Detection of Rooftop Regions in Rural Areas Using Support Vector Machine

Liya Joseph\textsuperscript{1}, Laya Devadas\textsuperscript{2}

\textsuperscript{1}(M Tech Scholar, Department of Computer Science, College of Engineering Munnar, Kerala)
\textsuperscript{2}(Associate Professor, Department of Computer Science, College of Engineering Munnar, Kerala)

ABSTRACT
Rooftop detection in rural areas is an important task in many applications including vegetation identification, land encroachment detection, route planning to rural areas etc. This paper proposes a new approach for rooftop detection using machine learning techniques.

The rural area selected for this study is Munnar in Kerala. In the first step satellite images of Munnar are randomly collected from Google Maps. It consists of both rooftop and non-rooftop images. An initial Support Vector Machine (SVM) classifier is used to detect rooftop images. This rooftop image is segmented into different candidate rooftop regions using k-means clustering algorithm. Then each candidate region is given to a final Support Vector Machine classifier, which predicts the true rooftop candidate.

The performance of this method is evaluated using Mean Square Error (MSE) and Peak Signal-to-Noise Ratio (PSNR). The Results show that proposed method has lower value of MSE and higher value of PSNR compared to existing methods.

Keywords – Feature extraction, Image segmentation, K means clustering, Machine learning techniques, Support Vector Machine

1. INTRODUCTION
In recent years, there has been an increasing demand for rooftop detection due to its variety of applications. All these methods are mainly focus on urban area rooftop detection. But this paper proposes a new approach for rooftop detection in rural areas. In rural areas, the crimes like unofficial settlements in government land, land encroachment are increases day by day. To detect these crimes as well as for the other applications like vegetation identification, change detection, route planning to rural areas based on rooftop density, tourism development can be detected by this new approach.

Section 2 describes related work, section 3 describes proposed method, section 4 describes results and discussions and section 5 concludes the paper.

2. RELATED WORK
Rooftop detection is a tedious task, however many rooftop detection methods are exists. Most of the earlier work on rooftop detection has based on edge detection, corner detection, and image segmentation.

Detection of building with polygonal shapes rooftops [1] is an edge and corner based detection technique. It is based on detecting lines and their intersections using a graph representation. Then find a polygonal shape in the graph which corresponds to loop in the graph. It detects only polygonal shaped rooftops.

An automatic building extraction from remote sensing images [2] is based on both region growing and morphological methods. But this approach could not detect buildings with dark rooftops. Another method based on both edge detection and Hough transform algorithm [3].

The existing methods focus only on detection of rooftops in urban area. But the proposed method mainly focus on detection of rooftops in rural area particularly Munnar at Idukki district in Kerala. Munnar is a hill station area with enchanting range of vegetation. The proposed method is capable of detecting rooftops in urban areas also.

3. PROPOSED METHOD
Proposed rooftop detection system consists of following steps:
3.1 DETECTION OF AN IMAGE AS ROOF TOP OR NON ROOF TOP
In the first step, satellite images of Munnar are randomly collected from Google maps. Initial training dataset consists of both rooftops and non-rooftops images. Then features of input image are extracted and an initial SVM classifier is used to distinguish between rooftop images from the non-rooftop images.

3.2 FEATURE EXTRACTION AND INITIAL SVM CLASSIFICATION
Features are numerical attributes which characterize the object to be classified. So the extracted features are those which hold the properties which can help to distinguish rooftops and non rooftops in an image [6].

In the proposed method, 7 features are considered for classification of rooftop and non-rooftop images. The features are listed below:
1. Area: Area is the number of pixels used to represent a particular segment. This feature helps to distinguish rooftop and non-rooftop segments. This feature filters out objects which are too small or too large.
2. Ratio of Minor to Major Axis Lengths: This is basically the width to length ratio of the segmented regions. Figure 2 shows the minor and major axes of a building rooftop. The minor to major axis ratio for buildings are comparable, whereas this is drastically different for elongated non-rooftop objects such as roads, rivers etc.
3. Variance in intensity: This is the variance of the pixel intensities within a segmented region. A rooftop would tend to be fairly homogeneous in appearance, and as such the corresponding region would also have a lower variance of intensity when compared to non-rooftop region [7].
4. Visible Vegetation Index: Visible Vegetation Index (VVI) is the presence of vegetation. Normally, VVI is calculated for multispectral images. But here for RGB images VVI can be calculated as follows:

\[
VVI = \left[\left(1 - \frac{R - R_0}{R + R_0}\right) \left(1 - \frac{G - G_0}{G + G_0}\right) \left(1 - \frac{B - B_0}{B + B_0}\right)\right]^{\frac{1}{3}}
\]  

Here three variables R, G, B are used to denote the red, green, and blue intensities in the image, whereas \(R_0\), \(G_0\), \(B_0\) are values of red, green, blue used to reference green colour. Where ‘w’ is used to adjust the sensitivity of the scale which is known as weight component.
5. Homogeneity: Homogeneity measures the closeness of distribution of pixels in an image. Values of homogeneity ranges from 0 to 1. For a perfectly homogeneous image the value of homogeneity is 1. Since, rooftop regions are more homogeneous, so they tend to have a high value of homogeneity.
6. Solidity: Solidity can be calculated as the ratio of the total area of a region to the area of the convex hull of the region. Because most rooftops are rectangular in shape, rooftop-related regions in an image are likely to have higher values of solidity.
7. Contrast: Contrast can be defined as the measure of the intensity difference between a pixel and its neighbour pixel over the whole image. Usually rooftop regions in the image are homogeneous, so they tend to have lower contrast.

