Chapter 4

IMPLEMENTATION OF MINIMUM DISTANCE CLASSIFICATION ALGORITHM

4.1. Introduction

In this chapter the implementation of the minimum distance classification technique for location-wise classification is studied / analyzed. Location-wise classification technique is used to find the location of the image where a large amount of resources are available. In the algorithm for location-wise classification using the minimum distance technique the minimum distance classification technique is used for classifying the images after the location is identified.

Minimum distance classification technique is one of the techniques used for classifying the images. Among the various techniques used for classifying the images, minimum distance classification is used for classifying the images according to the closest region of interest. In minimum distance classification technique initially the mean value for all classes of images is calculated in each band of data. The minimum distance is initialized to be the high value. The Euclidean distance from each unknown pixel to the mean vector for each class is calculated. All pixels are classified to the closest region of interest class. The distance is defined as an index of similarity so that the minimum distance is
identical to the maximum similarity. Selecting the minimum distance value among all distances does the classification of pixel.

When a pixel is assigned to a corresponding class the number of pixels classified to that class is incremented. It is to indicate that the pixel is classified under this class. After all the pixels are classified it will be possible to conclude how many pixels are associated to a particular class.

4.2. Background

The **minimum distance classifier** is used to classify unknown image data to classes that minimize the distance between the image data and the class in multi-feature space. The distance is defined as an index of similarity so that the minimum distance is identical to the maximum similarity.

The distances between the pixel to be classified and each class center are compared. The pixel is assigned to the class whose center is the closest to the pixel [PCIG1999].

The minimum Euclidean distance classifier is defined by the following equation:

\[ T \]

\[ G_i(X) = (X-U_i) \ast (X-U_i) \]
= \text{SUM}[(x_j-u_j)^2] \text{ for } j = 1 \text{ to } d.

\text{Gi}(X) \quad \text{is the result for class } i \text{ on pixel } X.

T \quad \text{indicates transposition of the elements in brackets.}

d \quad \text{is the number of channels in the classification.}

X=(x_1,\ldots,x_d) \quad \text{is the (d by 1) pixel vector of grey-levels.}

U_i=(u_1,\ldots,u_d) \quad \text{is the (d by 1) mean vector for class } i.

j \quad \text{is the subscript of } j^{th} \text{ element of a vector.}

\text{SUM[]} \quad \text{is the total of elements inside brackets.}

\text{If for all } i \text{ not equal to } j, \text{G}_j(X) < \text{G}_i(X), \text{ then } X \text{ is classified as } j.

The minimum distance classification uses the mean vectors of each region of interest and calculates the Euclidean distance from each unknown pixel to the mean vector for each class. All pixels are classified to the closest region of interest class unless the user specifies standard deviation or distance thresholds, in which case some pixels may be unclassified if they do not meet the following selected criteria.

1. Classification using the CLASSES: This criterion employs the default parameters or various standard deviations or maximum distance errors.
2. Image linking and dynamic overlay: This criterion compares this classification to the color composite image or to the previous unsupervised or supervised classifications.

Minimum distance classifies image data on a database file using a set of 256 possible class signature segments as specified by signature parameter. Each segment specified in signature, for example, stores signature data pertaining to a particular class. Only the mean vector in each class signature segment is used.

The result of the classification is a theme map directed to a specified database image channel. A theme map encodes each class with a unique gray level. The gray-level value used to encode a class is specified when the class signature is created. If the theme map is later transferred to the display, then a pseudo-color table should be loaded so that each class is represented by a different color.

Minimum Distance Classifier assigns a pixel to the class of minimum distance. Distance measure uses Euclidean distance from pixel to cluster mean.

\[ d_{x,m} = \sqrt{x^2 - m^2} \]

\( x \) is the tested pixel.

