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Evaluation of Segmentation Algorithms for Apple Fruit Grading

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Abstract: ***In recent years, wide range of image segmentation applications are present in agriculture, industry, military and medical fields. Fruit grading system is one of them. Fruit grading technique will grade the fruits using their shapes, color and outer look. This emphasizes the necessity of image segmentation which extracts important features from an image. This paper consist of analysis of different segmentation algorithms for detecting damage part of fruit. Marker based watershed algorithm uses powerful morphological tool to extract region of interest from an image. Quadtree and merge algorithm divides an image within a complete tree representation and then merge the regions based on some criteria. Seed region growing algorithm selects the seed point and grows the region according to pre-defined criteria. The comparison of the present approach in terms of the measures like energy, discrete entropy, relative entropy, mutual information, normalized mutual information and redundancy is also carried out.***

Keywords: Fruit grading, Image segmentation, Marker based watershed algorithm, Quadtree and merge algorithm, Seed region growing algorithm.

1. Introduction

In recent years, in order to free the employees from the tedious work of grading fruits, many scientists work hard on the computer with powerful data processing capability, trying to make initial screening from a large number of fruits, so that employees can focus on those suspected fruits, and make timely diagnosis[4]. Image segmentation plays an important role in computer vision and image analysis. It has big range of applications in industry, agriculture, medical, military and other fields [5]. People are interested in particular parts of the image in the research and application of the image. These parts are called as target or foreground (other part is known as background), they generally referred to an image in a particular and unique nature of the area. It is necessary to identify and analyze the objects in order to separate them. Watershed can be widely applied to various types of image segmentation tasks because of its high processing speed and high accuracy in finding the weak edges of neighbouring regions. But, the traditional watershed segmentation is prone to noise, causes serious Over segmentation [3]. In order to come over this problem, the marker-controlled watershed algorithm which uses morphological opening-closing and reconstruction is implemented [9].

The quadtree segmentation uses region splitting tool. Region splitting tool divides complete image into smaller quadrants based on some pre-defined criteria[6].But quadtree may causes Over segmentation so merging is applied to eliminate this problem. Seed region growing (SRG) is an image segmentation process which start with a set of "seed" pixels and adds the neighbouring pixels which has the similar properties with the seed pixels to form the region [9]. The different parameters used for performance evaluation of all above mentioned algorithms are energy, discrete entropy, relative entropy, mutual information, normalized mutual information and redundancy [9].

2. Marker Based Watershed Algorithm

The marker based watershed algorithm uses rainfall based watershed algorithm approach. Rainy water drops fall on the mountain (topographic surface) and move to descending direction because of the gravity until they reach to the local minimum surface. The algorithm tracks the path of water drop for each point on the surface towards the local minimum, if rain drops pass through that point or fall on that point. All points make a segment when water drops related to them flow downwards to the same deepest location.

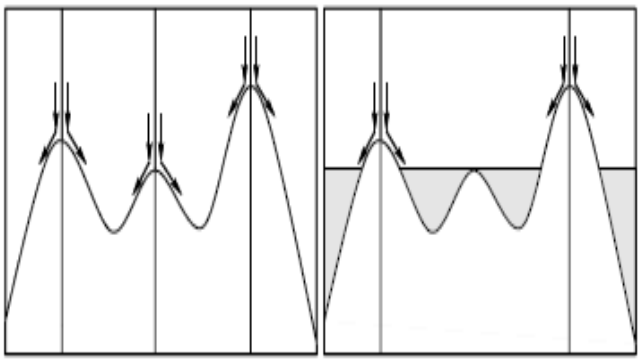

Figure 1: General concept of rainfalling watershed algorithm

A. Image Preprocessing

The original image needs preprocessing before applying it watershed segmentation. Here first grayscale conversion of image is done and then morphological filters are used to enhance the contrast of the image. Here first, opening and closing operations are performed and then using the morphological reconstruction, opening-by-reconstruction operation and closing-by-reconstruction operation are performed to smooth image and eliminate the noise. Compared to simple opening and closing, reconstruction-based opening and closing can restore the original shapes of the objects after erosion or dilation [1].

