Image Object Classification and Identification using Soft Computing Tolls: A Review

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Abstract

Aerial photography is an important option using which we can obtain the information related to land use and land cover. Remote sensing is one form of aerial photography in which the information extraction is done using the technique known as classification. Classification can be easily performed by the human eye but is a challenging task for the machines. The advancement in capacity of the computer and increase in the need for automatic image and video analysis has lead to an increased development in the object classification algorithms. This paper reviews some of the classification algorithms such as maximum likelihood, kNN and probabilistic neural networks, widely used at present.

Keywords: Maximum likelihood, kNN and Probabilistic Neural Network (PNN)

I. INTRODUCTION

An important criterion for the land use and land cover information is to have sufficient information of the earth's surface. The accuracy with which this information is obtained decides the reliability rate of the decisions and in turn the results obtained.

Human eye is sensitive to the visible region of the electromagnetic (EM) spectrum whereas the machines can work with any region of the EM spectrum. Thus the satellite images have gained a lot of attention due to their wide spectrum. The extraction of information from these multiband satellite images is an important task. Classification is one of the best methods to extract the information from the satellite images.

Classification is the process of differentiating the different feature in an image and grouping the similar ones together and assigns a label to each group. This classification is carried out using a classification system, the input to which is the raw satellite data and the output produced is the distinguished classes or themes, different land use and land cover areas present in the input. The identification of the different classes is done on the basis of the features extracted that may be spectral, spatial or texture features.

The main goal of soft computing here is to obtain results close to human decisions. And find an answer to an imprecisely/precisely formulated problem received from the satellite data.

II. RELATED WORK

1) Paper [1] says that the classification is the process of separating and labelling the different objects in an image. The different classification algorithms described here are decision tree, support vector machine (SVM), Artificial neural network (ANN).
2) Paper [2] describes the need for the development of the classification. Image classification involves the following steps image acquisition, preprocessing, feature extraction, model selection and training, evaluation.
3) Paper [3] proposes a new classification method using mapping technique for high spatial resolution images. Image can be classified on the bases of pixels or objects in an image. The mapping technique combines both the pixel based and object based classification using the mapping technique to get the classification results.
4) Paper [4] proposes the classification of LISS -3 images using the probabilistic neural network. The classification accuracy is analysed using the kappa coefficient and confusion matrix.
5) Paper [5] gives an overview of the emerging deep learning concept in neural networks. Supervised and unsupervised learning is explained in this paper.

III. METHODOLOGY

The different objects in an image transmit different electromagnetic radiations depending on the molecular components present in those objects this radiation is captured by the sensor and the corresponding spectral signature is obtained by measuring the radiation over a broad spectral band. This spectral signature is used to differentiate among the different classes in the image. The complete classification system has the following components (figure 1).

A. Data Acquisition:

One important requirement of the classification systems is to have enough amount of the required data. That is atleast 10 times more the data used for training.

B. Preprocessing:

Preprocessing is another essential step in image processing. This involves noise removal using filtering and conditioning techniques. Normalisation is one technique used for conditioning.

C. Feature extraction:

The main function of feature extraction is to find the features of the target object which are unique and will help in separating it from the rest unwanted objects.

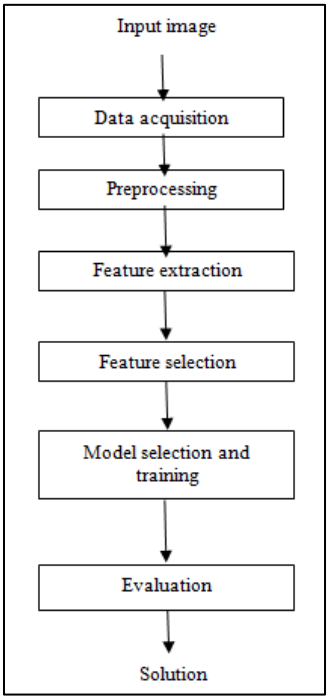

Fig. 1: Steps Involved In Pattern Recognisation

D. Feature Selection:

The feature selection, is a process in which a subset of the extracted features which are most unique are selected.for example,selecting the most unique ‘p’ features out of the possible ‘x’features.