\( m \) is the mean value of the cluster.
4.3. Description

The number of pixels used for classification is initialized. It is the product of resolution of x co-ordinate and the resolution of y co-ordinate. The number of bands used in this classification technique is initialized as three. In this processing band refers to red, green or blue. The number of class of images used for classification is initialized as three. The mean values for the three classes of images are assigned. For each class of images three bands of mean values are calculated. The mean values are obtained by summing all the pixel information for a band and dividing by the number of pixels. This mean value is calculated for each band of data. For example the variable mclass[1][2] refers to the mean value for band 2 (green) of class 1 image. Similarly the mean value for different bands for different classes is assigned.

The row value and column value which indicate the location where classification is necessary is used to find the beginning and the end of row value and the beginning and the end of column value for the purpose of classification. If the beginning of row is less than zero it is initialized as zero. Similarly if the beginning of column value is less than zero it is initialized as zero. If the end of row is greater than or equal to y resolution it is initialized as one less than the y resolution. Similarly if the end of column is greater than or equal to x resolution it is initialized as one less than the x resolution. Only for the co-ordinates of row and column beginning and row and column ending the classification is performed.
For each pixel in the selected area the minimum distance is found by comparing all classes using the Euclidean distance measure. The Euclidean distance measure is the sum of the squares of the difference of original image pixel value and the class value. The pixel count is incremented to the respective class to which it is closer.

From the original image the numbers of pixels that fall on the particular class are printed.
4.4. Flow Diagram

Assign the number of pixels, number of bands, number of classes and mean value for various bands of each class.

Initialize the pixel count for all classes as zero.

Assign the beginning of row and column as well as end of row and column for indicating the location for classification using the row and column value specified.

Initialize the minimum distance to be a high value.
For each pixel in the selected area find the minimum distance by comparing all classes using the Euclidean distance measure. Increase the number of pixel count to the respective class to which it is closer.

Print the number of pixels classified under various classes.
4.2. High Level Algorithm

Step 1: Assign the number of pixels, number of bands, number of classes and mean value for various bands of each class.

Step 2: Initialize the pixel count for all classes as zero.

Step 3: Assign the beginning of row and column as well as end of row and column for indicating the location for classification using the row and column value specified (set the boundary location for classification).

Step 4: Initialize the minimum distance to be a high value.

Step 5: For each pixel in the selected area find the minimum distance by comparing all classes using the Euclidean distance measure. Increment the pixel count to the respective class to which it is closer.

Step 6: Print the number of pixels classified under various classes.
4.6. Algorithm for Location-wise classification using the Minimum Distance Technique

Algorithm $\text{locclmindis}(\text{pixels}[], \text{rowval}, \text{colval})$

// pixels – the one dimensional pixel array that contains the pixel value of an image.

// rowval – the row location for classification.

// colval – the column location for classification.

// npix – number of pixels.

// nband – number of bands.

// nclass - number of classes.

// mclass[i][j] – the mean value of each class.

\[ i \text{ – the class number.} \]

\[ j \text{ – the band number.} \]

//nofpix(c )- number of pixels classified under class c.

\[ c \text{ – the class number.} \]

1. \[ \text{npix} = (\text{xres}*(\text{yres}+1)) \];
2. \[ \text{nband} = 3; \]
3. \[ \text{nclass} = 3; \]
4. \[ \text{System.out.println("Total number of pixels in the image : "+npix);} \]
5. \[ \text{int mclass[][] = new int[nclass+1][nband+1]; //minclass(class,band)} \]
6. \[ \text{int nofpix[]} = \text{new int[nclass+1]; //nofpix(class)} \]
7. \[ \text{int band[][] = new int[npix+10][nband+1];} \]
8. \[ \text{int modipix[]} = \text{new int [xres*(yres+1)];} \]
int pix, i, j;

for (c = 1; c <= nclass; c++)
	nofpix[c] = 0;

for (p = 0; p < npix - 1; p++)
{
    modipix[p] = pixels[p];
}

mclass[1][1] = -16796591;

mclass[1][2] = -16770740;

mclass[1][3] = -16796591;

mclass[2][1] = -12945563;

mclass[2][2] = -12927899;

mclass[2][3] = -12945563;

mclass[3][1] = -4541305;

mclass[3][2] = -4555326;

mclass[3][3] = -4541305;