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B. Markers

An alternative approach to watershed is to imagine the landscape being immersed in a lake with holes pierced in local minima. Basins (also called `catchment basins') will fill up with water starting at these local minima and at points where water coming from different basins would meet, dams are built. When the water level has reached the highest peak in the landscape, the process is stopped. As a result, the landscape is partitioned into regions or basins separated by dams called watershed lines or simply watersheds [11]. Hence, to find out catchment basins and watershed lines, markers are used. A marker finds connected component from an image. Internal and external markers are used to find out region of interest. Internal markers are used to find object of interest and external markers belongs to background.

1) Foreground markers- Foreground markers can be defined as-

- Foreground markers forms region surrounded by higher altitude.
- Points in region form connected components having same intensity [11]. The foreground markers are found out by extracting the local maxima of image. All the pixels in the local maxima form connected components. All connected components are having same intensity and all other remaining pixels are having different values.

2) Background markers- External markers can be defined as-

- Each external marker is having single internal marker and part of background[11].
- To find background markers, image binarisation is done first and then distance transform of foreground marker image is achieved. Hence, binary image is converted to distance map having minimum distance between background and foreground pixels. Finally, background markers are obtained by taking watershed transform of the distance map[1] .

C. Segmentation

The watershed transform can be applied to the gradient magnitude image. The sobel filter is used to find gradient image.It contains a measurement for the variation trend of gray levels. It is better to reflect the variation trend of the image than the original image [12]. The extracted foreground markers and background markers are imposed on the original gradient magnitude image. Finally, the ideal segmentation result is achieved by computing the watershed transform on the modified gradient magnitude image [1].

3. Quadtree & Merge Algorithm

The QT structure divides an image into a complete tree representation using neighbourhood information.

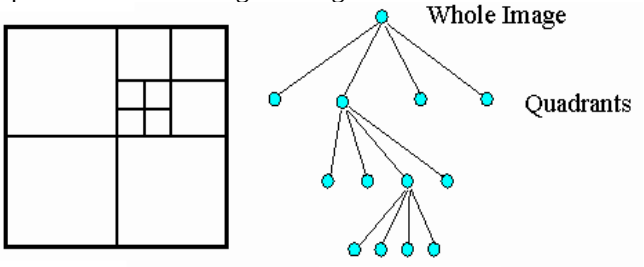

Figure 2: General concept of quadtree algorithm[7]

The quadtree-based segmentation can be summarise as follows-

1) The criteria for image segmentation is defined by setting a threshold and a minimum partition scale.
2) The threshold is used to find if the study region has the same property or not.
3) The maximum difference between pixels in the study area is calculated.
4) If the difference between the pixels is greater than the threshold already defined, indicating measurable difference between the pixels, cross-segmentation is done to divide the regions into four square sized equal parts. Then take each part separately and go to step ii.
5) If the difference between pixels is smaller than the threshold or the size of study region has reached its minimum limit, segmentation is stopped [6].

The merging process is exactly opposite of quadtree process. The merging process starts with initialization of threshold value. Then it checks the regions or quadrants form by quadtree algorithm. If the quadrants satisfy the merging criteria then they are merged else they are left as it is.

4. Seed Region Growing Algorithm

Region growing is a simple region-based image segmentation method. It is also classified as a pixel-based image segmentation method since it involves the selection of initial seed points. This approach to segmentation examines neighboring pixels of initial “seed points” and determines whether the pixel neighbors should be added to the region[2].