E. Model Selection and Training:

In this step we determine a function that will map the given x-dimensional input to the correct encoded class information.The optimization algorithms are an option of the mathematical tools that can be used if the classification is considered as a function approximation problem.

F. Performance Evaluation:

For performance evaluation, the data collected for the required target is divided into two sets i.e., the training set and the testing set. Training set is used to train the algorithm and the testing dataset is used to test the algorithm.

IV. IMAGE CLASSIFICATION TECHNIQUES

The image data classification involves two steps. The first step is to construct a classifier by using a training dataset .The second step is the testing stage. Here we determine the classification accuracy using the testing dataset. Here we discuss some of the classification techniques such as maximum likelihood, k-NN, and probabilistic neural network.

A. Maximum Likelihood:

Maximum likelihood allows the parameters of the image to be considered as values which are fixed but not known. The possibility of getting the particular set data from a given selected probability distribution model ,is said to be the likelihood of that data. The unknown values due to which the sample likelihood maximizes is considered to be the "maximum likelihood estimates(MLE)" (figure 2).
The posterior probability of a pixel belonging to class 'k' is called the likelihood 'Lk' and it is given as follows,

$$Lk = P\left(\frac{k}{X}\right) = P(k) * \frac{P\left(\frac{X}{k}\right)}{\sum(P(i)*P\left(\frac{X}{i}\right))} \quad (1)$$

Where P(k) = prior probability of class k
P (X/k) = conditional probability to observe X from class k, or probability density function.
Thus P(X/k) is the variable on which the likelihood 'Lk' depends. This is the probability density function. For normal distribution ,the likelihood function is said to be as follows.

$$L_k(\mathbf{X}) = \frac{1}{(2\pi)^{\frac{n}{2}}|\boldsymbol{\Sigma}_k|^{\frac{1}{2}}} \exp\left|-\frac{1}{2}(\mathbf{X}-\boldsymbol{\mu}_k)\boldsymbol{\Sigma}_k^{-1}(\mathbf{X}-\boldsymbol{\mu}_k)^t\right| \quad (2)$$

Where n=number of bands
X=image data of n bands
$L_k(X)$ = likelihood of X belonging to class k
μ_k = mean vector of class k
$\sum_k$ =variance-covariance matrix of class k
$|\sum_k|$=determinant of $\sum_k$
Some of the requirements of the maximum likelihood method are

1) For the mean vector and variance-covariance matrix computation, sampling of enough amount of ground truth data is required.
2) When two bands are highly correlated or the ground truth data are homogeneous, then the principal component analysis is used to reduce the number of bands.
3) Maximum likelihood method is used when the distribution is not normal.

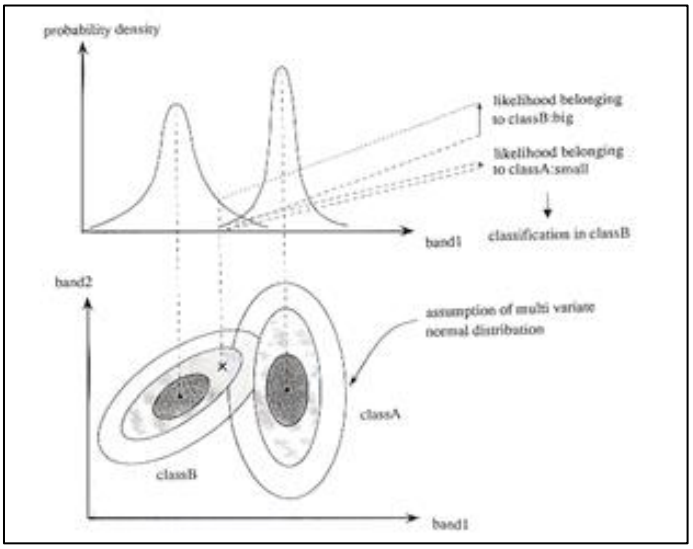

Fig. 2: Concept of Maximum Likelihood Method

B. K-Nearest Neighbor:

KNN is a simple classification method with good accuracy. It depends on the majority vote of the k-nearest neighbour classes. Thus the result can be considered as the best fit class for that point. For example if k = 5, the algorithm will take a call of its 5 nearest neighbour. Consider the figure (3a) here the point X belongs to class 3. If k = 5 as in figure (3b) the point X belongs to class 1 because of the majority vote from the five nearest points. Euclidean distance is the parameter used to determine the distance between the target point and cases from the example classes

