Multi-sensor Satellite Image Analysis Using Niche Genetic Algorithm for Flood Assessment

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Abstract. In this paper, cluster splitting and merging algorithms are used for flood assessment using LISS-III (before flood) and SAR (during flood) images. Bayesian Information Criteria (BIC) is used to determine the optimal number of clusters. Keeping this constraint, the cluster centers are generated using the cluster splitting techniques, namely Mean Shift Clustering (MSC), and Niche Genetic Algorithm (NGA). The merging method is used to group the data points into their respective classes, using the cluster centers obtained from the above techniques. These techniques are applied on the LISS-III and SAR image. Further, the resultant images are overlaid to analyze the extent of the flood in individual land classes. A performance comparison of these techniques (MSC and NGA) is presented. From the results obtained, we deduce that the NGA is efficient.

1 Introduction

Floods cause extensive loss of life, land and property, and hence it is imperative that an effective flood assessment model be developed to help gather information about the occurrence and damage caused by floods. Present methods employ satellite image classification to extract flood prone regions [1].

Optical sensors of the satellites are used to obtain the image of the region prior to the flood. But such sensors are dependent on illumination by the sun, and there is also a possibility of misinterpretation of land cover map under the cloudy weather conditions [2]. However, Synthetic Aperture Radar (SAR) images have the capability of distinguishing between the land cover even during the unfavorable weather conditions because of its active sensor system which uses dipolar effect to acquire the image [3]. Hence, SAR images are used to analyze the land during flood. The optical image is classified according to the various distinct types of land cover [4] and SAR images help to determine the flooded and unflooded regions [5].

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Different methods have been developed to cluster data sets by splitting and merging. Broadly, they can be classified into parametric and non-parametric methods. In parametric methods such as K-means [6], a prior assumption of the number of clusters is required. In non-parametric methods such as Mean Shift Clustering (MSC) (which use single point for locating local maxima) [7], [8], no prior assumptions is made on the number of clusters.

Recently, researchers are interested in locating multiple local optima of a given multi-modal function in a *d*–dimensional search space. For this purpose nature inspired techniques [9] are used. In Niche Genetic Algorithm (NGA) [10], Genetic Algorithm [11] is modified by using niching technique [12] to locate the multiple modes within the search space. Brits et al. [13] developed Niche Particle Swarm Optimization (NPSO), which is a variant of Particle Swarm Optimization (PSO) [14], [15]. Many researchers have successfully applied niche technique to obtain local optima [16], [17].

In this paper, we use cluster splitting and merging techniques namely MSC and NGA, for flood assessment using satellite images. The images used are LISS-III (before flood) and SAR (during flood). LISS-III image is used to analyze the condition prior to the flood. On the other hand, SAR image is used to assess condition during the flood. We classify these images by using cluster splitting and merging techniques. The main challenge here is to optimally split the cluster centers and group (merge) the data set into their respective classes. The care has been taken to split the complex large data set into a number of cluster centers by satisfying Bayesian Information Criteria (BIC) [18], which is commonly used in model selection. We combine the classified LISS-III and SAR images to estimate the extent of land cover affected by the flood. A comparative study of these techniques is done to analyze their performance.

2 Methodology

Clustering involves sub-division of the data set into clusters based on some similarity metrics. In this study, MSC and NGA algorithms are applied. These techniques make use of kernel functions for locating maxima for a given set of discrete data points.

2.1 Splitting Methodology

For large data sets, it is difficult to determine the number of clusters required, as it depends on the distribution of the given data. Bayesian Information Criteria (BIC) is a model fitting approach, which provides the optimal number of clusters. The splitting of data set using BIC into number of clusters is given by

$$BIC = L(\theta) - 0.5*k_j*\log(n) \tag{1}$$

where $L(\theta)$ is the log-likelihood measure for the data set, k_j is the number of free parameters for the specific number of clusters and n is the number of data points for a given data set.