layer (the yield/output layer), conceivably in the wake of navigating the layers on numerous occasions as in Figure 1.

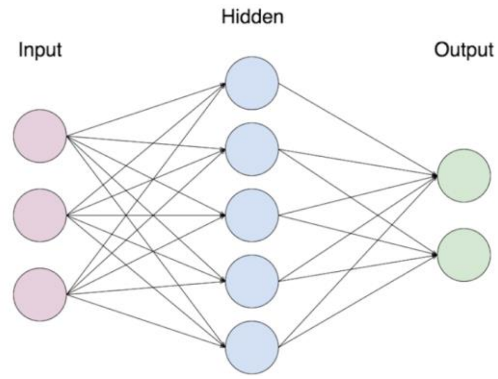

Figure 1- Information flow in ANN

The network is framed by associating the yield of specific neurons to the contribution of different neurons shaping a coordinated, weighted diagram. The weights just as the functions that figure the activities can be adjusted by a procedure called learning which is administered by a learning rule.

The learning rule is a standard or a calculation which changes the parameters of the neural network, all together for an offered contribution to the system to deliver a favoured yield. This learning procedure ordinarily sums to altering the weights and threshold of the factors inside the system.

3.1 Components of Artificial Neural Network

Neurons

A neuron that is labelled as j after receiving an input p_j(t) from antecedent neurons comprises of the accompanying segments:

- an activation a_j(t) representing the state of neuron,
- threshold θ_j, which is usually fixed,
- an activation function f used in the computation of the new activation at a time $t+1$ from a_j(t), θ_j and the p_j(t) which gives the following relation

$$a_j(t+1)=f(a_j(t), p_j(t), \theta_j),$$

- and an output function f_{out}

$$o_j(t) = f_{out}(a_j(t)).$$

Generally, the output function is essentially the Identity function.

Connections, weights and biases

The network comprises of associations (connections), every association exchanging the output of a neuron i to the input of a neuron j. In such a way that input neuron i is the ancestor of output neuron j. Every association is appointed a weight w_{ij}. Now and again an inclination term is added to the all out weighted aggregate of contributions to fill in as a limit to move the activation function.

Propagation function

The propagation registers the contribution to the inputs $p_j(t)$ from the outputs $o_i(t)$ of antecedent neurons and commonly has the structure

$$p_j(t) = \sum_i o_i(t) w_{ij}$$

At the point when a bias is included with the capacity, the above structure changes to

$$p_j(t) = \sum_i o_i(t) w_{ij} + w_{0j}, \quad \text{where } w_{0j} \text{ is a bias.}$$

4. METAHEURISTICS

In software engineering and mathematical optimization, a metaheuristic is a more elevated amount methodology or heuristic intended to discover, create, or select a heuristic (partial search algorithm) that may give an adequately decent answer for an advancement issue, particularly with fragmented or flawed data or constrained calculation limit [5]. Metaheuristics test a lot of arrangements which is too vast to even think about being totally inspected. Metaheuristics in general makes a couple of presumptions about the improvement issue being illuminated, thus they might be usable for a variety of issues.

Contrasted with improvement calculations and iterative techniques, metaheuristics don't ensure that an all around ideal arrangement can be found on some class of problems.[6] Many metaheuristics actualize some type of stochastic advancement, so the arrangement found is reliant on the arrangement of arbitrary factors generated.[5] In combinatorial optimization, via looking over a huge arrangement of possible arrangements, metaheuristics can frequently discover great arrangements with less computational exertion than enhancement calculations, iterative strategies, or basic heuristics.[6] As such, they are helpful methodologies for advancement issues.

Properties

These are properties that describe generally metaheuristics:

- Metaheuristics are systems that direct the hunt (search) procedure.
- The objective is to effectively investigate the hunt space so as to discover near– ideal arrangements.
- Techniques which comprise metaheuristic calculations extend from basic neighbourhood seek techniques to complex learning forms.
- Metaheuristic calculations are rough and more often than not non-deterministic.
- Metaheuristics are not issue explicit.

Types of metaheuristics

There are wide assortments of metaheuristics and various properties as for which to arrange them.

- Local search vs. global search
- Single-solution vs. population-based
- Hybridization and memetic algorithms
- Parallel metaheuristics
- Nature-inspired metaheuristics

Applications

- used for combinatorial advancement in which an ideal arrangement is looked for over a discrete hunt space.
- multidimensional combinatorial issues, incorporating most structure issues in designing which experience the ill effects of the curse of dimensionality.
- Metaheuristics are additionally generally utilized for job shop booking and occupation determination issues.

Heuristics is a path by trial and mistake to create satisfactory answers for a perplexing issue in a sensibly down to earth time. The point is to discover great doable arrangement in an adequate timescale.

Two noteworthy parts of metaheuristic calculations are:

- Intensification
- Diversification

Diversification intends to produce differing arrangements in order to investigate the hunt space on the global scale, while intensification intends to concentrate on the inquiry in a nearby district by using the data that a present decent arrangement is found in this area. The great mix of these two noteworthy parts will for the most part guarantee that the worldwide optimality.

