CERTIFICATION OF APPROVAL

TEXTURE SEGMENTATION METHODS FOR SATELLITE RADAR IMAGES

By

Fadli Bin Mohd Ariffin

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Approved by,

____

(Norashikin Bt Yahya)

Lecturer,

Electrical & Electronic Engineering Department

Universiti Teknologi PETRONAS

CERTIFICATION OF ORIGINALITY

This is to guarantee that I am in charge of the work submitted in this extend, that the first work is my own particular aside from as indicated in the references and acknowledgements, and that the first work held thus have not been attempted or done by unspecified sources or persons.

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(FADLI BIN MOHD ARIFFIN)

ABSTRACT

Segmentation for Synthetic Aperture Radar (SAR) is a very important aspect for satellite radar images. It is important to separate areas that be clustered based on characteristics or features of the image. Nowadays, there have a lot of segmentation techniques of SAR images. In this thesis, the techniques being investigated are edge adaptive smoothing, watershed transform, mean shft segmentation and region merging via boundary melting techniques which is the best among segmentation techniques. The comparison or evalution among the techniques is in term of number of edges retained in the segmented images and also in visual inspection. In this research, we use two different type of images, which is real SAR image and non-real SAR image (house). Results generated from this research has shown that edge adaptive smoothing is the best one compared to the other segmentation techniques.

CHAPTER 1

INTRODUCTION

1.1 Background

The word of radar is stand for Radio Detection and Ranging (RADAR). It was built in World War II for military purpose. It is an important technology for them to locate enemy. It have 3 main functions. Firstly, it transmit radio signal to a target. Then, it receives the part of the transmitted energy reflected from the target and from that reflection, it note strength and time delay of reflection signals.

Two dimension images of target and world's exterior built by using radar, which also known as Synthetic Aperture Radar (SAR) was introduced by Wiley in 1951[1]. Two dimensions of actual sensor resolution are range resolution and azimuth resolution. For range resolution, it based on processor straint and built-in radar which is the resolution will increase when the pulses result be decreased. Radar data are discharged to the ground range plane when it be processed to the image eventhough it was built in the slant range domain. The radar beam to the ground will produce the range of angular beam. That is called azimuth resolution. Azimuth direction will divide two objects by more gap than beam width in the ground.

A microvave sensor which transferring in mocrowave and observe the wave which is send back by the target or objects is called Synthetic Aperture Radar (SAR) [2]. It's one types of radar that produce a high resolution image from multiple radar images by mounting an antenna to a moving platform such as satellite and aircraft. In last 10 years, SAR imaging system are one of the most used remote sensing technique that be used. To obtained high resolution image, SAR system use long range propagation characteristics of radar signal and transforming competence of modern digital electronics.

1.2 Problem Statement and Objective

In monitoring using satellite radar images, the differentiation of texture is very important. Despite the fact that a human is promptly equipped to outwardly fragment any textured picture no unsupervised machine system has been planned that reliably and vigorously performs the same assignment. As to compete with the fast growing technologies todays, it is important to carry on this project.

Therefore, the main objective of this project is to evaluate the performance of different image segmentation methods for segmentation of SAR images.

1.3 Scope of Study

For scope of study, the project starts by studying and revising the fundamentals of texture segmentation methods from any trusted sources such as published articles, journals, books and conference papers. By doing that, deeper understanding can be gained and comparison of theory and practical studies can be made.

The starting point of this project is to focussed on formation of SAR system. The author will analyzing on how SAR system processed to produce SAR images. As discussed above, there have many techniques of segmentation of SAR images. So, the author will focus on analyzing all the techniques of segmentation of SAR images and its importance. And finally, the author will find new method by combining the best method that already be researched to increase the performance of texture segmentation in SAR images.

CHAPTER 2

LITERATURE REVIEW

2.1 Segmentation method of SAR images

Nowadays, satellite radar images become important to the world. It is not only be used in military field, but it also be used widely to monitor world weather, oceanography, astronomy, surveillance, communication and etc.

The segmentation method of SAR images is a very important aspect for satellite radar images. According to [3], in remote sensing applications, SAR imaging is so effective because it has very superior resolution. Segmentation subdivides an image into its constituent regions or objects [5]. There have two types properties of image intensity, which is discontinuity and similarity. For discontinuity, it is for image to be differentiated or clustered based on vast variation in intensity. For similarity, it is clustering image into regions which is same based on criteria that already be set.

