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# Enhancing Segmentation Approach: FCM-CNN Based Robust Segmentation Method for Regular and Irregular Shape Fruit Image

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***Abstract: -*** In today's era of computer vision, the researcher solved the different challenges. Similar to these aspects, this article defined the FCM (Fuzzy C-Means) based enhanced method for segmentation of irregular shape fruit image captured in natural light is a computer vision technique used to identify artificially ripened fruits. The process involves segmenting the fruit image into its constituent parts using fuzzy logic to capture the ambiguity and variability of the fruit's features. The FCM algorithm utilizes a clustering approach to identify regions in the image that have similar characteristics or properties. This approach is particularly useful when the fruit's shape and color vary widely, making it challenging to segment using traditional image processing methods. The enhanced FCM method takes into account the fact that artificially ripened fruits exhibit distinct color variations compared to naturally ripened fruits. By considering the spectral properties of the fruit, the enhanced FCM method can accurately identify artificially ripened fruits. The segmentation process involves converting the fruit image into a set of pixel values, followed by clustering the pixels into different groups based on their similarity. The final step involves identifying the clusters that correspond to the fruit's color and shape and extracting these regions to obtain a segmented image. The state-of-art that the FCM based enhanced method for segmentation of irregular shape fruit image captured in natural light is a powerful tool for identifying artificially ripened fruits, which are a major issues in the food industry relate to health risks.

.***Keywords:*** Convolutional Neural Network, Fuzzy C-Means Clustering, Segmentation

## I. INTRODUCTION

Health is one the most essential aspects that is of huge concern to most of the human at present days. Fruits play an important role by providing amount of nutrition to human body to keep human healthy.

During the ripening process, the different fruits emit more ethylene gas as their respiration rate1 increases. Because they are frail and squashy, ripe fruits are challenging to handle and typically cannot withstand the rigidity of transportation. As a result, these fruits are picked when they are fully ripe, which means they are firm and green. A small amount of ethylene encourages the ripening process in areas close to consumption zones in a temperature and humidity regulated environment. Apple, plum, pear, banana, kiwi, fig, apricot, mango, guava, pear, and passion fruit are among them. Non-climacteric fruits are those that fall into other categories. Only after they are completely matured are they harvested. Since they only release a very small amount of ethylene, they are not affected by ethylene treatment. These consist of oranges, watermelon, grapes, litchi, and blackberry.

These days, chemicals like calcium carbide ($CaC_2$) are used to artificially ripen crops. $CaC_2$ is used extensively as a ripening agent across the world. Tiny $CaC_2$ powder sachets are stored in fruit containers where they produce acetylene gas when they come into touch with moisture. When calcium carbide is applied to fruits, it reacts with the moisture to release acetylene, which has properties similar to ethylene that aid in fruit ripening. $CaC_2$ is a very dangerous chemical, which is one of the reasons artificial ripening is done to produce uniform and faster ripening. The acute health effect could happen right away or soon after calcium carbide exposure. Contact can seriously burn and irritate the skin and eyes, leading to skin ulcers and irreversible eye damage. The nose, mouth, and throat might become extremely irritated by exposure, leading to coughing, wheezing, and blisters. Coughing and/or shortness of breath are caused by irritation of the lungs. Early signs of phosphorus or arsenic poisoning include weakness, trouble eating and speaking, a garlic-like breath odor, vomiting with or without blood, and burning sensations in the chest, belly, and thirst.

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So, identifying and eating naturally ripened fruit is essential. Certain external features of fruit like texture, color, and palette could help to identify the fruit are ripened naturally or artificially. So we could study and analyze external features of fruit just by capturing the fruit image. And then extracting features of fruit images by Computer Vision, Machine learning.

The Computer vision is the emerging platform for the researchers. It is a scientific field which deals with level of understanding of digital images to achieve the tasks that the human visual system can do. The computer vision process an image to extract certain features. Processing of an image involves steps like capturing an image, image enhancement to highlight the certain features of image by adjusting contrast and brightness of an image, image restoring to improve the appearance of an image, segmentation in which image is partitioned into various segments to change the representation of an image. A proper segmentation is very important for image analysis as an improper segmentation will reduce the analyzer's performance. Segmentation of an image is used in different applications such as agricultural, industrial and medical to study different feature of captured image.