// System.out.println("class selected is "+clas);

rowbegin = rowval - 25;

rowend = rowval + 25;

colbegin = colval - 25;

colend = colval + 25;

if (rowbegin <= 0) rowbegin = 0;

if (rowend >= yres) rowend = yres - 1;
if (colbegin <= 0) colbegin = 0;
if (colend >= xres) colend = xres-1;
k = 0;
for(i = rowbegin; i<=rowend;i++)
for(j = colbegin; j<=colend;j++)
{
  pidx = (j+ xres*i);
  band[k][1] = pixels[pidx];
  band[k][2] = pixels[pidx + 1];
  band[k][3] = pixels[pidx + 2];
  k = k + 1;
}
npix = k;
for( p = 0;p<= npix-1;p++)
{
  MINDIST = 999999999;
  for (c = 1;c<= nclass;c++)
  {
    sum = 0;
    for( b = 1;b<= nbond;b++)
    {
      tband = Math.abs(band[p][b]);
      tmiclass = Math.abs(mclass[c][b]);
    }
if (tband > tmclass)
   d = tband - tmclass;
else
   d = tmclass - tband;
sum = sum + d * d;
}
dist = (long) Math.sqrt(Math.abs(sum));
if (dist < MINDIST)
{
   MINDIST = dist;
   clas = c;
}
nofpix[clas] = nofpix[clas] + 1;
}
System.out.println("Amount of resources like class 1, class 2 and class 3");
System.out.println("Total number of pixels under the selected location "+npix);
System.out.println("CLASS 1 Resource "+norfpx[1]);
System.out.println("CLASS 2 Resource "+norfpx[2]);
System.out.println("CLASS 3 Resource "+norfpx[3]);
}
4.2. Complexity Analysis

The assignments of data in step 1 and step 2 of the high level algorithm take place in constant time (fixed time for execution, whatever may the row and column value, the constant time steps executed in order of $O(1)$). Set the beginning of row and column as well as the end of row and column for indicating the location for classification in step 3 is finished in a constant time. Set the minimum distance to a high value in step 4 is completed in a constant time.

The calculation of minimum distance in step 5 depends upon the number of classes ($c$) selected and the number of pixels ($p$) in the selected area. The pixel count is incremented to the respective class in which it is closer. This depends on the number of classes. So the computing time at this step is $O(cp)$.

Printing the number of pixels classified under various classes in step 6 finished in a constant time.

4.3. Merits and Demerits

The pixels classified under various classes are based on the minimum distance. The result of the classification is a theme map directed to a specified database image channel. A theme map encodes each class with a unique gray level. Simple, efficient, minimum user input is needed to perform classification.
In this method the minimum value of the distance between the image data and the class in multi-feature space is selected.

The minimum distance to means approach results in all pixels being assigned to a class [JS2000].

It is insensitive to different degrees of variance in the spectral response data. It is not sensitive to variance in the training data. This method is not used in applications where spectral classes are close to one another in the measurement space and have high variance.

The minimum distance algorithm allocates each cell by its minimum Euclidean distance to the respective centroid for that group of pixels. Three bands are used in the classification process.

It is possible to have a pixel that in no way resembles any of the classes be assigned to one class using minimum distance classification method. This can result in lower accuracies in the classification [JS2000].
4.9. Sample Result

4.9.1. Description of Results

The results arrived at using the implementation of minimum distance classification near a specific location are presented below for the image named as img-org.

