Detection of Tree Crown from Satellite Imagery using Object Based Image Examination

Sujata R. Kadu, Balaji G. Hogade, Imdad Rizvi

Abstract: Detection and delineation of individual tree mainly depends on high resolution satellite images or LiDAR data. Urban green structure, specially urban tree plays a key role in enhancing the life of people. Now a day’s more than half of population is leaving in cities and urban areas. Methods to quantify and monitor trees are not efficient. The traditional methods for forest survey and ground survey are complex because of changes occur in urban environment. The objective of this research is to extract vegetation using colour based and decision tree method, which can be further sub-classify to obtain area under tree canopy. The results obtained through Object Based Image Analysis (OBIA) method are also compared with existing Gaussian Mixture Model (GMM) method. The overall accuracy achieved thereby is 93.85% using Decision tree-multiresolution segmentation and 93.31% using Decision tree-GMM method.

Keywords: object based image analysis, decision tree, colour based segmentation, Gaussian mixture model, multi resolution segmentation.

I. INTRODUCTION

The vegetation is the primary factor which affects the environmental conditions. Urban ecosystem depends on accurate mapping and monitoring of vegetation [1]. The lack of fresh water resources increases the water demands. In 2019, inadequate amount of water affects every continent and it is one of the largest global risks over the next decade [2]. Global risk occurs because of world population, changing consumption pattern and deforestation. Planting trees is one of the efficient methods for increasing the level of ground water. Study shows few plants are helped to increase the ground water level through root system e.g. Ashok tree, Neem tree, Imli tree and Jamun tree etc. Various algorithms have been introduced to map and monitor urban canopy [3]. Different algorithms are available for extraction of urban tree canopy. Segmentation is one of the methods for extraction of urban vegetation [4]. Different models like fuzzy model, water shade model, multi resolution segmentation etc. are used for segmentation. Multiresolution water shade transform based image segmentation has been used, followed by modified CBF which improves classification accuracy [5].

Textured is one of the criteria for extracting information from imagery [6]. There are different methods available [7] but the most popular is statistical approach. In this research object-based multi resolution method is used for tree mapping. This paper deals with colour based segmentation and decision tree algorithm, for extraction of vegetation. This vegetation further classifies, with the help of multi resolution segmentation to extract the tree canopy. In this research GMM method is also employed to compare with proposed methodology. This paper is organized as follows: section 2 presents propose methodology, section 3 discuss experimental results and discussion. Conclusion follows in section 4.

II. PROPOSED METHODOLOGY

Gaussian Mixture Model:

In real life, many data sets are modelled by Gaussian distribution, so it is natural to assume that clusters came from different Gaussian distribution. In GMM method, pixel of each image is considered as a random variable. Density function of random variable is a Gaussian mixture [8]. In GMM method most of the data sets are modelled by Gaussian distribution, so most of cluster comes from Gaussian distribution. In this research, GMM model is used with iterative Expectation Maximization (EM) algorithm for extraction of tree canopy.

EM algorithm is used for parameters calculation although there is no any closed form solution. This algorithm has wide applications, which includes automatic speech recognition, data clustering, infectious disease tracking etc. The expected maximum algorithm estimates probability density function, from incomplete data. It also called as an iterative maximum likely hood estimation method to estimate parameters from complex data. The main goal of EM algorithm is to estimate maximum likely hood function with the parameters mean ($\mu_j$), covariance ($\Sigma_j$) and mixing coefficient ($\pi_j$).

Standard EM algorithm performs following steps [9].

**E - Steps:** Estimate the value of latent variables.

$$\gamma_j(x) = \frac{\pi_k \phi(x | \mu_k, \Sigma_k)}{\sum_{m=1}^{K} \pi_m \phi(x | \mu_m, \Sigma_m)}$$

(1)

**M-Steps:** Update the value of parameters.

$$\mu_j = \frac{\sum_{n=1}^{N} \gamma_j(x_n) x_n}{\sum_{n=1}^{N} \gamma_j(x_n)}$$

$$\Sigma_j = \frac{\sum_{n=1}^{N} \gamma_j(x_n) (x_n - \mu_j)(x_n - \mu_j)^T}{\sum_{n=1}^{N} \gamma_j(x_n)}$$

(2)

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\[
\Sigma_j = \frac{\sum_{n=1}^{N_j} (X_n - \mu_j)(X_n - \mu_j)^T}{\sum_{n=1}^{N_j} (X_n)}
\]  

(3)

\[
\pi_j = \frac{1}{N} \sum_{n=1}^{N} \gamma_j \left( X_n \right)
\]  

(4)

Evaluate log-likelihood

\[
\ln p(X | \mu, \Sigma, \pi) = \sum_{k=1}^{K} \ln \pi_k \ln \mathcal{N} \left( X_n | \mu_k, \Sigma_k \right)
\]  

(5)

**Algorithm:**

1. **Step 1:** Initialize the mean, covariance and mixing coefficient.
2. **Step 2:** Compute the latent variables for all K clusters.
3. **Step 3:** Again compute all the parameters using the current values.
4. **Step 4:** Compute log-likelihood function. If a log-likelihood function gives the same value then stop, else return to Step 2.