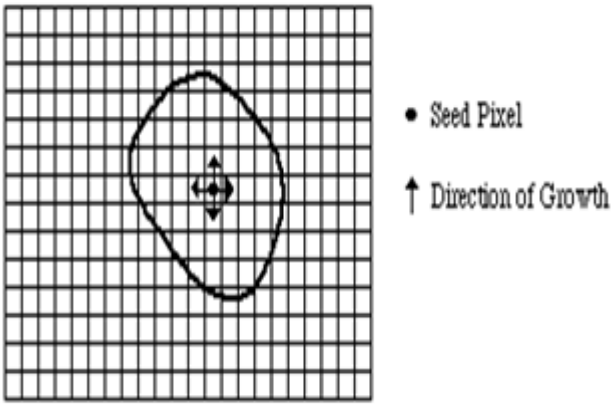

Figure 3: General concept of seed region growing algorithm

The first step in region growing is to select a set of seed points. Seed point selection is based on some user criterion

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(for example, pixels in a certain gray-level range, pixels evenly spaced on a grid, etc.). The initial region begins as the exact location of these seeds. The regions are then grown from these seed points to adjacent points depending on a region membership criterion and then merge the same or similar property of seed points (Based on a pre-determined growing or similar formula to determine) with the seed points around the seed points domain into the domain of seed points. These new pixels as a new seed points to continue the above process until no more pixels that satisfy the condition can be included and then the region growing is stopped[8].

5. Quantitative Assessment

A. Energy

The gray level energy describes the distribution of gray levels. The larger value of energy indicates the lower number of gray levels, which means simple. The smaller energy indicates to the higher number of gray levels, which means complex [9].

B. Discrete Entropy (DE)

The discrete entropy is the amount of information contained in image, which may be described as the average uncertainty of information source. For image processing, the discrete entropy indicates how many bits needed for coding the image data, which is a statistical measure of randomness. The maximal entropy is obtained when all potential outcomes are equal. The minimal entropy occurs which is equal to zero, when the outcome is certainty. The discrete entropy is the representation of the average amount of information conveyed from each individual image. Higher value represents complex algorithm whereas smaller value of discrete entropy gives simplification of algorithm [16].

C. Relative Entropy (RE)

Consider if two discrete probability distributions of the images have the probability functions of p and q. The relative entropy of p considering q can be defined as the summation of all possible states of the system. The smaller values indicate higher similarities between the input and output images[16].

D. Mutual Information (MI)

The term the mutual information can be applied as objective metric. The mutual information gives the mutual dependence between input and output images. The mutual information can be considered as symmetric function which gives measure of symmetricity between two images [9]. The better match between the input and output images, the less value of the mutual information.

E. Normalized Mutual Information (NMI)

The normalized mutual information can be defined as the measure covering contents from both discrete entropies and mutual information. Similar to that of the mutual information, the better match between the input and output images, the smaller the normalized mutual information[16].

F. Redundancy (RD)

Redundancy is the symmetric parameter which is used to indicate redundancy in image segmentation. The redundancy will have its value zero when all variables are dependant [9].The greater dependence between two images, the higher is the value of information redundancy[16].

6. Experimental Results and Evaluation

To test the accuracy of the segmentation algorithms, three steps are followed.

- First, an apple fruit image is taken as input.
- Second, segmentation algorithms are applied for those images to detect damage part.
- Third, the non linear objective assessment is applied for different algorithms for evaluation of images.

