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Analysis of Water Quality Using Adaptive Superpixel Method

M.Shobia, P.Sindhuja, D.Soundhar,

Dept. of ECE, Builders Engineering College, Tirupur, Tamilnadu, India

ABSTRACT: Water is one of the most essential resources of our environment. The water bodies often face the quality issue because of many pollutants like chemical wastes, wastes from power plants etc. In this method satellite images have been considered, from which water portion have been separated for water quality analysis using adaptive superpixels, entropy, mean error, standard deviation comparisons. Superpixels are the group of pixels which have similar properties such as color, texture or other low level features. As the pixels do not represent any natural entities we go for superpixels because they adhere well to the boundaries of natural entities. Water body can be finally classified based on the standard values.

KEYWORDS: Adaptive superpixels, Segmentation, Feature extraction, Quality analysis.

I. INTRODUCTION

Water is a precious element in our environment but it gets affected when mixed with various pollutants like wastes from chemical and dying industries, oil industry wastes. When these pollutants get mixed with the water of the sources like lakes, acquifers, rivers, oceans etc it necessitates periodic testing of these water bodies. In this method the concern of regular quality testing of water bodies has become an issue.

Satellite images have been selected for detection of water body from it and for quality assessment of the water body which is detected. Generally, three common techniques have been employed to separate the water body from the chosen satellite image. They are 1. Supervised classification technique 2. Unsupervised classification technique 3. Object based classification technique. In supervised classification the user supervises the pixel classification process and specifies the various pixel values or spectral signature that should be associated with each class. This is done by selecting representative sample sites of known cover type called training sites. Then computer algorithm classify the whole image based on the spectral signatures.

In case of unsupervised classification technique the pixels are first grouped into clusters based on the properties. In order to create clusters, analysts use image clustering algorithms such as k-means and ISODATA. The clustering is a process of organizing objects into groups whose members are similar in some way. In the object based classification technique the pixels are categorized based on the spatial relationship with the surrounding pixels. This technique is based on the information from a set of similar pixels called objects.

After the technique has been chosen for detection of water body the feature which is the basis of separating water body can be considered. Different reflectance values cam be used to detect the water portion in the surface. The values of reflectance may vary depending on the physical properties.

II. SEGMENTATION

Adaptive superpixel segmentation focuses on the color difference based on a standard and the weights of different features are automatically adjusted depending on the discriminabilities in different images. It is an iterative and adaptive algorithm. The task of segmenting an image into superpixels is widely referred to as oversegmentation of an image. Superpixels may have different properties which first of all impose a visual difference. The basic requirements of superpixels are superpixels should respect object boundaries, Superpixels should be generated as efficiently as

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possible, Superpixels should not lower the achievable performance of subsequent processing steps. Superpixels are often categorized as either graph based methods or gradient ascent methods. Both expect a color image I: W x H $\rightarrow$ R^3, W x H= {1,….,W}, with width W, height H and N=WH pixels to be given and aim to generate a superpixel segmentation,

$$S= \{S_1,\ldots,S_k\}$$

For this superpixel segmentation to be valid we demand the superpixels S_i to represent connected components. Additionally, we enforce the superpixels to be disjoint and resemble the whole image.

Adaptive superpixel method is based on a linear iterative algorithm which can be categorized as a gradient ascent method growing superpixel from initial superpixel centers using color similarity and spatial proximity and the pixels clustering is done in the direction where the change of gradient occurs quickly in each direction. It performs a local clustering where the search space is restricted to a local neighborhood around its center. The approach is easily implemented and adapted to custom needs as the weights are set automatically it is not a too much time consuming process.

III. FEATURES AND DISTANCE MEASURE

We propose a method which represents each pixel in the CIELCH where, L indicates lightness, C indicates Chroma and H indicates Hue respectively. While converting the color space from CIELAB to CIELCH vector the lightness will remain unchanged while chroma and hue represents the polar coordinates. The color difference d_c is calculated by,

$$d_c= \sqrt{(\frac{\Delta l}{k_l s_l})^2+(\frac{\Delta c}{k_c s_c})^2 + (\frac{\Delta h}{k_h s_h})^2}$$

where $\Delta l, \Delta c$ and Δh represent the differences of lightness, chroma and hue between two pixels whereas, k_l, s_l, k_c and k_h are constants while s_c and s_h can be computed regarding the compared pixel values.

Spatial distance d_s is calculated by using the distance which is measured between the pixel coordinates known as Euclidean distance.

$$d(p,q) = d(q,p) = \sqrt{(q_1-p_1)^2+(q_2-p_2)^2+\cdots+(q_n-p_n)^2} = \sqrt{\sum_{i=1}^{n}(q_i-p_i)^2}. \quad \text{------------------(1)}$$

Image gradient which is used to measure the directional intensity changes in a given image and the magnitude of which is calculated by means of square root of the sum of squared directional changes of intensity. In this method we denote the magnitude of the gradient by g and calculate it in the lightness domain as the human eye is very sensitive to the light and the difference in gradient is denoted as d_g.

