REGION BASED SEGEMENTATION

The objective of Segmentation is to partition an image into regions. The region-based segmentation techniques find the regions directly.

Extract those regions in the image whose pixel's have some common property in terms of any one of these:

* Pixel Intensity
* Pixel Colour
* Texture
* Range or Depth (for laser images)
* Temperature (for thermal images)
* Echo (for ultrasound sound images)
* etc.

Generally There are three methods for Region Based Segmentation.

* Region Growing
* Region Splitting
* Region Splitting and Merging

Region-based Segmentation: Preliminaries

Image Segmentation can be viewed as a process that partitions an image ***R*** into n subregions R_1, R_2, R_3, ... R_n.

such that

* Union of R_i (for $i = 0$ to n) is equal to image ***R.***

  Which means whole image is segmented or segmentation is complete.

* R_i is a connected region.

  The points in a region are connected either with four connectivity or eight connectivity.

* The regions R_i (for $i = 0$ to n) are disjoint.

  For any two regions R_i and R_j there is no common point

* A predicate (a common property) is true for all the R_i (for $i = 0$ to n) regions.

* The predicate is false for the union of any two regions.

  It means any two regions (combined together) are different on the basis of the predicate.

REGION GROWING

The procedure is also known as Region Merging. It is a process which groups adjacent image pixel's or sub-regions into larger regions which meet one or more than one properties.

These properties are known as region growing/merging criteria. The most common criteria is similarity in some pixel property (such as intensity, texture, colour etc.).

Simple Method: Pixel Aggregation

* Starts form a set of seed points
* These seeds are grown into regions that have similar properties

Problems with Region Growing Process

* How to select seed points ?
* How many seed points to start with ?
* When and where to stop region growing ?

REGION SPLITTING

Region splitting is the opposite approach to region growing or merging.

* Starts with the whole image as a single region

* Divide the image successively into smaller regions until each smaller region meets the similarity criterion

* Splitting stops when the sub-regions satisfies the criteria

Criterion for Similarity in Intensity

Region Uniformity

The Computation involved at the region level are the calculation of intensity mean, variance or standard Deviation etc. for each region and sub-regions from pixel's to image level.

Implementation of Region Uniformity Criterion

A number of alternatives, depending on the amount of computation and the effectiveness of the criterion.

***** Involves only the Intensity Mean of sub-regions and the parent regions.

> *Region Merging*: Continue merging until the intensity mean of sub-regions and merged region are nearly equal.
>
> *Region Splitting*: Stop splitting when intensity mean of the parent and sub-regions become nearly equal.

***** Involves the intensity-based Standard Deviation of sub-regions and parent regions. A uniformity threshold in terms of standard deviation is used.

> *Region Merging*: Continue merging if the intensity mean of the sub-regions are nearly equal and standard deviation of the parent (merged) region is below the uniformity threshold.
>
> *Region Splitting*: Stop splitting when the standard deviation of the regions falls below the uniformity threshold.

***** Involves intensity Variance of the sub-regions and parent region. Recursive calculation of variance is economical than direct pixel based calculation of standard deviation.

Region Merging and Splitting

For Merging Only:

* One needs to start from pixel's level and it requires lot of computation.

* The most suitable seeds are difficult to find.

* The segmentation results depend on the number of seeds and the location of seeds in the image.

* Useful when there are lot of uniform regions in the image.

For Splitting only:

* One starts from the whole image and starts splitting.

* The segmentation results depends on how to split in terms of the shape of the partitioned regions.

* The computation depends on the shape of uniform regions and how one is splitting.

* Useful when there are only a few and regular uniform regions in the image. Otherwise, lot of computation.

A combination of merging and splitting will enjoy the benefits of both methods.

Region Merging and Splitting

(Cont.)

Quadtree Representation

A hierarchical data structure for representing images. The quadtree representation is based on the successive sub-division of an image into quadrants.

* It is a tree of out-degree four.

* The root node represents the whole image of 2^n x 2^n pixel's where ***n*** is the maximum number of levels of the quadtree.

* The four sons of the root represent the four quadrants of an image.

* The terminal nodes either represent the uniform region or pixel's.

When the shape of the partitioned regions can be taken as squared, quadtrees are best suited for region splitting based segmentation.

Region Merging and Splitting

(Cont.)

When a quadtree is employed for Region Splitting and if the uniform region is neither a squared one nor perfectly aligned with the image quadrants or sub-quadrants.

* The segmentation will not be complete

* Extra uniform regions will be extracted which requires further merging.

Outcome is the Region Splitting and Merging Algorithm:

Step 1: Start from any quadtree based partitions (R_1, R_2, R_3, ... R_n) of an image.

Step 2: Split a region $\boldsymbol{R_i}$ if it satisfies the splitting (non-uniformity) criterion.

Step 3: Merge any adjacent regions $\boldsymbol{R_j}$ and $\boldsymbol{R_k}$ if they satisfy the merging (uniformity) criterion.

Step 4: Continue until no further merging or splitting is possible.

Region Merging and Splitting

(Cont.)

A number of variations of the Merging and Splitting approach exist.

The following procedure only employs the quadtree structure for both merging and splitting.

* Split the image initially into a set of squared blocks.

* Perform further splitting if the splitting criterion is satisfied.

* Merge only the groups of four blocks which are brothers/sisters and satisfy the merging criterion.

* If no further merging is possible, then perform a ***final merge*** step for different sized regions satisfying the merging criterion (similar to Step 3).

* Terminate the procedure.