Points, lines and edges detection are the methods that be used todays to detect intensity discontinuities that be mentioned before. Edge detection be used to extract the directory of varying in the image's regions which the regions or areas that have same pixels of images will be clustered to the same regions [6] such as similar color or brightness. Meanwhile point detection means detection of isolated points contained in regions of sustained intensity in an image.

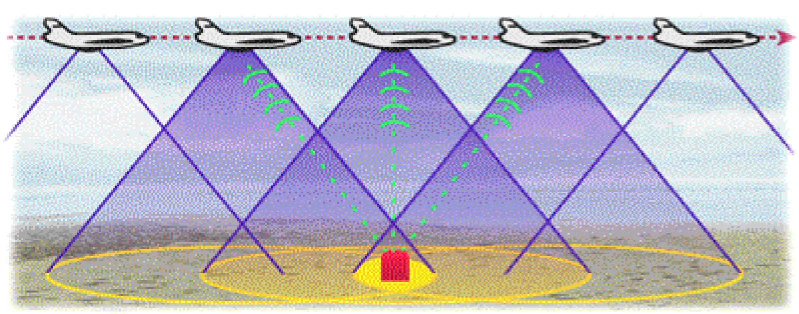


Figure 1: Synthetic Aperture Radar [1]

As we see in the Figure 1, the antenna from the aircraft produces a series of beam during their ways to the target scene and hence illuminate it at different distances and times. As the beam illuminate the target scene, the echo waveforms will then be produced and back to the antenna at different position of previous antenna’s position as the aircraft are on moving.

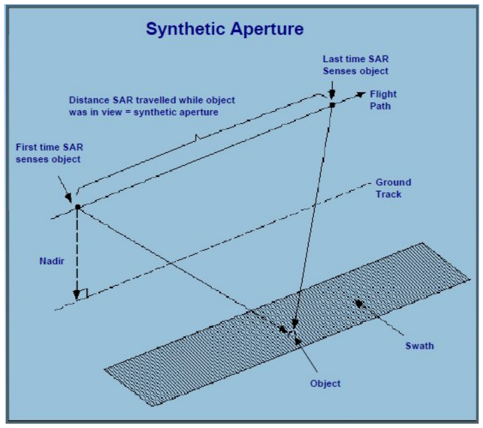


Figure 2: Synthetic Aperture Radar [Canada Centre for Remote Sensing]

Therefore, the times and distances that echo waveforms will determined about the size and shape of the target scene as from that record of echo waveforms, processing is needed to produce radar images. We can see the Figure 2 that the distances is from the first time SAR senses object to the last time SAR senses target scene.

‘Azimuth’ is the along track dimension meanwhile the across track dimension is called as ‘range’ where azimuth and range are high resolution two-dimensional (2-D) image that being analyzed from the reflections received by the antenna platform by using the Range Doppler Algorithm (RDA). SAR obtain higher resolution than the conventional radar because it using digital signal processing. To make sure the maximum resolution of radar images, the antenna will be make sure to produce narrower beam as the wider beam will complicate the radar to distinguish the reflection.

Function of SAR image segmentation is to separate areas that be clustered based on characteristics or features of the image [3]. It is very important steps for SAR images interpretation. Nowadays, there have a few of methods of segmentation of SAR images. Among of it are global segmentation techniques, fuzzy clustering methods, spectral clustering algorithms and active contour model and level set.

Global Segmentation Techniques is segmenting a whole image. Usually, this method is used for segments that have large number of pixels. The parametric of this method use polygonal grid model with a suppositional unknown number of regions [3] which is estimated by minimizing the stochastic complexity. When Gamma pdf not accurately corrected the gray values of SAR images, this technique will fail. In addition, as the number of pixels available for global segmentation high, it will affect to the typical number of dinstinct segments expected to be encountered [9]. As a consequence, this method will disallow segments that have less than specified number of pixels in attempt to reduce over segmentation.

Fuzzy C Means (FCM) clustering is among the the methods that be used widely todays for image segmentation.The method is the best method in fuzzy clustering method,compared to other clustering method such as hard clustering and k-means clustering . It was introduced by Dunn in 1973. However, it was improved in 1981 by Bezdek by using pattern recognition. For this method, based on provided specification, a finite collection of points will be splitted into a group of C fuzzy cluster [7] which it will acknowledge one point suited to one or more than one clusters. In other words, every point will have a degree that be suited to cluster in fuzzy clustering [8].