Weber local descriptor is used to extract the local features of the image. The feature is calculated as a ratio comprises of two terms which are the difference in light intensity of the current pixel with the surrounding pixels and the lightness of the current pixel. The texture difference is denoted as d_u. By comining all the features (color, gradient, texture, contour and spatial) the pixels can be represented and the distance between the pixels can be measured by,

$$D= \sqrt{w_c(d_c)^2+ w_s(d_s)^2+ w_g(d_g)^2+ w_u(d_u)^2}$$

Where w_c, w_g and w_u are the corresponding weights for d_c, d_s, d_g and d_u respectively.

The discriminabilities of different features are compared and then the measure has been applied to adapt the feature weights automatically. The main principle of weighing the feature is to assign larger weight to a feature with smaller sum and assign a smaller weight to a feature with a larger sum within the cluster distances. The weights of all the features are initialized equally at first and then in each iteration the discriminability of each feature is measured.

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IV. METHODOLOGY

A. Data collection: Image data has been collected from a website which consists of satellite images. Many test images have been selected for satisfactory results. These images have been taken based on the presence of water body.

B. Method: The methodology of this work comprises of following steps.

i) PREPROCESSING: The given test image is preprocessed in order to sharpen the image features such as edges, boundaries etc. The aim of preprocessing is an improvement of the image data that suppresses unwanted distortions or enhances some image features that are important for further processing.

ii) SEGMENTATION: It is a process of partitioning an image into multiple segments. The main goal of segmentation is to simplify and change the representation of an image into something that is more meaningful and easier to analyze. In this work the water portion is segmented from the given image on the basis of thresholding.

iii) FEATURE EXTRACTION: Feature extraction techniques are applied to get features that will be useful in classifying and recognition of images. The main goal of feature extraction is to obtain the most relevant information from the original data and represent that information in a lower dimensionality space. Transforming the input data into the set of features is called feature extraction. Principle component analysis is used for feature extraction. The idea behind principle component analysis is to reduce the dimensionality of a data set consisting of many variables correlated with each other either heavily or lightly, while retaining the variation present in the dataset upto the maximum extent. In this work mean, entropy, standard deviation and maximum pixel value has been extracted from the given image.

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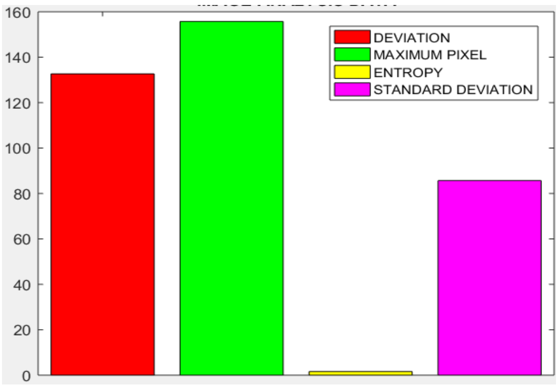

iv) CLASSIFICATION: The classification of the image is based on the Decision tree algorithm. It belongs to the family of supervised learning algorithm. Unlike other supervised learning algorithms, decision tree algorithm creates a training model which can use to predict a class or value of target variables by learning decision rules inferred from prior data (training data). The decision tree algorithm tries to solve the problem by using tree representation where each internal node of the tree corresponds to an attribute and each leaf node corresponds to a class label. The best attribute of the dataset is placed at the root of the tree. The training set is split into subsets. Subsets should be made in such a way that each subset contains data with the same value for an attribute. These steps are repeated until the leaf node is found in all the branches of the tree. In this algorithm for predicting a class label for a record we start from the root of the tree. Then the values of the root attribute is compared with the record's attribute. On the basis of comparison we follow the branch corresponding to that value and jump to the next node. We continue comparing our record's attribute values with other internal nodes of the tree until we reach a leaf node with predicted class value. In this work our input image is finally classified based on the degree of affected portion in the image.

Affected part in %	Quality of water
Below 15	Normal
15 to 25	A
25 to 30	B
30 to 35	C
35 to 40	D
Above 40	E

From the above table we can decide that if the affected portion in the given image is within the specified range the image is classified as excellent, better, good, bad and poor.

V. RESULT AND DISCUSSION

From the methodology and the table shown, it can be concluded that if there is some percentage of water body in the test images any type of water body can be qualified. If we want to test the water quality of an area the only thing we need to check at first is the amount of water portion to segment and the features are extracted to compare it with the standard database. This method estimate the number of impurity objects present in the water after segmentation which are pseudo labeled.

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VI. CONCLUSION AND FUTURE WORK

An easy way has been presented here to measure water quality of different water bodies. Mainly adaptive super pixel clustering algorithm has been applied to a satellite image to separate its water body from other features. Then features matching has been performed using Euclidean distance to assess the water body as excellent, better, good and so on. Since in this work we have considered different types of images such as .tiff, .jpg, .png. The approximate level of impurity has been generated as report which can also be shown in IOT cloud in future work for various analysis.

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E-mail: mp.ece@builderscollege.edu.in

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