Location-wise classification using minimum distance
Enter the row value used in classification : 100
Enter the column value used in classification : 100
Total number of pixels in the image : 43000
Amount of resources like class 1, class 2 and class 3
Total number of pixels under the selected location 2601
CLASS 1 Resource 1974
CLASS 2 Resource 517
CLASS 3 Resource 110

Location-wise classification using minimum distance
Enter the row value used in classification : 50
Enter the column value used in classification : 225
Total number of pixels in the image : 43000
Amount of resources like class 1, class 2 and class 3
Total number of pixels under the selected location 2601

CLASS 1 Resource 1008

CLASS 2 Resource 1315

CLASS 3 Resource 278

Location-wise classification using minimum distance

Enter the row value used in classification : 200

Enter the column value used in classification : 50

Total number of pixels in the image : 43000

Amount of resources like class 1, class 2 and class 3

Total number of pixels under the selected location 1071

CLASS 1 Resource 58

CLASS 2 Resource 270

CLASS 3 Resource 743

The results of location-wise classification are used to find the resources by specifying the coordinates. The location calculating formula is used to find the related information of pixels from the array of pixel values. The minimum distance classification algorithm is used to find the classification of the resources in an obvious one. This classification is useful for the scientist to find the place where a large amount of valuable resources are available.
4.9.2. Analysis of Results

The classification of the whole image named as img-org using minimum distance classification is shown in table 4.9.2.1. The total number of pixels considered for classification is 43000.

The result indicates that a maximum number of the pixels are classified under class 3 resources. The next maximum numbers of pixels are classified under class 1. Only a minimum number of pixels are classified under class 2.

Table 4.9.2.1. Classification of img-org using the Minimum distance classification technique.

<table>
<thead>
<tr>
<th>Serial No</th>
<th>Class selected for classification</th>
<th>Number of pixels classified</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Class 1</td>
<td>5932</td>
</tr>
<tr>
<td>2</td>
<td>Class 2</td>
<td>2883</td>
</tr>
<tr>
<td>3</td>
<td>Class 3</td>
<td>34185</td>
</tr>
</tbody>
</table>

The classification of the whole image named as fische-ocean using minimum distance classification is shown in table 4.9.2.2. The total number of pixels considered for classification is 25500.
The result indicates that a maximum number of the pixels are classified as fish. The next maximum numbers of pixels are classified as black resource. Only a minimum number of pixels are classified as algae.

Table 4.9.2.2. Classification of fish-ocean using the Minimum distance classification technique

<table>
<thead>
<tr>
<th>Serial No</th>
<th>Class selected for classification</th>
<th>Number of pixels classified</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Black</td>
<td>3901</td>
</tr>
<tr>
<td>2</td>
<td>Fish</td>
<td>19467</td>
</tr>
<tr>
<td>3</td>
<td>Algae</td>
<td>2131</td>
</tr>
</tbody>
</table>

The classification of the image named as img-org in location-wise classification using minimum distance technique is shown in table 4.9.2.3. The location selected for classification is 100,100. The total number of pixels considered for classification in the selected location is 2601.

The result indicates that a maximum number of the pixels are classified under class 1 resource. The next maximum numbers of pixels are classified under class 2. Only a minimum number of pixels are classified under class 3.
Table 4.9.2.3. Location-wise classification of img-org using the Minimum distance classification technique

<table>
<thead>
<tr>
<th>Serial No</th>
<th>Class selected for classification</th>
<th>Number of pixels classified</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Class 1</td>
<td>1974</td>
</tr>
<tr>
<td>2</td>
<td>Class 2</td>
<td>517</td>
</tr>
<tr>
<td>3</td>
<td>Class 3</td>
<td>110</td>
</tr>
</tbody>
</table>

The classification of the image named as fishe-ocean in location-wise classification using minimum distance technique is shown in table 4.9.2.4. The location selected for classification is 50.125. The total number of pixels considered for classification in the selected location is 2601.

The result indicates that a maximum number of the pixels are classified as fish. The next maximum numbers of pixels are classified as algae. The next maximum numbers of pixels are classified as black area.
Table 4.9.2.4. Location wise classification of fishe-ocean using the
Minimum distance classification technique

<table>
<thead>
<tr>
<th>Serial No</th>
<th>Class selected for classification</th>
<th>Number of pixels classified</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Black</td>
<td>402</td>
</tr>
<tr>
<td>2</td>
<td>Fish</td>
<td>1793</td>
</tr>
<tr>
<td>3</td>
<td>Algae</td>
<td>406</td>
</tr>
</tbody>
</table>