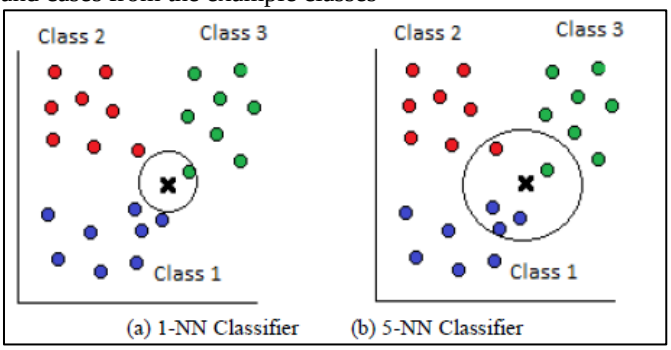

Fig. 3: K-Nearest Neighbour Classification

C. Probabilistic Neural Network:

Application of neural network plays a major role in image classification. Probabilistic neural network (PNN) is one widely used neural network. The PNN architecture is as shown in figure (4). It consists of interconnected processing units also called as neurons arranged in layers one after the other. The input layer simply forwards the given input to the pattern layer and does not take part in any computation.

Suppose the input given to the pattern layer neuron 'xij' is 'x'. The pattern layer output is

$$\frac{1}{(2\pi^{d/2})\sigma^d} exp\left[\frac{-(x-x_{ij})^T(x-x_{ij})}{2\sigma^2}\right] \qquad (3)$$

Where d = dimension of the feature vector 'x'

σ = smoothing parameter.

The summation layer neuron determines the maximum possibility of pattern 'x' being classified into 'C_i'. Thus summing the output of all the neurons belonging to the same class.

$$\frac{1}{(2\pi)^{\frac{d}{2}}\sigma^d}\frac{1}{N_i}\sum_{j=1}^{N_i} exp\left(\frac{-(x-x_{ij})^T(x-x_{ij})}{2\sigma^2}\right) \qquad (4)$$

Where N_i= total number of samples in class 'C_i'.

The decision layer uses the Bayes's decision rule for the classification of output obtained from the summation layer.

$$C(x) = \arg\max \{p_i(x)\} \quad ; i = 1,2,..,m \qquad (5)$$

Where C(x) = estimated class of pattern x.

m = total number of classes in the training samples.

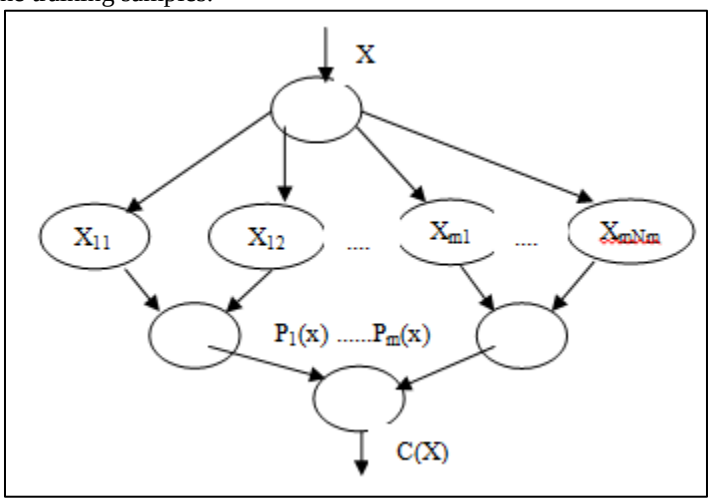

Fig. 4: Diagram of PNN

V. CONCLUSION

For earth monitoring programs an important source of input is the remote sensing and needs access to the entire database. Thus it is known as lazy learning images. The remote sensing images are an easy source of update of the vegetation inventories spread over a large area. Thus the paper gives a review some of the classification algorithms used for the study of the satellite images.

The kNN, classifies an unknown instance only on request for the processing or memory based learning and is in contrast to the eager learning algorithms such as the neural networks in general. Maximum likelihood is used across several stress cells and approximation of the model parameters is done during the life distribution parameters. As the sample size increases the Maximum likelihood function makes the minimum variance estimators unbiased.

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