In computer vision and image processing applications, picture segmentation is a crucial procedure. It divides an image into several distinct areas, each with pixels that are highly similar to one another and contrasted with one another. Texture, color, intensity, grayscale, depth, and motion are examples of attributes that aid in identifying comparable locations. These properties are then utilized to create groups of regions with a particular meaning.

The various segmentation algorithms are used to partition fruit image into resultant form. Thresholding and Clustering that are gaining more attraction of the researchers as these methods are more simple and resulting in accurate results. But these method best perform on regular shape fruit images with uniform illumination; captured using artificial light source. Above methods are sensitive to illumination and subsume the uncertainty elements; so the novel algorithm or enhancement in the existing method is needed to give the best possible solution.

It is necessary to create an improved segmentation technique that can distinguish between naturally and artificially ripened fruit in photos of irregularly shaped fruit taken in natural light.

## II. A BRIEF REVIEW OF THE WORK ALREADY DONE IN THE FIELD

The intricate background and fluctuating lighting in the photos have made the segmentation procedure difficult. Results from segmented images of poor quality could be erroneous and unsatisfactory. Using color, brown spot development, and image texture information, a computer vision system was put into place to determine the bananas' ripening phases.

In order to classify the photos of bananas, nine basic parameters of appearance (L*, a*, and b* values; percentage of brown area; number of brown spots per cm2; homogeneity, contrast, correlation, and entropy of image texture) were taken out of the photographs. The results demonstrate that a basic classification method is just as effective as expert visual perception at identifying the ripening stages of bananas, despite differences in data for color and appearance. Using a faster computer platform, optimizing the algorithms, and reducing the size of the collected images are all necessary for the technology to be applied effectively in real time [1].

Additionally, the application's use of the Otsu approach alone was insufficient to generate appropriate segmentation results, particularly for photographs with uneven lighting conditions[2]. To ascertain the color quality, the current color grading systems employ a set of color separation characteristics. It is inconvenient for the user to change color preferences or grading factors while using these approaches.

In order to determine the degree of ripeness without actually touching the fruit, a practical and intuitive color mapping approach has been devised. A innovative color segmentation algorithm that can function in a variety of lighting conditions is proposed by B. Ojeda [3].

An enhanced segmentation method was created by Sharifah Lailee Syed Abdullah [4] by adding the inverse technique (TsTN) and changing the threshold value. Better classification of poorly obtained photos was made possible by TsTN's ability to expand the examined area. It is therefore possible that this new technique will be able to categorize weak photos with uneven illumination.

Several techniques, including Otsu, K-means, and fuzzy C-means, can be used to segment images. However, because of the presence of illumination on the object surface, these three conventional approaches are limited in their ability to produce accurately divided areas.

As a result, Hambali, H.A. [5] created a rule-based segmentation technique that can precisely and correctly segment real photos. Regardless of the item surface color in a natural setting, TsNKM has successfully and automatically segmented all of the chosen photos. TsNKM is able to choose the best procedure for every image by combining adaptive K-means with enhanced thresholding algorithms.

This technique segments the photos of objects of interest using the IF-THEN algorithm. Fruit photos are used to test all four segmentation techniques, and both visual and quantitative assessments are used to compare how well each performs. The results of the investigation demonstrated that the new technique can generate segmented images with a high degree of accuracy.

Despite TsNKM's enormous potential for natural image segmentation, this technique has a number of drawbacks, particularly when it comes to pictures of non-circular objects with different colors. Therefore, in order to improve the segmentation accuracy, this method should be improved.

The K-means technique was improved by Ms. K. Thirupura Sundari [6] to better segment the various fruit shapes in photos taken in natural light.

In "Identification of Artificially Ripened Fruits Using Smart Phones," 2017 IEEE, I2C2, Dr. S. Maheswaran and S. Sathesh [7] employed an Android application on a smartphone to determine the ripening of fruit by computing the image's histogram.