Spectral Clustering (SC) algorithm was introduced by Donath and Hoffman in 1973. Then, this method were improved by established spectral clustering algorithm by Hagen and Kahng. The advantage of this method is it can get clusters in sample spaces with arbitrary shape. The method compute the eigenvectors of the affinity matrix. This is because the complication of calculations exists in these methods and they are computationally expensive because of using an affinity matrix established by the likeness of each pair of pixels [3].

Active Contour Model and Level Set is used by separate structures and background on the image [10]. To construct an active contour, it must explicit or Lagrangian approach and resulting interfaces called snakes. The name snakes come from the similarity of evaluating of the contour with a moving snake. Besides that, to construct an active contour, it must implicit or Eulerian approach and resulting interfaces called level sets.

CHAPTER 3

METHODOLOGY

3.1 Research Methodology

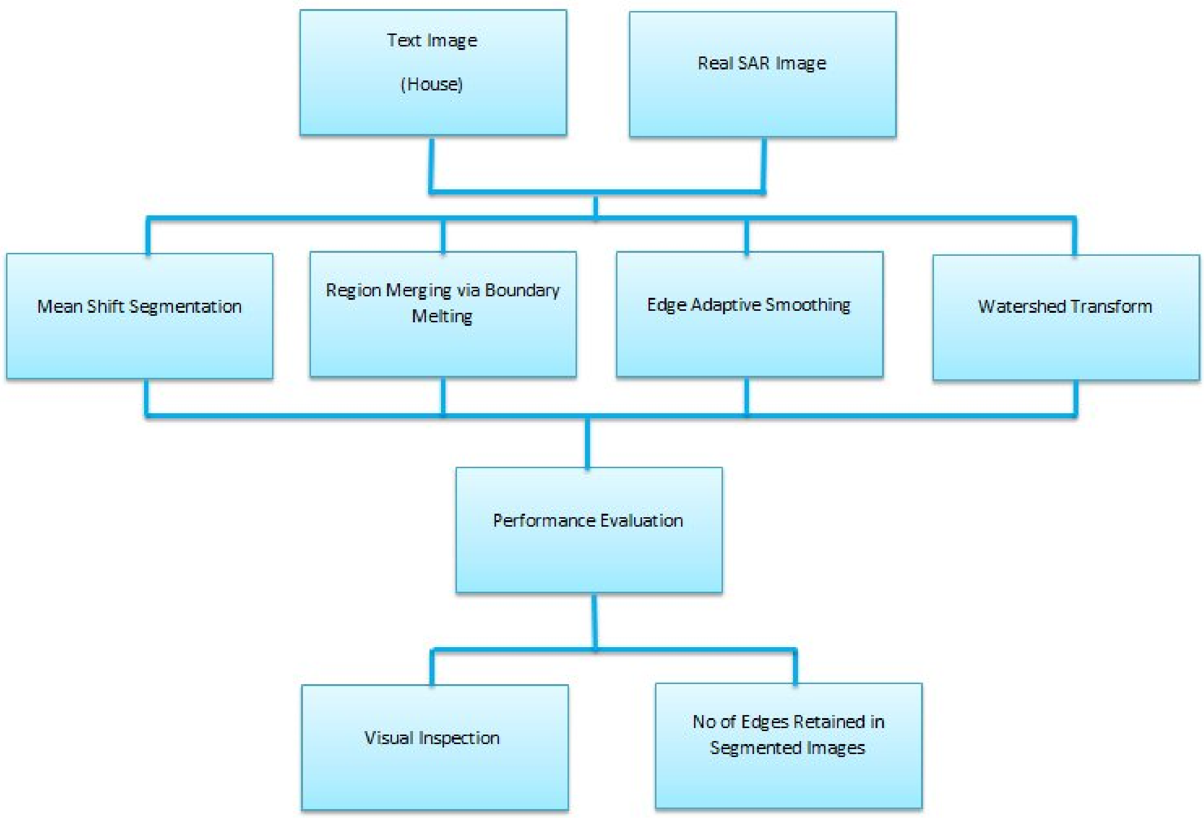


Figure 3: Methodology of the project

In this research, we will first need to understand the main point for this project, which is image processing. The author select two type of images, real SAR image and non-real SAR image, which the author use house image as non-real SAR image. The purpose of using two types of images is to make comparison among it. After that, the images will be converted into gray scale image. Then, the author will apply four segmentation techniques to be tested on images by sing MATLAB software, which is mean shift segmentation, region merging via boundary melting, edge adaptive smoothing and watershed transform technique. The results or performance evaluation for the images is based on visual inspection and no edges retained in segmented images.

