1   Region growing

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Region growing is one of the simplest region-based [image segmentation](#) methods and it can also be classified as one of the pixel-based [image segmentations](#) because it involves the selection of initial [seed points](#).

This approach to segmentation examines the neighboring pixels of the initial "[seed points](#)" and determines if the pixel should be added to the seed point or not. The process is iterated as same as [data clustering](#). We describe the algorithm as below.

2   Region-based segmentation

The main goal of segmentation is to partition an image into regions. Some segmentation methods such as "[Thresholding](#)", achieve the goal by looking for the boundaries between regions based on discontinuities in [gray levels](#) or [color](#) properties. [Region-based segmentation](#) is a technique finding the region directly. Here are the basic formulation for [Region-Based Segmentation](#):

(a) $\bigcup_{i=1}^{n} R_i = R.$

(b) R_i is a connected region, i = 1, 2, ...,n

(c) $R_i \bigcap R_j = \varnothing$ for all $i = 1, 2, ..., n.$

(d) $P(R_i) = TRUE$ for $i = 1,2,...,n.$

(e) $P(R_i \bigcup R_j) = FALSE$ for any adjacent region R_i and $R_j.$

$P(R_i)$ is a [logical predicate](#) defined over the points in set $P(R_k)$ and $\varnothing$ is the null set.

(a) indicates that the segmentation must be complete; that is, every pixel must be in a region.

(b) requires that points in a region must be connected in some predefined sense.

(c) indicates that the regions must be disjoint.

(d) deals with the properties that must be satisfied by the pixels in a segmented region-for example $P(R_i)$ = TRUE if all pixels in R_i have the same gray level.

And the condition (e) indicates that region R_i and R_j are different in the sense of predicate P.

3   Basic concept of seedpoints

First of all, we choose a set of seed points. And the initial region now is the exact location of these seeds. Then the regions are grown from these seed points to adjacent points depending on a threshold or criteria we make. The threshold could be made by user. It could be intensity, gray level texture, or color. Since the regions are grown on the basis of the threshold, the image information is important for us. For example, getting to know the [histogram](#) of the image would help us a lot since we can take it as a reference to choose the threshold.

There is a very simple example followed below. Here we use [4-connected neighborhood](#) to grow from the seed points. We can also choose [8-connected neighborhood](#) for our pixels adjacent relationship. And the criteria we make here is the same pixel value. That is, we keep examining the adjacent pixels of [seed points](#). If they have the same intensity value with the [seed points](#), we classify them into the [seed points](#). It is an iterated process until there are no change in two successive iterative stages. Of course, we can make other criteria, but the main goal is to classify the similarity of the image into regions.

4   The value, "Similarity threshold value".

If the difference of pixel-value or the difference value of average [gray level](#) of a set of pixels less than "Similarity threshold value", the regions will be considered as a same region. The criteria of similarities or so called homogeneity we choose are also important. It usually depends on the original image and the segmentation result we want. Here are some **criteria** we often use : *[Gray level](#)*(average intensity or variance), *[color](#)*, and *[texture](#)* or *shape*.

5 Simulation examples

Here we show a simple example for **region growing**. Figure. 1 is the original image which is a gray-scale lightning image. The gray-scale value of this image is from 0 to 255. The purpose we apply **region growing** on this image is that we want to mark the strongest lightning part of the image and we also want the result is connected without being split apart. Therefore, we choose the points having the highest gray-scale value which is 255 as the seed points showed in the Figure. 2.

After determining the seed points, we have to determine the range of threshold. Always keeps in mind that the purpose we want to do is to mark the strongest light in the image. The third figure is the **region growing** result from choosing the threshold between 225 and the value of seed points (which is 255). It means we only want to mark out the points whose gray-scale values are above 225.
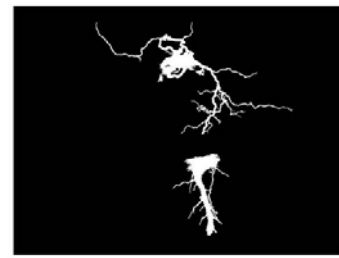

Fig. 2   Fig. 3 Threshold：225~255   Fig. 4 Threshold：155~255

If we make the range of threshold wider, we will get a result having a bigger area of the lightning region show as the Figure. 3 and the Figure. 4. As we can see in Figure. 3 to Figure. 4, the segmented result in this example are seed-oriented connected. That means the result grew from the same seed points are the same regions. And the points will not be grown without connected with the seed points in the beginning. Therefore, we can mention that there are still lots of points in the original image having the gray-scale value above 155 which are not marked in Figure. 4. This characteristic ensures the reliable for the segmentation and provides the ability to resist from noise. For this example, this characteristic prevents us marking out the non-lightning part in the image because the lightning is always connected as one part.

6 The advantages and disadvantages of region growing

Advantages：

1. **Region growing** methods can correctly separate the regions that have the same properties we define.

2. **Region growing** methods can provide good segmentation results if the original images have clear edges.

3. The concept is **simple**. We only need a small numbers of seed point to represent the property we want, then grow the region.

4. We can determine the seed points and the criteria we want to make.

5. We can choose the multiple criteria at the same time.

6. It performs well with respect to noise.

Disadvantage：

1. The computation is consuming, no matter the time or power.

2. Noise or variation of intensity may result in holes or oversegmentation.

3. This method may not distinguish the shading of the real images.

We can conquer the noise problem easily by using some mask to filter the holes or outlier. Therefore, the problem or noise actually does not exist. In conclusion, it is obvious that the most serious problem of region growing is the **power and time consuming**.