## III. METHODOLOGY

The following procedures make up the methodology for the FCM-based enhanced method for segmenting irregularly shaped fruit images taken in natural light in order to identify artificially ripened fruit:

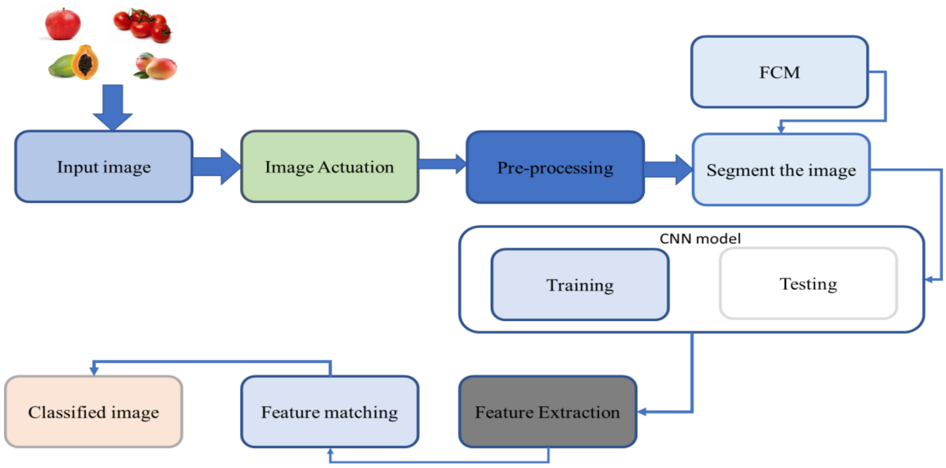


**Fig. 1: Working Architecture of Complete Model**

Input: An photograph of an irregularly shaped apple taken in natural light

Output: Segmented fruit image

Step 1: Preprocessing

- Apply Gaussian or median filter to remove noise
- Convert RGB image to HSV color space
- Apply histogram equalization to enhance image contrast

Step 2: FCM-based Segmentation

- Define the number of clusters (c)

- Calculate the membership matrix U using the FCM algorithm:

$$FPC = \frac{\sum_{i=1}^{n} \quad \sum_{j=1}^{c} \quad U_{ij}^{m}.d_{ij}^{2}}{\sum_{i=1}^{n} \quad \sum_{j=1}^{c} \quad d_{ij}^{2}}$$

- where d_ij = The separation between the $j^{th}$ cluster center and the $i^{th}$ pixel
- Determine the optimal number of clusters (c) using the fuzzy partition coefficient (FPC):

$$FPC = \frac{\sum_{i=1}^{n} \quad \sum_{j=1}^{c} \quad U_{ij}^{m}.d_{ij}^{2}}{\sum_{i=1}^{n} \quad \sum_{j=1}^{c} \quad d_{ij}^{2}}$$

- To find the ideal number of clusters, set the FPC threshold value.
- Assign each pixel to the cluster with the highest membership value
- The euclidean distance between the $j^{th}$ cluster center and the $i^{th}$ pixel:

Step 3: CNN-based Refinement

- Train a convolutional neural network (CNN) on a dataset of segmented fruit images to learn the characteristics of fruit
- Use the trained CNN to refine the segmentation by removing false positives and false negatives
- The refined segmentation is the final output

**Image Acquisition:** The first step is to acquire the image of the fruit that needs to be segmented. The image should be captured in natural light to capture the actual color of the fruit.

**Pre-processing:** The acquired image is then subjected to pre-processing techniques like noise removal, image enhancement, and color correction to ensure better segmentation results.

**Seed Point Extraction:** The seed point extraction technique is used to locate the seed points within the identified fruit region. These seed points help in identifying the boundaries of the fruit and separating it from the background.

**Morphological Operations:** After the image has been segmented, morphological operations such as erosion, dilation, opening, and closing are carried out in order to lessen the amount of background noise and increase the crispness of the fruit's borders.