3.1 Techniques in Segmentation of SAR Images

The selected segmentation techniques that be used in this project is mean shift segmentation, region merging via boundary melting, edge adaptive smoothing and watershed transform technique.

3.1.1 Mean Shift Segmentation

This algorithm was introduced by Fukunaga and Hostetler (Fukunaga & Hostetler, 1975), and then being improved by Cheng (Cheng, 1995) for image analysis and then be improved by Comaniciu, Meer and Ramesh to low-level vision problems, including, segmentation (Comaniciu & Meer, 2002), adaptive smoothing (Comaniciu & Meer, 2002) and tracking (Comaniciu, Ramesh & Meer, 2003).

Mean shift segmentation is an advanced and vertisale technique for clustering based segmentation. It does not need number of clusters, and does not constrain the shape of the clusters. Kernel density estimation is a non parametric way to predict the density function of a random variable. It is a popular method for estimating probability density.

3.1.2 Region Merging via boundary melting

For this method, the animage will be divided into a few regions. Regions are sets of pixel and grown by combining smaller pixel, meanwhile the pixel being elementary regions. It usually be used with statistical test to find the region merging. Regions also will be merged if there are separated mostly by weak edges. Actually, most of segmentation techniques been employed for region region merging including the use of simple thresholds, size biased thresholds and iterative methods. . A good region merging algorithm has to find a suitable balance between preserving this unit and the risk of overmerging for the remaining regions.

3.1.3 Edge Adaptive Smoothing

Image smoothing is a key technology of image improvement. It able to eliminate noise in images hence the image quality can be improved. An efficient smoothing algorithm able to eliminate both various noises and preserve details. A robust smoothing algorithm is based on non linear and linear filtering from respective adaptation to different noises.

Actually, noises are from many causes. Different factors can cause various type of noise. Image smoothing always making blur and offsets of the edges. While the edge information is much essential for image analysis and interpretation. Thus it is essential to keep the precision of edge’s position in image smoothing.

3.1.4 Watershed Transform

Watershed transformation is one of segmentation techniques which introduced by Beucher and Lantu´ejoul (Beucher and Lantu´ejoul, 1979; Beucher, 1990). It is the method of choice for image segmentation in the field of mathematical morphology.

Actually, this method are from geography, either landscape or topographic where flooded by water. Then, watersheds be the divide lines of the domains of attraction of rain falling over the region. By using watershed transform, it can give closed contours. Watershed transformation also need low computation times compare to the other methods. The disadvantages of this method is it produce oversegmented image when we use a standard morphological watershed transformation on the original image.

3.5 Tool and Software Required

Tools & softwares that will be used throughout the project are:

- Laptop
- Microsoft Office (Excel & Word)
- SAR Images
- Matlab R2010a

CHAPTER 4

RESULT AND DISCUSSION

4.1 Performance Evaluation based on visual inspection

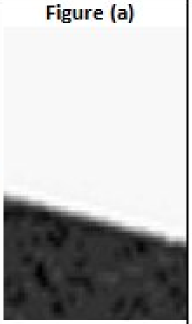
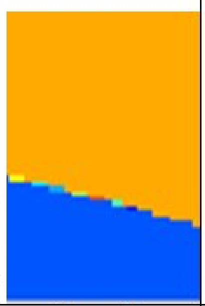
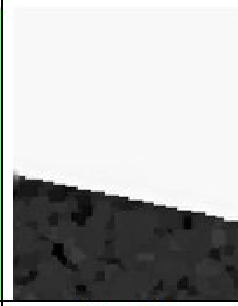
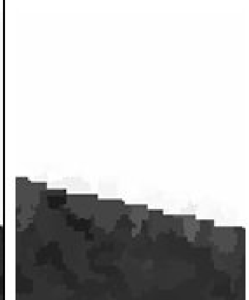
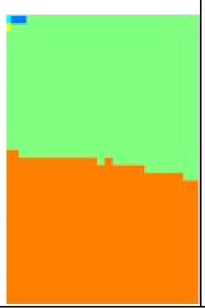
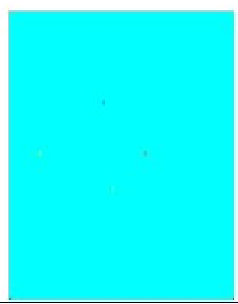
TYPE OF IMAGE	ORIGINAL IMAGE	MEAN SHIFT SEGMENTATION	REGION MERGING VIA BOUNDARY MELTING	EDGE ADAPTIVE SMOOTHING	WATERSHED TRANSFORM
HOUSE	Figure (a) 	Figure (b) 	Figure (c)	Figure (d) 	Figure (e) 
SAR	Figure (f) 	Figure (g) 	Figure (h) 	Figure (i) 	Figure (j) 