4.1 NATURE-INSPIRED METAHEURISTICS ALGORITHMS

Nature roused metaheuristic calculations are notable efficient methodologies for taking care of a few hard advancement issues. These calculations are roused from explicit qualities of creatures existing in nature and natural marvels.

Nature enlivened metaheuristic calculations can be arranged into four noteworthy divisions:

- Evolution- Based Method
- Physics-Based Method
- Swarm-Based Method and
- Human-Based Method

A portion of the nature-inspired algorithms are as per the following:

- Ant colony optimization
- Ant lion optimizer
- Artificial bee colony algorithm
- Bat algorithm
- Cat swarm optimization
- Cuckoo search algorithm
- Differential evolution
- Firefly algorithm
- Harmony search
- Particle swarm optimization
- Shuffled complex evolution
- Simulated annealing

4.2 PARTICLE SWARM OPTIMISATION

In computational science, particle swarm optimization (PSO) is a strategy that upgrades an issue by iteratively attempting to improve a hopeful arrangement concerning a given proportion of value. It takes care of an issue by having a populace of candidate solutions, particles, and moving these particles around in the pursuit space as indicated by straightforward numerical formulae over the molecule's position and velocity [4].

PSO is instated with a gathering of unpredictable particles (solutions) and then checks for optima by reviving the generations. In each cycle, every particle is refreshed by following two "best" values. The first is the best solution (fitness) it has accomplished up until this point. This value is known to be pbest. The next "best" that's taken is the best value, obtained so distant by any particle within the populace. This best esteem is a global best and called gbest. lbest is chosen as the nearby best value when a particle removes a portion of the populace neighbours.

In the wake of finding the two best values, the particle refreshes it's velocity and position using the equations (a) and (b).

$$v[] = v[\,] + c1 * rand() * (pbest[\,] - present[]) + c2 * rand() * (gbest[\,] - present[\,]) \quad \text{(a)}$$

$$present[\,] = persent[] + v[\,] \quad \text{(b)}$$

$v[]$,the velocity of the particle, $present[]$ the present particle (solution). $rand()$, random number between (0,1). $c1$, $c2$ are the learning factors. Typically $c1 = c2 = 2$

The decision of PSO parameters can largely affect optimizing execution. Choosing PSO parameters that yield great execution has always been the subject of much research.

The PSO parameters can likewise be tuned by utilizing another overlaying analyzer, an idea known as meta-optimization, or even adjusted amid the improvement, e.g., by methods for fuzzy logic [4].

Advantages

- Simple to actualize.
- Just couple of parameters ought to be balanced.

4.3 USE OF METAHEURISTICS IN ORANGE IDENTIFICATION

So as to distinguish the kinds of oranges, a few highlights, for example, texture, colour, shape were recognized. The quantity of highlights range to hundreds. Each object found in the pictures is spoken to by a tuple of 263 qualities, portraying texture, colour, shape and state of the comparing object. This high dimensionality could prompt an issue of over fitting of the classifiers to the test information, known as the "curse of dimensionality". Another critical perspective to consider is the computational proficiency of the procedure, since the count of all the 263 highlights could be a container neck to accomplish continuous preparing.

Consequently, a few creators have proposed distinctive ways to deal with selecting the best highlights from a lot of accessible factors. The fundamental rule of these strategies is a blend of artificial neural networks (ANN) and a nature-inspired metaheuristic algorithm. The motivation behind the ANN is to give a classifier to the information tuples, which comprises in an established multilayer perception (MLP). The job of the second calculation is to control the progressive executions of the ANN, in an iterative way, until the ideal parameters of the system are chosen. The metaheuristic calculations were utilized in the investigations, offering ascend to half breed highlight determination approaches. Here we use Particle Swarm Optimization to train the neural network.

4.4 ARTIFICIAL NEURAL NETWORK – PARTICLE SWARM OPTIMISATION

Classification is the last stage in typical computer vision systems, such as those intended for fruit variety recognition. A set of tuple of features is given as input, the classifier is to predict the most likely class to which the given input tuple belongs to. In order to perform the task, the available data are divided and grouped into training and testing groups. The first part is used in training of the classifier, while the later is used to evaluate it's precision. In these cases, 60% of the samples of the three classes are randomly selected for the process of training and validation, and the remaining 40% of the samples are included in the testing group.

The basic classifier in the proposed framework is a MLP neural network. MLPs are characterized by a progression of parameters which decide the type of the system: number of layers; number of neurons in each layer; transfer function in each layer; back-proliferation training sequence; and back propogation weight/inclination learning function. It is notable that proper tuning of these parameters can fundamentally influence the precision of the technique. To the component selection procedure, a hybrid approach is proposed to locate the ideal parameters of the MLP. The thought comprises in utilizing a metaheuristic calculation, which executes the MLP with various setups of the parameters.

PSO is a promising strategy to prepare ANN. It is quicker and shows signs of improvement results as a rule. It helps in computing the system loads to locate the best reasonable answer for the given issue. PSO indicates quicker assembly. Particle swarm optimisation's outcomes present systems with great speculation on the informational indexes. Contrasted with evolutionary algorithms, PSO is quicker at drawing near to optima, however it can't adjust its speed step sizes for fine tuning.