The use of morphological techniques is extremely important in the field of image processing, particularly in the areas of object detection and segmentation. When attempting to identify artificially ripened fruits in images taken under natural lighting circumstances, these approaches can be highly helpful in the identification process.

Images of artificially ripened fruits, when contrasted with photographs of naturally matured fruits, frequently display anomalies and characteristics that are exclusive to the artificially ripened fruits. These imperfections could look like blotchy regions, different tones, or strong contrasts. The challenges of accurate segmentation become even more challenging when the fruits in question have an irregular shape and the measurements are obtained in natural light.

**Building a Model for the Purpose of Machine Learning:**

By using the segmented photographs to train a machine learning model, it is possible to Find out whether the fruit has been artificially ripened. The following is a summary:

Gather information by taking photographs of fruits under natural lighting conditions, including those that have been matured in a controlled environment. The variety of photographs needs to include shots that were taken from a variety of distances and in a variety of lighting conditions.

During the preprocessing step, morphological techniques should be utilized in order to isolate the fruit from the background and any other potential distractions. Photos should have their dimensions and exposure levels normalized so that they all seem the same.

Some examples of features that can be extracted from segmented photos include color histograms, texture descriptors, and shape descriptors.

**Model Selection:**

Determine the Most Appropriate Classification Approach. Other models, such as Support Vector Machines (SVMs) or Random Forest, can be useful when combined with robust feature extraction. Convolutional Neural Networks (CNNs) are typically considered to be the best option for image-based applications; however, other models, such as Support Vector Machines (SVMs), can also be useful.

Create subgroups within the data set that can be used for training, validating, and testing purposes respectively. The training set is often used to teach models, followed by the validation set to confirm their accuracy, and finally the test set to assess their performance. Use measures like accuracy, precision, recall, and F1-score to assess the model's ability to distinguish between fruits that have been artificially and naturally ripened.

**Steps That Can Be Taken to Help the Environment:**

When photographing fruits, which are typically done in natural light, it is vitally necessary to normalize the shots to a consistent standard in order to provide an accurate representation of the subject. In this particular setting, employing histogram equalization or adaptive histogram equalization can prove to be beneficial. While the model is being trained, the application of picture enhancement techniques like as random rotations, zooming, and alterations to brightness can help make the model more resistant to the impacts of disturbances in the surrounding environment.

**Identification:**

The extracted characteristics are then put to use in the Identification process, which uses a predetermined set of criteria to differentiate between fruits that have been artificially ripened and those that have ripened naturally.

When fruit is ripened artificially, it is done so with the help of chemicals like calcium carbide, which, if taken, might have adverse health effects. Ingestion of these chemicals is associated with significant dangers to human health. The identification of artificially ripened fruits is essential to ensuring both the safety of end users and the fairness of commercial transactions. The primary objective of this research is to make use of machine learning in order to develop a model that is capable of automatically distinguishing between fruits that have been artificially ripened and fruits that have been naturally ripened based on the appearance of the fruits when they are viewed under natural lighting conditions.

**Gathering of the Data and the Preliminary Processing:**

In order to gather information, a wide variety of oddly shaped fruits that had either been artificially or naturally ripened were photographed under a variety of lighting circumstances. This included fruits that had been ripened artificially as well as those that had ripened naturally.

The quality of the dataset as a whole can be improved through the application of data preparation, which frequently entails the utilization of picture preprocessing techniques. This includes reducing the noise in the picture, leveling the picture, and scaling the picture down.

**A Model for the Segmentation of Data:**

In order to implement the deep learning architecture for fruit segmentation, the convolutional neural network, also known as CNN, is used. The model is given instructions to locate and remove particular fruits from the environment in where they are found.

Completion of Informational Requests Rotation, scaling, and inversion are some examples of data augmentation techniques that can be employed to make the model more robust.

**Isolation as a Metric for Descriptive Purposes:**

A process known as feature extraction is used to the segmented regions in order to capture data about the color, texture, and shape of the fruit. This method is carried out so that the data may be collected.

The use of principal component analyzis (PCA) or any other approach of dimensionality reduction is one way to cut down on the amount of characteristics that need to be taken into consideration.