Figure 4: Result for image segmentation

In term of performance evaluation based on visual inspection, we can see that image segmented in figure (b) and figure (c) is showing no good result. Figure (b) and figure (c) not much clear, defined and not so contrast. Meanwhile for figure (e), the image segmented display better image contrast,sharper and defined than figure (b) and figure (c). For figure (d), it show more sharp, much more defined and image contrast much more better than the other techniques.

Therefore, the image segmented show that figure (d) which is edge adaptive smoothing is the better technique compared to the other techniques.

4.2 Performance Evaluation based on number of edges retained in segmented image

TYPES OF IMAGE SEGMENTATION TECHNIQUES	MEAN SHIFT SEGMENTATION	REGION MERGING VIA BOUNDARY MELTING	EDGE ADAPTIVE SMOOTHING	WATERSHED TRANSFORM
NO OF EGGES RETAINED IN SEGMENTED IMAGES	**0**	**0**	**93**	**8**

Figure 5: Result for number of edges retained in segmented image

From the result, it show that the mean shift segmentation and region merging via boundary melting not have any number of edges retained in segmented images. Meanwhile for watershed transform, the number of edges retained in segmented images for this technique is eight. In edge adaptive smoothing technique, it get the most number of edges retained in segmented images compared to the other techniques, which is 93. Therefore,edge adaptive smoothing technique is the best in term of performance evaluation based on number of edges retained in segmented image.

4.2 Computation Time

TYPES OF IMAGE SEGMENTATION TECHNIQUES	MEAN SHIFT SEGMENTATION	REGION MERGING VIA BOUNDARY MELTING	EDGE ADAPTIVE SMOOTHING	WATERSHED TRANSFORM
TIME TAKEN (SECONDS)	5.045	28.419	1.074	2.543

Figure 6: Result for computation time

Result shows that mean shift segmentation techniques takes about five seconds for computation time, region merging via boundary melting technique takes about 28 seconds, edge adaptive smoothing technique takes about one second and watershed transform take about three seconds. From the result generated from this evaluation,it show that edge adaptive smoothing technique is the best among the other techniques in terms of computation time.

CHAPTER 5

CONCLUSION

Interpretation and classification of satellite radar images is an active research field. Image segmentation is an important process of SAR images. By doing this research paper, the author will evaluate the performance of different image segmentation techniques of SAR images. In this research, the author evaluate the performace of image segmentation by visual inspection and number of edges retained in segmented image. From the result generated from these evaluation, the author can conclude that edge adaptive smoothing technique is the best one among the other techniques.

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APPENDIX i :