5. IMPLEMENTATION

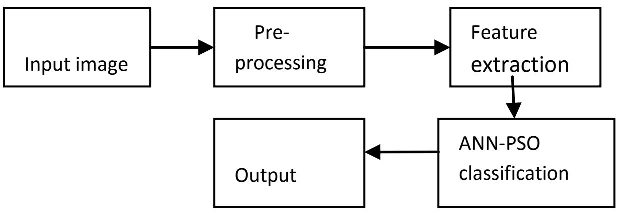

Figure 2 - Block diagram of the proposed method for orange identification.

Figure 2 shows the block diagram of the proposed method for orange identification. A total of 12 input images 4 for each type of oranges are taken. All of the images were captured with high-resolution digital camera with a resolution of 1280 * 960 pixels.

The image is then resized into 256*256 pixels and the resized image is displayed in Figure 3.

Figure 3 - Input images for three types of oranges

The image of the fruit is then segmented from it's background. Thresholding is the least complex technique for segmenting an image and can be used to produce binary image from the gray scale image. The oranges are segregated and have a black background and therefore the segmentation issue is direct.

The shape of object is characterized by their boundaries which are nothing but linked edges. Boundaries are used in the computation of the geometrical features such as size or orientation of the image. Here, sobel operator is used to perform the edge detection operation. After edge detection, binary representation is used to differentiate the image and it's background. Morphological operations were applied to clean small noise areas and refine the shape of the objects. For this open and close operators were used and the image thus obtained is displayed in Figure 4.

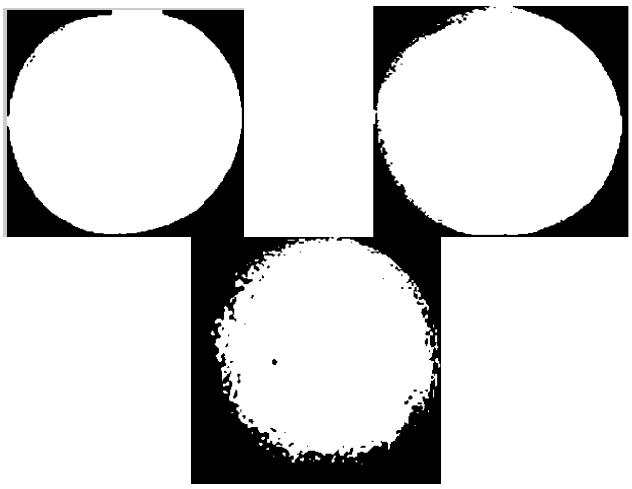

Figure 4 - Binary output of the oranges after edge detection.

Feature extraction assumes a major role in computer vision algorithms, in light of the fact that a bigger quantities of them builds the likelihood of discovering highlights that differences the diverse existing classes. For this reason, 263 features of three types have been found and taken into account. Some of the features are contrast, correlation, energy, entropy, homogeneity, Standard deviation, normalized value, mean and variance. And then, these are fed to the ANN-PSO network in order to identify the given image and the results are shown in Figure 5

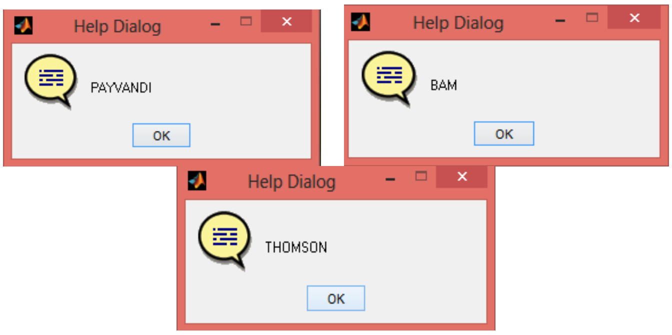

Figure 5 - The results of the identified orange type.

6. CONCLUSIONS

Exact and productive identification of natural products is a fundamental issue in post-gathering processes completed in business manufacturing plants. Programmed acknowledgment of organic product assortments represents an open test, because of the extraordinary comparability's that may exist between them. In this paper, another methodology for perceiving three regular orange assortments has been displayed, exhibiting it's down to earth practicality through a broad arrangement of trials. The proposed framework can be effectively inserted into the handling chain of a nourishment plant. To start with, natural products are fragmented utilizing a satisfactory thresholding in the RGB space and mathematical morphology operators, accomplishing an exceptionally exact discovery of the oranges.

The incredible preferred standpoint of the proposed methodology is that it tends to be specifically applied to different organic products, varieties and properties, since the choice of highlights and the setup of the system are naturally performed by metaheuristic calculations.

7. FUTURE WORK

Different AI and soft computing strategies are to be utilized for natural product arrangement and deformity discovery to give better quality item at the customer end for future work centers around the advances in programmed organic product characterization utilizing soft computing. The present system cannot classify overlapped images of objects. Hence, in future, the system should be upgraded to identify overlapped objects.

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