1) Image 1-

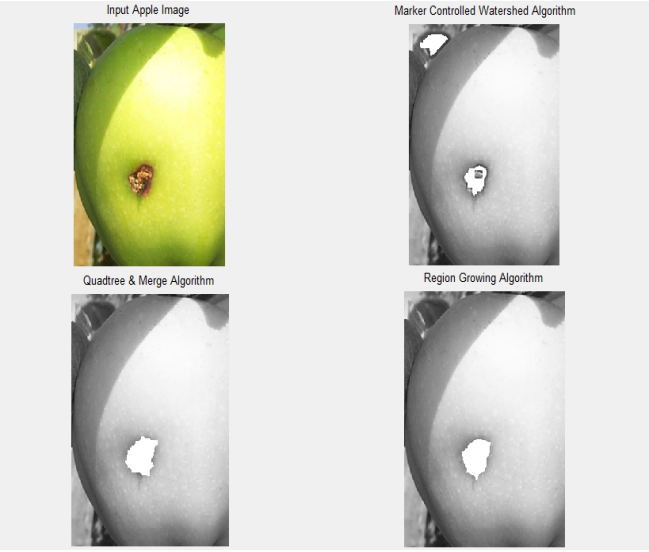

Figure 4: Output of different segmentation algorithms for image1

Quantitative Assessment

Parameter Name	Watershed	Quadtree & Merge	Region Growing
Energy	0.960988	0.958237	0.962487
Discrete Entropy	0.104949	0.108409	0.09976
Relative Entropy	0.611119	0.659743	0.588672
Mutual Information	0.037665	0.019074	0.018107
Normalized Mutual Information	0.037477	0.018310	0.018183
Redundancy	0.004947	0.002502	0.002379

Figure 5: Quantitative assessment for image 1

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2) Image 2-

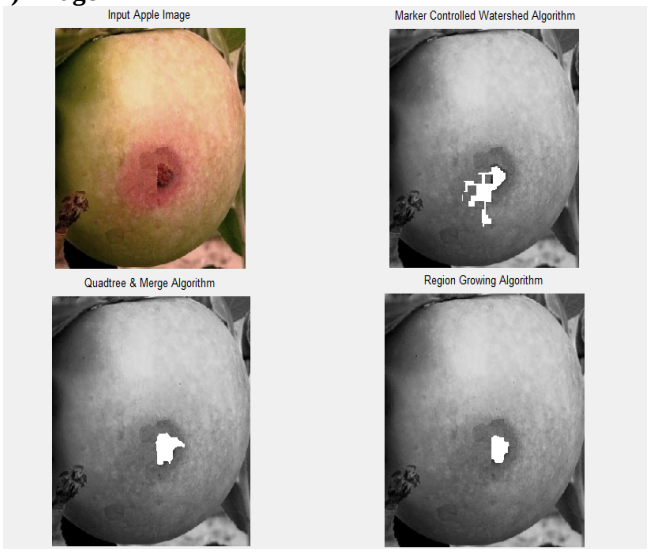

Figure 6: Output of different segmentation algorithms for image 2

Quantitative Assessment

Parameter Name	Watershed	Quadtree & Merge	Region Growing
Energy	0.962885	0.97742	0.98456
Discrete Entropy	0.102501	0.066221	0.048345
Relative Entropy	0.003448	0.001001	0.000958
Mutual Information	0.027895	0.013114	0.011836
Normalized Mutual Information	0.028260	0.016122	0.017075
Redundancy	0.003598	0.001700	0.001539

Figure 7: Quantitative assessment for image 2

3) Image 3-

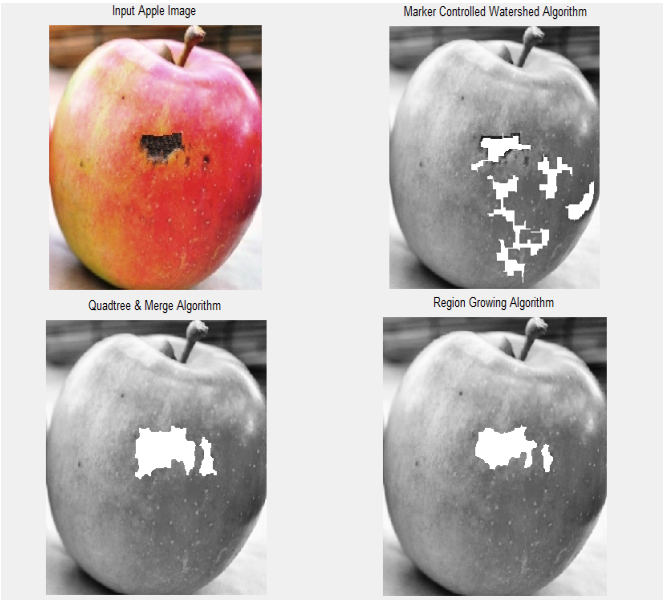

Figure 8: Output of different segmentation algorithms for image 3

Quantitative Assessment

Parameter Name	Watershed	Quadtree & Merge	Region Growing
Energy	0.883065	0.917608	0.938797
Discrete Entropy	0.258947	0.188486	0.149092
Relative Entropy	1.9722	1.35909	0.987498
Mutual Information	0.074066	0.045098	0.040415
Normalized Mutual Information	0.047419	0.032723	0.033040
Redundancy	0.009332	0.005733	0.005173

