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## Shape Feature Extraction Techniques for Fruits: A Review

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### Abstract

Fruits sorting, recognizing, and classifying are essential post-harvest operations, as they contribute to the quality of food industry, thereby increasing the exported quantity of food. Today, an automated system for fruit classification and recognition is very important, especially when exporting to markets where quality of fruit must be high. In this study, the advantages and disadvantages of the various shape-based feature extraction algorithms and technologies that are used in sorting, classifying, and grading of fruits, as well as fruits quality estimation, are discussed in order to provide a good understanding of the use of shape-based feature extraction techniques.

**Keywords:** Fruits, Shape Features, Classification, Feature Extraction.

### تقنيات استخراج ميزات الاشكال للفواكه: مراجعة

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### الخلاصة:

يعتبر فرز الثمار، التعرف عليها وتصنيفها من العمليات الأساسية لما بعد الحصاد، لأنها تساهم في جودة صناعة الأغذية، وبالتالي زيادة كمية الصادرات. اليوم، يعد النظام الآلي لتصنيف الفاكهة والتعرف عليها مهماً للغاية خاصة عند التصدير إلى السوق حيث يجب أن تكون جودة الفاكهة عالية. في هذه الدراسة، تمت مناقشة مزايا وعيوب خوارزميات وتقنيات استخراج الخصائص المختلفة بالاعتماد على الشكل والتي تستخدم في فرز الفواكه وتصنيفها بالإضافة إلى تقدير جودة الثمار من أجل توفير فهم جيد لاستخدام الخصائص التي تعتمد على الشكل.

### 1. Introduction

Fruits are one of the main sources of vitamins, fibers, minerals, and energy. Humans rely on fruits as a source of healthy food that is free of fat, particularly cholesterol. Fruits vary in their colors, shapes, sizes, and number of petals. Farmers use different fruit attributes to identify fruit species. Fruit classification is quite a difficult and challenging process because the same kind of fruit may be varying from a country to another. Thus, fruit species identification is often time consuming, repetitive, tiresome, and tedious. Due to that, automated species classification is becoming one of the most important processes, especially in fruit sorting and grading and, hence, in food industry. Classification

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systems contain databases that are used to compare new objects with the predefined ones. Fruit classification is a complex and challenging process because the climatic factors (extreme heat and humidity) and poor storage may change the shape of the fruit and thus negatively affect the fruit classification process. The shape of an object is an important guide to identify objects by eyes in real-world. Object's shape is a significant feature for object representation. A sufficient shape features should be invariant to rotation, scaling, translation, and reflection [1]. Shape is the most paramount parameter to select high quality fruits. Fresh fruits have incontrovertible shape features. Thus, fruit's damage or infection causes changes in shape. Thus, the irregularity of fruit shape can be used as a quality measure. Graphical data that are extracted using shape features play an important role in automated fruit grading [2-3].

## 2. Fruit Shape-Based Feature Extraction Techniques

Any object has its own characteristics or features which are key factors in object recognition and classification. Features can be extraction using different techniques, such as:

A. Wavelet transform: this is a successful method that uses a set of wavelets (basic function). It decomposes an image without the need of large storage space. An image is decomposed in 4-sub bands "LL","HH","LH" and "HL". Wavelets are widely applied to image compression, signal denoising, fractal analysis, and image smoothing. Wavelets technique has loss of generality and difficulty in designing filters. It also provides a good accuracy on fruit grading [4].

B. Fourier Transform: this is a technique that is used to convert digital data into its component frequencies. It is used for signing the encoded object. One- dimensional Fourier transform is applied to an object's boundaries in order to derive its signature. Two-dimensional Fourier transform is applied to the region(area of the object). The Fourier descriptors can extract global object features. It is easy to implement and represents objects' boundaries independently of their size, location, and orientation. Nevertheless, it doesn't provide local information of shape and the sharp irregularities of object's boundaries are not competently captured by Fourier analysis [5].

C. Scale-space: this is a rich representation technique of object's boundaries. It deals with object's structure at various scales. It is a useful tool for describing significant shape features. Low-pass Gaussian filters, which have variable widths, are used to track the position of deviation points. The remainder deviation points after the filtering process are the relevant object features [6]. Scale-space is robustness to noise but has computational complexity; local features for deformable shapes can be extracted using an effective method, as described previously [7].

D. Chain code: this is an effective algorithm that is used to encode curves. In the chain code, a set of connected components can be represented in a specified direction, based on 4 or 8 segments' connectivity. This representation must preserve the morphological and topological information [8-9]. Characters and digits can be recognized successfully by using the chain code technique, which provides compact encoding of any object's boundary and translation invariant. Chain code technique reduces storage volume but is not invariant to rotation, being also sensitive to noise and loss of generality [10].