Matlab Code for Edge Adaptive Smoothing and Watershed Transform Technique

```
clc;close all;clear all;
% I   = double(imread('roof_tiles.png'));
 I   = double(imread('house.tif'));
 x1 = 388:494;
y1 = 65:180;
 I =I(:,:,1);
I = I(y1,x1);
% I = imnoise(I,'speckle',0.01);
figure;imshow(I,[]);xlabel('original');
%%%%%%%%%%%% watershed %%%%%
i0 =50; %the threshold above which a minimum must stand out, in order to be called a minimum
ws =3; %so window size becomes 3x3
[out1,brd1,av1]=ch6_watershed(I,i0,ws);
figure;imshow(av1,[]);xlabel('watershed');
ex = double(imread('GTHouse1.png'));
ex = ex(y1,x1);
ex = ex(:,:,1);
ex = invert(ex);
figure; imshow(double(ex)); xlabel('groundtruth')
[r,c]    = find(ex==1);  %%%% berapa bayank pixel yg conrrespond to edges
[rr cr]  = size(r);
%%%%%%%%%%%%%%%%%%%%%%%%% detected edges
countx = 0;
for i=1:rr;
    if ex(r(i),c(i)) == 1
        countx = countx + 1;
end
```

```
thresh = 0.15;%[0.06,0.1];

sigma  = 1; % 1 is default value

% l = label2rgb(av1);

% l = l(:,:,1);

ey     = edge(av1,'canny',thresh,sigma);

%%%%%%%%%%%%%%%%%%%%%%%% detected edges
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

county = 0;

for i=1:rr-1;

        if ey(r(i),c(i)) == 1

            county = county + 1;

        end

end

%%%%%%%%%%%% smoothing follow by watershed %%%%%

% mask = [1 3 1;3 5 3;1 3 1];

ws=2;

flat = 0;

sim = ch4_edge_preserve_smoothing(I,ws,flat);

figure;imshow(sim,[]);xlabel('smooth sahaja');

es     = edge(sim,'canny',thresh,sigma);

%%%%%%%%%%%%%%%%%%%%%%%% detected edges counts = 0;

for i=1:rr-1;

        if es(r(i),c(i)) == 1

            counts = counts + 1;

        end

end

i0 =50; %the threshold above which a minimum must stand out, in order to be called a minimum

ws =3; %so window size becomes 3x3

[out2,brd2,av2]=ch6_watershed(sim,i0,ws)

figure;imshow(av2,[]);xlabel('smooth + watershed')

ez     = edge(av2,'canny',thresh,sigma);
```

```
%%%%%%%%%%%%%%%%%%%%%%%% detected edges
countz = 0;
for i=1:rr-1;
    if ez(r(i),c(i)) == 1
        countz = countz + 1;
    end
end
figure;imshow(ex);
figure;imshow(es);
figure;imshow(ey);
figure;imshow(ez);
```

APPENDIX ii :

Matlab Code for Mean Shift Segmentation

```
clc;close all;clear all;
tic;
% img = imread('images/roof_tiles.png');
img  = imread('house.tif');
% img = rgb2gray(img);
x1 = 388:494;
y1 = 65:180;
img = img(y1,x1);
img=imresize(img,0.5) ;
l=meanshsegm(img,10,30) ;
figure;imshow(img,[]);title('input image') ;
figure;imshow(label2rgb(l,'jet','w','shuffle'));title('segmented') ;
axis image ; axis off ;
thresh = 0.15;%[0.06,0.1];
sigma  = 1; % 1 is default value
% eLe5   = edge(Le5,'canny',thresh,sigma);
ex = double(imread('GTHouse1.png'));
x1 = 388:494;
y1 = 65:180;
ex = ex(y1,x1);
ex  = ex(:,:,1);
ex  = invert(ex);
figure; imshow(double(ex)); xlabel('groundtruth')
[r,c]    = find(ex==1);
[rr cr]  = size(r);
thresh = 0.15;%[0.06,0.1];
```

```
sigma  = 1; % 1 is default value
l = label2rgb(l);
l = l(:,:,1);
ey     = edge(l,'canny',thresh,sigma);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% detected edges
county = 0;
for i=1:rr;
        if ey(r(i),c(i)) == 1
            county = county + 1;
        end
end
toc;
```

APPENDIX iii :

Matlab Code for Region Merging via Boundary Melting

```
clc;close all;clear all
tic;
% img = imread('images/roof_tiles.png');
img  = imread('house.tif');
img = img(:,:,1);
% img = rgb2gray(img);
x1 = 388:494;
y1 = 65:180;
img = img(y1,x1);
img=imresize(img,[120 160],'nearest') ;
img=medfilt2(img,[3 3]) ;
l=regmerge(img,5,40,0.2,0.3) ;
figure;imshow(img,[]);title('input image') ;
figure;imshow(label2rgb(l,'jet','w','shuffle'));title('segmented') ;
axis image ; axis off ;
thresh = 0.15;%[0.06,0.1];
sigma  = 1; % 1 is default value
% eLe5   = edge(Le5,'canny',thresh,sigma);
ex = double(imread('GTHouse1.png'));
x1 = 388:494;
y1 = 65:180;
ex = ex(y1,x1);
ex  = ex(:,:,1);
ex  = invert(ex);
figure; imshow(double(ex)); xlabel('groundtruth')
[r,c]    = find(ex==1);[rr cr]  = size(r);
```

```
thresh = 0.15;%[0.06,0.1];

sigma  = 1; % 1 is default value

l = label2rgb(l);

l = l(:,:,1);

ey     = edge(l,'canny',thresh,sigma);

%%%%%%%%%%%%%%%%%%%%%%%%%% detected edges county = 0;

for i=1:rr;

        if ey(r(i),c(i)) == 1

            county = county + 1;

        end

end

toc;
```