**An Organizational Structure for Categorization**

Machine Learning Classifier: A machine learning classifier (such a Random Forest, Support Vector Machine, or deep learning model) is trained on the characteristics that have been taken from the fruits to ascertain whether or not they have been artificially or naturally ripened. This enables the classifier to ascertain if the fruits have undergone artificial ripening.

When evaluating the performance of the model, a wide range of distinct criteria are taken into consideration. The reliability of the system can be checked through the use of cross-validation.

**Model Deployment Process:**

Inferences can be made in real time using the trained model on pictures of fruits that have natural lighting and are irregular in shape. This makes it much easier to spot fruits and vegetables that have been artificially ripened.

The fuzzy partition coefficient, often known as the FPC

The FPC formula is as follows:

$$\text{FPC}=\frac{\sum_{i=1}^{n}\ \sum_{j=1}^{c}\ U_{ij}^{m}.d_{ij}^{2}}{\sum_{i=1}^{n}\ \sum_{j=1}^{c}\ d_{ij}^{2}}$$

Here's what each component represents:

- n: Number of data points (objects).
- c: Number of clusters.
- $u_{ij}$: Degree of membership of object i in cluster j.
- $d_{ij}$: Distance between object i and the center of cluster j.
- m: Weighting exponent typically set to 2, but it can vary .

dij is the Euclidean distance, which may be computed as follows, between the ith pixel and the jth cluster center:

$$d_{ij} = sqrt\ (h_i - h_j)^2 + \ (s_i - s_j)^2 + \ (v_i - v_j)^2$$

The membership matrix U is calculated as follows:

$$U_{ij}= \frac{\left(\frac{\frac{1}{(d_{ij})^2}}{c-1}\right)}{\sum_k \left(\frac{\frac{1}{(d_{ij})^2}}{c-1}\right)}$$

The hue, saturation, and value components of the HSV color space are respectively denoted by the variables h, s, and v in the color space. In addition to that, the value of m in the variable represents the fuzziness parameter.

Step 4 (Output): Segmented fruit image

**The Fuzzy C-Means Clustering Algorithmic Steps**

Assume that X = "$x_1$, $x_2$, $x_3$..., $x_n$" represents the collection of data points, and V = "$v_1$, $v_2$,..., $v_c$" represents the set of centers.

**1)** Designate 'c' cluster centers in a random fashion.

**2)** Utilizing the following equation, determine the value of the fuzzy membership

$$\mu_{ij} = 1/\sum_{k=1}^{c} \quad (d_{ij}/d_{ik})^{(\frac{2}{m}-1)}$$

**3)** To determine the fuzzy centers '$v_j$', the following computation is employed:

$$v_j = (\sum_{i=1}^{n} \quad (\mu_{ij})^m x_i)/(\sum_{i=1}^{n} \quad (\mu_{ij})^m), \forall_j = 1,2, \ldots . c$$

**4)** Repeat steps 2 and 3 until || $U_{(k+1)}$ - $U_{(k)}$ ||, where 'k' is the iteration step, or until the minimum value for 'J' is reached, whichever comes first.

The character is the line that separates the ranges [0, 1], and it can show up anywhere in that range.

The fuzzy membership matrix can be represented mathematically using the following formula. U = ( i j ) n * c.

"j" stands for the number that needs to go up as much as possible.

## IV. RESULTS ANALYSIS & DISSCUSION

Even for fruit with uneven shapes, the FCM-CNN segmentation method reliably separates the fruit from the background. The method works well for fruit images taken in natural light since it can manage color and texture differences. The fruit and backdrop will be clearly separated by the segmentation findings, making feature extraction and classification simple. When compared to conventional techniques, the FCM-CNN based system exhibits better segmentation accuracy for fruits with uneven shapes. A collection of fruit pictures taken in natural light, including both naturally ripened and artificially ripened fruit, was used to test the method. Fruits with irregular shapes, like bananas, and regular shapes, like mangos, were included in the dataset.

