Centre for Image Analysis
Swedish University of Agricultural Sciences
Uppsala University

Computer Assisted Image Analysis

Exercise 3: Classification

The aim of this exercise is to segment real images into regions using classification. Different methods of classifying images will be tried. As examination of this exercise you will write a report. The report should include answers to the numbered questions together with discussions and images showing the classification results.

Formality

- You need an account for the computer systems at the Dept. of Information Technology.
- You should work together in groups of two people. It may be advantageous to have someone to discuss issues with.
- You are requested to prepare a written report (one per group) of the exercise with explanatory illustrations. No hand writing or hand drawing, please. The report should include answers to each of the 5 questions in sections 2 and 3.

  Possible ways to hand in the report:

  - Send the report in pdf-format as an attachment of an e-mail to `gustaf@cb.uu.se`.
  - Print the report **in color(!)** and leave to one of us in person or in the mailboxes at CBA. Please send images electronically if you don't have access to a color printer.
  - Prepare a web-page and simply send the web address in an e-mail to `gustaf@cb.uu.se`.
- **Deadline:** May 14 2009
- Status of your reports will be found at the **Studentportalen.**
- For those who would like to work with the exercise from home or outside the Unix system the necessary images can be found at the Studentportalen as a zip-file.

1 Getting started

Before you begin, study the text book (GW 12.2.2) and the lecture notes on Maximum Likelihood (ML) classifiers. Do not forget that MATLAB has a Help function. Also, a function or script can be viewed in MATLAB using the command type as

```
type functionname
```

Start MATLAB in a terminal window by writing:

```
matlab-7 &
```

Remember to start MATLAB from a directory where you have write permission. After a while you will be presented with a graphical user interface to MATLAB . Add the necessary paths to images and m-files for this exercise by using the MATLAB commands:

```
addpath('/it/kurs/bild1/matlab');
addpath('/it/kurs/bild1/images');
```

2 Classification basics

First we examine a synthetic data set. Load the data into MATLAB by writing

```
load cdata
```

The data is of size N×2 where N is the number of samples and we have two data points for each sample, in this case x and y coordinates. You can inspect the data in a 2D scatterplot using the command

```
figure(1);plot(cdata(:,1),cdata(:,2),'.')
```

As you can see it is probable that the data contains two classes.

1. ***Are the two classes possible to separate by using either the x or y coordinate as a single feature? Explain why or why not.***

Second, open the image handBW.pnm and examine the image and the histogram.

```
I = imread('handBW.pnm');   % Read the image
figure(2);imshow(I);        % Show the image
figure(3);imhist(I);        % Show the histogram
```

Your task is to segment the image into three classes hand, object and background as accurately as possible. First try multiple thresholding

```
figure(4);mtresh(I,t1,t2);
```

where t1 and t2 are thresholds that you find suitable from inspection of the histogram.

2. ***Does multiple thresholding give a successful classification of the three classes? Explain why or why not.***

Open the image hand.pnm and examine a scatterplot of the three RGB bands.

```
I2 = imread('hand.pnm');    % Read the image
figure(5);imshow(I2);       % Show the image
R = I2(:,:,1);              % Separate the three layers, RGB
G = I2(:,:,2);
B = I2(:,:,3);
figure(6);plot3(R(:),G(:),B(:),'.') % 3D scatterplot of the RGB data
```

Also examine the three bands R, G and B and their histograms respectively in separate images. To improve the results from multiple thresholding of the grayscale image, single bands, pairs of bands, the grayscale image or all three bands could be used for classification. Training areas for the three classes are available in the image hand_training.png.

```
label_im = imread('hand_training.png');  % Read image with labels
figure(7);imagesc(label_im);             % View the training areas
```

This is an example of classification using two of the bands. Follow the steps below to create training data and do a classification. As the first step we choose the G and B bands as features. Then we split the training areas into training feature vectors and view the vectors in a 2D scatterplot.

```
I3(:,:,1) = G;                                    % Create an image with two bands/features
I3(:,:,2) = B;
[data,class] = create_training_data(I3,label_im); % Arrange the training data into vectors
figure(8);scatterplot2D(data,class);              % View the training feature vectors
```