Figure 9: Quantitative assessment for image 3

7. Conclusion

The application of image processing has widely applied in our life, in which the digital image processing technology is widely used in all aspects of life. Image segmentation is most practical approach among virtually all automated image recognition systems. In this paper, algorithms taken for comparison are marker based watershed algorithm, quadtree and merge algorithm and seed region growing algorithm. Analysis of all above algorithms is performed based on parameters such as energy, discrete entropy, relative entropy, mutual information, normalized mutual information and redundancy. After evaluation it is observed that seed region growing algorithm forms simple output image as compared to other algorithms. Also, it gives less value of discrete entropy, relative entropy, mutual information and redundancy which is most suited for detecting damage part of apple fruit.

References

[1] Lulu Xu, Huaxiang Lu, "Automatic Morphological Measurement of the Quantum Dots Based on Marker Controlled Watershed Algorithm", IEEE Transaction On Nanotechnology,vol 10,No 1,pp 51-56,Jan 2013.
[2] M.Mary Synthuja Jain, Dr.L.Padma Suresh, M.John Bosco, "Image Segmentation Using Seeded Region Growing", in IEEE International Conference on Computing, Electronics and Electrical Technologies,pp.576-583, 2012.
[3] Yuncai Zhou, Hui Ren, "Segmentation Method for Rock Particles Image Based on Improved Watershed Algorithm", in International Conference on Computer Science and Service System, IEEE -2012.
[4] P.Deepa and Dr.S.N. Geethalakshmi, "Improved Watershed Segmentation for Apple Fruit Grading", IEEE 2011.
[5] Wei Zhang, DaLing Jiang, "The Marker-Based Watershed Segmentation Algorithm of Ore Image",IEEE -2011.

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[6] Liu Jinmei, Wang Guoyu, "A Refined Quadtree- based Automatic Classification Method for Remote Sensing Image",IEEE International Conference on Computer Science and Network Technology,2011.
[7] Haiyang Yu, Yumin Zhang, Gang Cheng, Xiaosan Ge, "Rural Residential Building Extraction from Laser Scanning Data and Aerophotograph Based on Quadtree Segmentation" ,IEEE -2011.
[8] Jun Tang, "A Color Image Segmentation algorithm Based on Region Growing", in IEEE 2nd International Conference On Computer Engineering And Technology, Vol.6,pp.634-637,2010.
[9] Dr.G.Padmavathi, Mr.M.Muthukumar, Mr. Suresh Kumar Thakur , "Implementation and Comparison of Different Segmentation Algorithms used for Underwater Images Based on Nonlinear Objective Assessments",in IEEE 3rd International Conference on Advanced Computer Theory and Engineering(ICACTE),Vol.2,pp.393-397,2010.
[10] William.K.Pratt, "Digital Image Processing",4th edition,Wiley Publication.
[11] Rafeal C.Gonzalez and Richard E.Woods, "Digital Image Processing ",3rd Edition.
[12] Wen-Xiong Kang, Qing-Qiang Yang, Run-Peng Liang, "The Comparative Research on Image Segmentation Algorithms", First International Workshop on Education Technology and Computer Science, vol. 2, pp.703-707, 2009.
[13] John.C.Russ, "Image Processing Handbook",6th edition,CRC Press.
[14] L.Lucchese and S.K. Mitra, "Color Image Segmentation: A State-of-the-Art Survey".
[15] Ashwin Kumar, Pradeep Kumar, "A New Framework for Color Image Segmentation Using Watershed Algorithm".
[16] Zhengmao ye, "objective assessment of Nonlinear Segmentation Approaches to Gray Level Underwater Images", ICGST-GVIP Journal, pp. 39-46, No.2, Vol. 9, April 2009.

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