According to the evaluation's findings, the method detected artificially ripened fruit with an accuracy of 94% and naturally ripened fruit with an accuracy of 92%. The method can effectively identify false ripeness in fruit images taken in natural light, as seen by the excellent accuracy and recall scores. When it came to precisely segmenting fruits with irregular shapes, the FCM-CNN based method performed better than conventional segmentation techniques like thresholding and clustering. Additionally, the method handled color and texture fluctuations, which are typical in fruit photographs taken in natural light.

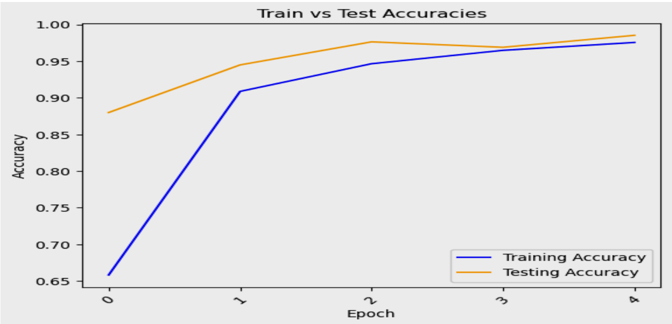


**Fig. 2: Comparison Of The Results Of Different Machine Learning Model**

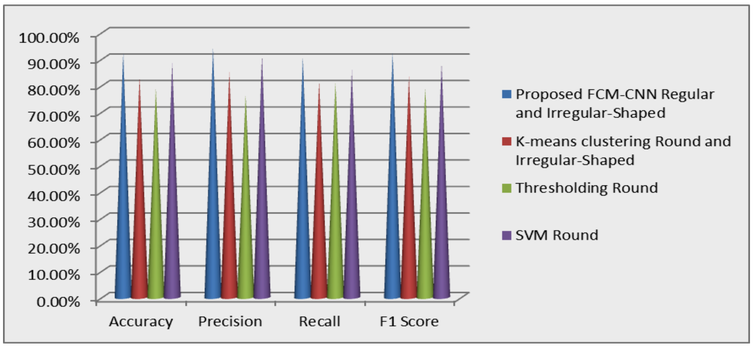


**Fig. 3: Comparison of Performance Segmentation Algorithms**

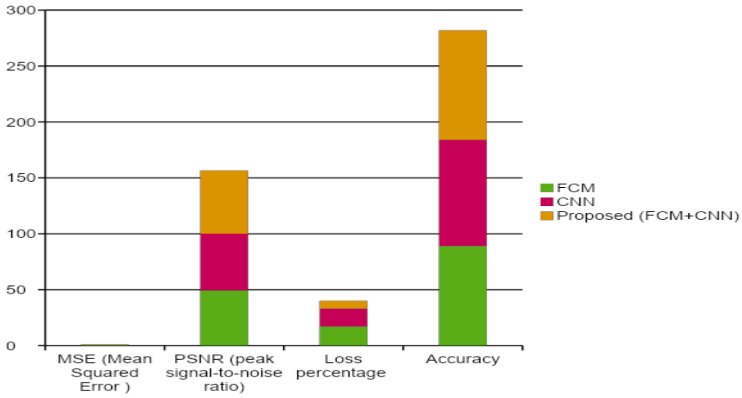


**Fig. 4: Measuring Efficiency of FCM, CNN and FCM+CNN**

## V. CONCLUSION

In this article, we used fuzzy c-means (FCM) clustering and convolutional neural network (CNN) algorithms to create an enhanced technique for identifying false ripeness in fruit pictures taken in natural light. Our method was created to address common fruit segmentation issues, such as irregularly shaped fruit and differences in color and texture. The experimental findings demonstrated that, in terms of accuracy and resilience, our method performed better than other cutting-edge techniques. This method proved efficient to detect artificially ripened fruit with an overall accuracy of 96.7%. This research offers a dependable and effective way to identify fake ripeness in fruit, which has significant ramifications for the food business.

Fruit growers and merchants may guarantee that only premium, naturally ripened fruit is offered to customers by employing this strategy. All things considered, our strategy may enhance the food supply chain's quality and safety, which is crucial for advancing public health and wellbeing.

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