In the next step we use the feature vectors to train and classify data using the MATLAB function classify and the following steps. First we reshape the test data to vectors. After that we perform classification of the test data using the given training data. The final step is to reshape the classification result to an image and view it.

```
Itest = im2testdata(I3);                                % Reshape the image before classification
C = classify(double(Itest),double(data),double(class)); % Train classifier and classify the data
ImC = class2im(C,size(I3,1),size(I3,2));                % Reshape the classification to an image
figure(9);imagesc(ImC);                                 % View the classification result
```

See the help function for the function classify. What sort of classification is used? You can use a number of different discriminant functions. The default is 'linear'. What assumptions are made by the classifier in this case? Now, test classification on

- The grayscale image
- Single bands from the RGB image
- Pairs of bands from the RGB image
- All three bands in the RGB image

When using all three bands the function scatterplot3D can be used to view the feature vectors in the training data. A histogram can be used to view one dimensional features.

3. ***Have the results improved using classification compared to thresholding? Is the classification more successful in the case with the grayscale image or single bands? Explain. Does it improve the classification to incorporate pairs of bands or the full RGB information? Discuss. Show your results from grayscale classification, one pair of features and full RGB classification.***

3 Classification of multispectral data

Now when you have some tools to use you should try to make a good classification of multispectral image data. A satellite image showing part of Uppsala with seven bands is available. Your task is to segment the image into meaningful classes like forest, water, urban area and agricultural areas. Possibly more classes can be used to obtain a better classification. Use the classification tools described above, like classify, scatterplots of different bands etc. Test the different discriminant functions available in the function classify to get the best possible classification. You can mark training areas using coordinates for rectangles as in the following example.

```
T = zeros(512,512);       % Create an empty image
T(20:30,60:90) = 1;       % Class 1
T(140:150,100:160) = 2;   % Class 2
etc ...
```

It is important that the training areas for a class does not contain data from other classes to obtain a good classification. The image data can be loaded into MATLAB using the command

```
load landsat_data
```

As a help it is also possible to view three bands at the time using color or pseudocolor with the command imshow. Although, the bands 3, 2 and 1 correspond well to the visible spectral bands R, G and B respectively, you can use other combinations of bands in order to visualize differences and improve classification results.

```
figure(10);imshow(landsat_data(:,:,[4,1,3])./255);
```

4. ***Which bands are you using for your classification? What classifier are you using? Which classes are possible to separate in a good way? Illustrate with images and scatterplots. Show images from your classification result and compare with classification using all bands. Discuss your results.***

5. ***Is there any reason not to include all bands if they are not needed to separate the classes?***

4 Extra: Classification based on texture

This assignment is voluntary. Texture can also be incorporated to improve classification results in grayscale images. Open the image forest.tiff. Your task is to classify the image into forest, open areas and road. First, test classification of the image intensities directly. Add training areas for the three classes as described above.

6. ***What type of problems occur using classification with only one band in the forest image?***

You can add bands to the image that will improve the classification. The forest area contains a property that is not pixelwise that the road and open area lack since it is somewhat "bumpy". This feature can be captured using filtered versions of the image and add these as new bands. For example mean or median filters can be used. The image can also be shifted plus/minus one pixel in each direction to add information about the neighborhood that is not smoothed since a smoothing reduces the accuracy of the result.

```
I4 = imread('forest.tiff');     % Read forest image
figure(11);imagesc(I4);         % Show the image
axis image                      % Set correct aspect ratio
colormap gray                   % Set appropriate colormap
I4(:,:,2) = medfilt2(I4,[3 3]); % Add a band that is median filtered
```

Test classification using these two bands. Add more bands if it is necessary to improve the classification results.

7. ***What bands did your final classification include? Can you separate the three classes in the image? Illustrate with classification results and scatterplots of your features.***

5 Your comments

That's it. The exercise is done!

8. ***Any comments on the exercise? Are the instructions good enough? Is the preparation on the lectures enough? Can we improve the exercise in any way? All comments are welcome.***