E. Fractal dimension calculation: this is a technique that can describe complex objects and irregular shapes that classical geometry methods fail to analyze. Fractal dimension is the best for capturing boundaries of irregular objects like fruits [11]. The best application of fractal dimension is in medical images, which are very complex and have different sizes and irregular shapes [12]. Selecting the fractal dimension calculation method of an image requires more attention, since the large number of boxes provides less accuracy than that of small boxes. An appropriate method of this type was described in an earlier work [13].

F. Convex hull: Objects can be represented by the convex hull method, which extracts a series of pixels included in the smallest convex area that encircles all white pixels in a digital image. For two shape circumference points, the straight line between these two points has to drop entirely within the surface curve [14].

G. Moments estimator method: A significant features can be extracted using the moments method, which is used to estimate inhabitant parameters. It is widely used to obtain relevant information about object's shape. The moments method is often simpler than the other methods [15].

## 3. Techniques Comparison

In this section various studies based on fruit's shape features are discussed and shown in Table -1.

**Table 1-**Comparison of studies based on fruit's shape features extraction techniques

Crop	Aim of study	Technique	Accuracy	Ref. No.
apple	classification	Fourier transform method	96.9%	[16]
tomato	grading	fractal, chaos and neural networks	-----	[17]
grape	detection	the zernike moments and support vector machine	99%	[18]
apple	identification and classification	the boundary of fruit is described by selecting the best marking points (36 points)	95%	[19]
apple	detecting the contour of the fruit	chain code technique; the method provided high processing speed, low storage space, and high accuracy	-----	[20]
papaya	classification	wavelets method is used to extract features as inputs for classification process	98%	[21]
apple	surface defect detection and grading	fractal dimension, an improved "box dimension" detection is used to calculate the fractal dimension of fruit, the results showed that the algorithm was effective and reliable in fruit defect identification	-----	[22]
apple	detection of surface defects	shape feature extracted, k-nearest neighbor classifier is used	85%	[23]
apple	recognition	fourier and multi fractal dimension were used, the recognition rate was the highest compared to other methods	-----	[24]
yellow bananas, granny smith apples, rome apples, tangerines, green plantains,	classification	a proposed approach for fruits classification based on wavelets	89.5%.	[25]

hass avocados, watermelons, cantaloupes, gold pineapples, passion fruits, bosc pears, anjou pears, green grapes, red grapes, black grapes, blackberries, strawberries, blueberries.				
apple, banana, cucumber, lemon, mango, tomato, strawberry	recognition and classification	convex polygon, shape signature: contour curvature, area function, height, width, bounding box	95.24%	[26]
apple, lemon, and orange	classification	needlman-wunsch algorithm used to compute shape association	82.96%	[27]
15 classes of fruits	recognition and classification	fractal dimension	97.78% to 100%	[28]
straw berry	classification	four descriptors are used: length of contour line, length of straw berry, code subtraction and the area, their method has flexibility and robustness	-----	[29]
Kiwi fruit	estimation	shape signature: contour curvature, area function, fruit length	98.3%	[30]

In Table -2, the advantages and disadvantages of fruit's shape features extraction techniques are listed.

**Table 2-** The advantages and disadvantages of features extraction techniques.

Techniques	Advantages	Disadvantages
Wavelet transform	provides a good accuracy	loss of generality and difficult in designing filters
Fourier transform	easy to implement, can represent objects boundary independently of their size, location and orientation	doesn't provide local information of shape, sharp irregularities of object's boundary
Scale-space	• robustness to noise	has computational complexity
Chain code	• reduced storage capacity	not invariant to rotation and very sensitive to noise, loss of majority
Fractal	• can deal with	do not uniquely define patterns,

	irregularity and roughness of shapes	has computational complexity
Convex hull	extremely simple and easy to implement	is not based on environmental elements to predict types occurrence, increased bias causes an increased number of eventuality
Moments methods	simple, can be performed by hand, the estimators of this technique are consistent	inefficient, sometimes fails to extract all important information of the sample, the parameter estimates may be inaccurate, more frequent with smaller than large samples

## 5. Conclusions

This paper reviewed the various techniques that are used to extract fruit features. Shape-based feature extraction approaches that are used in fruit classification, grading, and estimating of fruit quality are explained and described. Important techniques are explained which are Fourier transform, scale technique, chain code technique, wavelets transform (one and two dimensional), the moments, convex hull, and fractal-dimension. From these approaches, the chain code method was found to be the most suitable in classify fruit sub-categories. Fractal dimension method can provide a good measure of a fruit shape's complexity.

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