For each image, the above 7 features are extracted which is the initial data set. This data set and a label matrix are supplied to the initial SVM classifier for training. During training phase, a prediction rule is created. Based on this rule, the new data set is classified either it a rooftop image or non-rooftop image.

**3.3 DETECTION OF ROOFTOP REGIONS IN THE ROOFTOP IMAGE**

The previous step predicts given input image is rooftop or non-rooftop image. If it is a non rooftop image further processing is not possible. Otherwise rooftop image is segmented into four candidate regions using k-means clustering algorithm. And each candidate region is given to final SVM classifier which predicts true rooftop candidate.

3.3.1 Image Segmentation

Image segmentation is the process of dividing an image into various segments based on its colour properties. Image segmentation can be done by using k-means clustering algorithm. The choice of k as 4 gives the best result for these images. The k-means algorithm can be explained here.

3.3.1.1 K-Means Algorithm

The k-means algorithm is used to segment the image into different clusters, where each cluster’s center is represented by the mean value of the objects in that cluster [8].

Input

K denotes the number of clusters.
D is the data set containing n objects
A set of K clusters.

Method

1. Randomly choose K objects from D as the initial cluster centers. Set it as current cluster centroids.
2. For each object in D, compute Euclidian distance with each cluster centroid. And find the cluster center to which the data point having minimum distance, assign that data point into that particular cluster. Finally get k clusters.
3. Find mean value of each cluster.
4. Compare mean cluster centroids and current cluster centroids. If they are equal stop the process. Otherwise go to step 2
5. (re)assign each object to the cluster

6. Stop

Step-wise description of algorithm

1. Initialization
   Initialize K is the number of clusters and D is the matrix form of the image.
2. Assigning Data points into k clusters
   The Euclidian distance is calculated for each centroid from a data point and the data point having minimum distance from the centroid of a cluster is assigned to that particular cluster
3. Centroid Updation
   Find mean value of each cluster, which is the new cluster centroid. And then compare new cluster centroids and previous cluster centroid. If they are equal, this will be final clusters. Otherwise repeat process until convergence. Some convergence conditions are given below:
   - Stopping when reaching a given or defined number of iterations.
   - Stopping when there is no exchange of data points between the clusters.
   - Stopping when a threshold value is achieved.

3.3.2 Feature Extraction and Final SVM Classification

In section 3.2, we discussed about feature extraction. The same procedures are used here. But the features used here are Area, Ratio of Minor to Major Axis Lengths, Variance in intensity, and, Visible Vegetation Index. For each rooftop candidates these four features are extracted, which is the final data set. The data set and label matrix is also supplied to the final SVM classifier for training purpose. During training phase, a prediction rule is created. Based on this rule, it finds true rooftop candidate.

4. RESULTS AND DISCUSSION

DATA: For detecting rooftop regions in rural areas, images gathered from Google Maps were used. Google Maps images are easy to obtain and cost effective. The rural area selected for this study is Munnar in Kerala. Munnar data set consists of 50 images. 25 images are taken as training images and remaining 25 as test images.

Initially, an input image is given to initial SVM classifier. The classifier predicts if it is a rooftop image or non rooftop image. If this image is rooftop image, it will divide into four regions using k-means algorithm. Each candidate regions are shown below as Cluster1, Cluster2, Cluster3, Cluster 4 images.
Then final SVM classifier predicts true rooftop candidate image, which contains most of the rooftop pixels as shown below.

The evaluation metric used here is mean square error and peak signal-to-noise ratio.
<table>
<thead>
<tr>
<th>Evaluation Metrics</th>
<th>Existing Method</th>
<th>Our Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSE</td>
<td>0.3473</td>
<td>0.1171</td>
</tr>
<tr>
<td>PSNR</td>
<td>52.72</td>
<td>57.4458</td>
</tr>
</tbody>
</table>

5. CONCLUSION

This paper presented a new approach for detecting rooftop regions in rural areas using Machine Learning techniques like k-means and SVM. This novel approach initially detected rooftop images from the set of images. Most of the existing methods detect only same color rooftop regions. But this new approach detects rooftops of any color.

Applications of detecting rooftop regions in rural areas are vegetation identification, land encroachment detection, route planning to rural areas etc.

In future, this can be done as an online application to detect rooftops.

REFERENCES


