A New Semi-Automated Flood Detection Using Fuzzy Rule-Based Classification

S. Ranjini

Assistant Professor Department of Computer Applications AJK College of Arts and Science, Coimbatore, Tamilnadu, India

ABSTRACT: Image Processing is a technique to develop raw images received from cameras/sensors located on satellites, space probes and aircrafts or pictures taken in normal day-to-day life for various applications. Image Processing systems have easy availability of powerful personnel computers, large size memory devices, graphics software etc. In this present work, image processing is used with fuzzy set theory to detect flood areas.

Keywords: sensors, image processing, flood detection, fuzzy set theory

I. INTRODUCTION

Remote sensing is the measurement of the acquisition of data about the Earth's surface with no contact with it. This is complete by sensing and recording reflected or emitted electromagnetic radiation. Remote sensing involves analyzing and applying that information.

Floods are among the most critical natural disasters worldwide. Flood mapping is an initial step in flood disaster management. The main objective of this work is to propose an efficient methodology to recognize and map flooded areas by using TerraSAR-X imagery. First, a TerraSAR-X satellite image was captured during a flood event to map the inundated areas. Multispectral Landsat imagery was used to detect water bodies prior to the flooding. In the base work Object-oriented classification and Taguchi method were used for flood detection. In this approach the differences in the spatial resolutions in Landsat and TerraSAR-X images made few mis-classifications in the boundary of the water bodies such as river. And Taguchi method only dealt with a three parameter in this wok and the multi number parameter has obtained limitation.

In this technique we apply fuzzy set theory to multiple parameter decision making. The procedure can reduce the uncertainty for determining a weight of each response and it is a universal approach which can simultaneously deal with continuous and discrete parameter. Multiple parameter decision making (MPDM) involves the selection among some alternatives each having multiple, usually conflicting, parameters. To observe the efficiency of the proposed method, iterative self-organizing data analysis technique (ISODATA) classification method was applied on TerraSAR-X after employing the segmentation process and the results were compared.

II. METHODS AND MATERIAL

In the first stage, preprocessing was done for both images of Landsat and TerraSAR-X. Speckles were removed from TerraSAR-X using ISODATA method. Gap filling and pan-sharpening were applied for Landsat imagery in order to solve the problem of gaps in Landsat and increase the spatial resolution of this data. In order to perform object-oriented rule based classification schemes, two main steps should be done. The first stage is segmentation, which defines the boundary of the objects. Here, Taguchi optimization technique was used in order to find the optimum segmentation combination. In the second stage, rules were defined, and classification was done based on the derived rules. Three classes of vegetation, water, and urban were produced using the Landsat image. Similarly, TerraSAR-X was classified into two classes of water and non water bodies. By subtracting the two classes of water bodies from Landsat and TerraSAR-X, flooded areas were extracted. As a last step, validation was done using a confusion matrix, and reliability of flooded area map was assessed.

In the existing approach the differences in the spatial resolutions in Landsat and TerraSAR-X images made few misclassifications in the boundary of the water bodies such as river.

Taguchi method only dealt with a three parameter in the existing wok and the multi number parameter has obtained limitation.

To overcome the above drawbacks we apply fuzzy set theory to multiple parameter decision making. The procedure can reduce the uncertainty for determining a weight of each response and it is a universal approach which can simultaneously deal with continuous and discrete parameter.

Multiple parameter decision making (MPDM) involves the selection among some alternatives each having multiple, usually conflicting, parameters. From a practical viewpoint, the number of alternatives is predetermined in the MPDM problems. The term 'parameter' is referred to as a 'goal' or a 'criterion'.

This improves the segmentation accuracy than taguchi optimization approach.

This approach dealt with multiple parameters. So it gives efficient results when compared to existing approach.



Figure1. Process of flood mapping detection

III. RESULTS AND DISCUSSION

Image preprocessing

In this module, the preprocessing of Landsat and TerraSAR images are performed. The gaps in Landsat imagery must be filled, and the image must undergo pan-sharpening. The local linear histogram matching method filled the scan gap in the Landsat imagery. A scan gap mask was produced for each band that displays existing data as 1 and that denotes the missing data in the scan gap and areas to be filled by 0. Moreover, the Landsat imagery was pan-sharpened using the Gram-Schmidt (GS) spectral sharpening method. The spatial resolution of the Landsat image was 30 m; however, this method can improve this spatial resolution by merging the high-resolution pan image with the bands of low spatial resolution. Therefore, the spatial resolution of Landsat was enhanced to 15 m after pan-sharpening. Speckles should be removed from the TerraSAR-X image using Frost filter.

Segmentation based on fuzzy rule based decision

In this module, multiple parameters such as scale, color, shape, texture, position and segments should be defined properly to recognize flooded areas. Segmentation is the first stage in object-oriented analysis, and it partitions an image into non-overlapping regions. Segmentation precision significantly influences the quality of the final classified map. Therefore, this module used the fuzzy multiresolution segmentation algorithm. It began with one pixel and progressed until all of the criteria were fulfilled. This type of segmentation was achieved through parameters such as scale, color, shape, texture and position, which generate more than 300 combinations for segmentation. The fuzzy set theory technique can acquire the optimum combination of segmentation parameters to find the better segmentation precision.

Classification

Rule-based classification aims to enhance feature classification precision. Moreover, a user can create and flexibly manipulate rules until the best classification results are obtained. The necessary rules were manually defined according to the segment attributes of both images. Based on the rules, system segments and classifies the water and non water contents.

Performance comparison

The performance of Taguchi method and fuzzy set theory techniques are compared by using the following metrics,

- Overall Accuracy
- User Accuracy
- Producer Accuracy
- Kappa Accuracy

The performances are evaluated through the accuracy, precision, Recall and F-measure values.

A. Accuracy

The accuracy is the proportion of true results (both true positives and true negatives) among the total number of cases examined. The formula to find accuracy value is as follows

$$Accuracy = \frac{\text{TP} + \text{TN}}{\text{TP} + \text{TN} + \text{FP} + \text{FN}}$$

B. Precision

Precision value is calculated according to the feature classification at true positive prediction; false positive. It is expressed as follows:

$$Precision = \frac{True \ positive}{True \ positive + False \ positive}$$

C. Recall

Recall value is calculated according to the feature classification at true positive prediction, false negative. It is given as,

$$Recall = \frac{Truepositive}{(Truepositive + Falsenegative)}$$

D. F-Measure

F-measure is considered from the precision and recall value. It is calculated as:

$$f - measure = 2 \times \left(\frac{precision \times recall}{precision + recall}\right)$$

IV. CONCLUSION

The differences in the spatial resolutions in Land sat and TerraSAR-X images made few misclassifications in the boundary of the water bodies such as river by using the Taguchi optimization algorithm. In this technique we apply fuzzy set theory to multiple parameter decision making. The procedure can reduce the uncertainty for determining a weight of each response and it is a universal approach which can simultaneously deal with continuous and discrete parameter. Multiple parameter decision making (MPDM) involves the selection among some alternatives each having multiple, usually conflicting, parameters. The experimental results show that proposed system is efficient than existing system.

In future work Planners and researchers can therefore use the derived maps to study flood susceptibility, hazard, and risk mapping further and also improve the identification of flood using artificial neural network.

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