**Multi resolution segmentation:**

Image segmentation is the first step in object based image analysis method. It is the process of separating image into non-overlapping region. In other words, segmentation is the process of partitioning based on its parameters, such as homogeneity and heterogeneity [10]. There are different image segmentations techniques available [11]. One of the import techniques is region based. Region based technique is based on some regions property, depends on application. This segmentation may refer as spatial clustering. Spatial means pixels in the same category form a single connected component. Clustering means pixel with same values group together to form a cluster [12]. These regions are formed by certain methods like two neighbouring regions that do not have any common property [13-14]. Each region must have uniform conditions, there is overlapping of pixels because each pixel is belongs to single region. Region based segmentation is categorized into two different methods, ‘region growing’ and ‘region merging’. 

![Flowchart for proposed methodology used for UTC extraction](image)

**Decision tree classifies:**

A decision tree is a flow chart that divides data into smaller subdivisions on the graphical methods, modelling the decision sequence, simulating random events and results [15]. This method takes binary decision on pixels to place pixels into classes. Here each class is divided into more classes based on their feature selection and defines as many decision nodes as needed. The construction of decision tree classifier does not require any domain knowledge so it is appropriate imagery classification [16]. As mentioned in paper, decision tree classifier gives good accuracy. Decision tree has several advantages over traditional supervise classification procedure using remote sensing such as clustering and maximum likelihood algorithm.

This procedure involves three steps splitting nodes, determining which nodes are terminal nodes and assigning class label to terminal node. Decision tree is a tree where each node represents a feature (attribute), each link (branch) represents a decision (rule) and each leaf represents an outcome. Decision tree is build from training data set which consists of objects each of which is completely describes by set of attributes and class label. Attributes are collection of properties containing all the information about one object. This attributes forms internal node of a decision tree while the values of this attributes represents the branches of a tree. Leaf node represents a class of a classifying attributes. Several methods have been proposed to construct decision tree. This algorithm generally uses the recursive partitioning.
concept and its input required a set of training
e.g. a splitting rule and a stopping rule.
Decision tree works well for large amount of
data with lesser time, they are known for their
good performance against larger data sets.
Decision tree is one of the fastest ways to
identify most significant variables and relation
between two or more variables.

III. RESULTS AND DISCUSSION

Figure 2. Original Image[17]

Figure 3. FCC of Original Image

Figure 4. UTC Detection using colour base-GMM

Figure 5. Confusion Matrix

Figure 6. Accuracy and Kappa coefficient

Figure 7. UTC Detection using colour base-multi resolution

Figure 8. Confusion Matrix

Figure 9. Accuracy and Kappa coefficient
Table 1. Comparison of Multiresolution and GMM Model with Colour base method

<table>
<thead>
<tr>
<th>Parameter/Method</th>
<th>TP</th>
<th>TN</th>
<th>FP</th>
<th>FN</th>
<th>FPR</th>
<th>Recall</th>
<th>Precision</th>
<th>'F1-Score'</th>
<th>Accuracy</th>
<th>Kappa Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour base-multiresolution</td>
<td>7757</td>
<td>736123</td>
<td>876123</td>
<td>49244</td>
<td>0.1064</td>
<td>0.6117</td>
<td>0.4694</td>
<td>0.5312</td>
<td>0.8560</td>
<td>0.4578</td>
</tr>
<tr>
<td>Colour base –GMM</td>
<td>7795</td>
<td>735356</td>
<td>88459</td>
<td>48869</td>
<td>0.1074</td>
<td>0.6147</td>
<td>0.4684</td>
<td>0.5317</td>
<td>0.8555</td>
<td>0.4481</td>
</tr>
</tbody>
</table>

Figure 10. UTC Detection using Decision Tree - GMM model

Figure 11. Confusion Matrix

Figure 12. Accuracy and Kappa coefficient

Figure 13. UTC Detection using Decision Tree - multiresolution segmentation

Figure 14. Confusion Matrix

Figure 15. Accuracy and Kappa coefficient
Table 2. Comparison of Multiresolution and GMM Model with Decision Tree

<table>
<thead>
<tr>
<th>Parameter/Method</th>
<th>TP</th>
<th>TN</th>
<th>FP</th>
<th>FN</th>
<th>FPR</th>
<th>‘Recall’</th>
<th>Precision</th>
<th>‘F1-Score’</th>
<th>‘Accuracy’</th>
<th>Kappa Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decision Tree - Multiresolution</td>
<td>82062</td>
<td>810065</td>
<td>13750</td>
<td>44758</td>
<td>0.0167</td>
<td>0.6471</td>
<td>0.8565</td>
<td>0.7372</td>
<td>0.9385</td>
<td>0.7031</td>
</tr>
<tr>
<td>Decision Tree - GMM</td>
<td>77002</td>
<td>810025</td>
<td>13790</td>
<td>49818</td>
<td>0.0167</td>
<td>0.6072</td>
<td>0.8481</td>
<td>0.7077</td>
<td>0.9331</td>
<td>0.6711</td>
</tr>
</tbody>
</table>

IV. CONCLUSION

For the purpose of conducting this research, we consider the Google image of urban area of Powai. Here, vegetation detection using segmentation methods such as colour base and decision tree has been carried out. Subsequently within the area of detected vegetation, area of tree canopy is detected and segmented. The overall accuracy achieved thereby is 93.85% by Multiresolution Segmentation with Decision tree and 93.31% using GMM model with Decision tree. LIDAR data gives intensity and height information, so with this data more accurate results can be obtained.

REFERENCES
