RUNWAY DETECTION USING K-MEANS CLUSTERING METHOD USING UAVSAR DATA

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ABSTRACT

Remote sensing data gives the essential and critical information for detecting or identifying an object, a place, image fusion, change detection, and land cover classification of selected area of interest. The runway detection is an important topic because of its applications in military and civil aviation fields. This paper presents an approach for runway detection using Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVAR) data by implementing K-means clustering method. The obtained results reveal that we can obtain better detection, for the 9 and 11 classes, with iterations set to 10. In this work, the effectiveness of algorithm was demonstrated using quad polarimetric L-band Polarimetric Synthetic Aperture Radar(polSAR) imagery from NASA Jet Propulsion Laboratory's (JPL's) Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR). The study area is Louis Armstrong New Orleans International Airport, LA, USA.

KEYWORDS

Remote sensing, Runway detection, K-means clustering, polSAR

1. INTRODUCTION

Remote sensing is the acquisition of information about an object without making physical contact with the object and thus in contrast to on-site observation. Remote sensing is used in numerous fields, which includes geography, land surveying, military, intelligence, economic, planning, humanitarian applications, and so on. Remote sensing images contain large amount of geographical environmental information, giving new prospects in the field of the automatic detection of geospatial objects for multiple purposes [1]. Among these objects, runways have been the focus of consideration because of their significance in civil and military applications.

There are some literatures about remote-sensing imagery usage for detection and identification of airport runways in complex airport scenes, aerial optical imagery, and in synthetic aperture radar images. In main features of the runway, the most obvious feature is a straight line, so the runway target detection problem turns into, how to detect straight lines in the image. Generally, Hough transform was used to detect airport runway. The main advantage of the Hough transform is not sensitive to noise, better able to handle partial occlusion in the image and covering other issues. However, because it is a type of exhaustive search, so its computational complexity and space complexity is very high, which cannot meet the requirements of real-time systems [2]. One way to solve this would be to use cluster analysis. Cluster analysis is an unsupervised process of grouping observations (i.e., pixels) into classes or clusters, so that observations in the same class

Dhinaharan Nagamalai et al. (Eds) : AI, CSTY, SIGI - 2017
pp. 49– 54, 2017. © CS & IT-CSCP 2017 DOI: 10.5121/csit.2017.71805

share more common features than to those in other classes. Various algorithms perform this process, one of them is K-means clustering algorithm, which is the most popular method. The main advantage of K-means is: If variables are huge, then K-means may be computationally faster than hierarchical clustering (if K is small).

In this paper, runway detection is done using polarimetric synthetic aperture radar (polSAR) imagery. The detection of polSAR image data is performed to compute and analyze runways using K-means unsupervised clustering algorithm.

2. METHOD

2.1 OVERALL PROCEDURE

The proposed methodology for the detection of Runway is shown in Figure 1, is based on image data collected from polSAR format. Subset images or select region of interest (ROI) to detect the structural data of a runway. Basic filter application is performed to extract better image visualization and analyzation. And then K-means clustering is performed by taking classes and iterations as parameters, and this process is used for the detection of the runway.

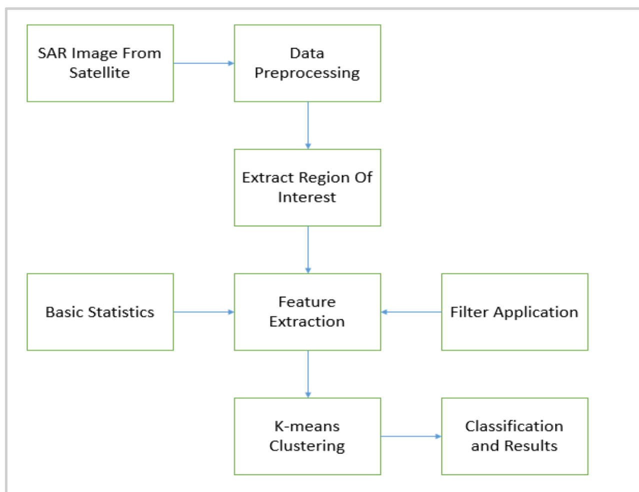

Figure 1. Overall procedure for the detection of Runways.

2.2 REGION OF INTEREST (ROI)

UAVSAR is a sensor that captures polSAR data in different polarizations. UAVSAR data is available in cross-polarized (HHHV, HHVV, HVVV) and co-polarized (HHHH, HVHV, VVVV) we have selected a fully cross-polarized image HVVV to perform our research work [3]. SAR polarimetry using quad-polarization data is the HV-polarization base in which an antenna transmits and receives horizontally and vertically polarized and different polarizations of the backscatter signal are detected as: VV (vertical transmit and vertical receive), HV (horizontal transmit and vertical receive), and HH (horizontal transmit and horizontal receive).

The Keyhole Markup Language (KML) file is used to find the test area from a satellite image, Keyhole Markup Language Zipped (KMZ) files represent the ground projected data, is used to display on Google earth map, as shown in Figure 2.

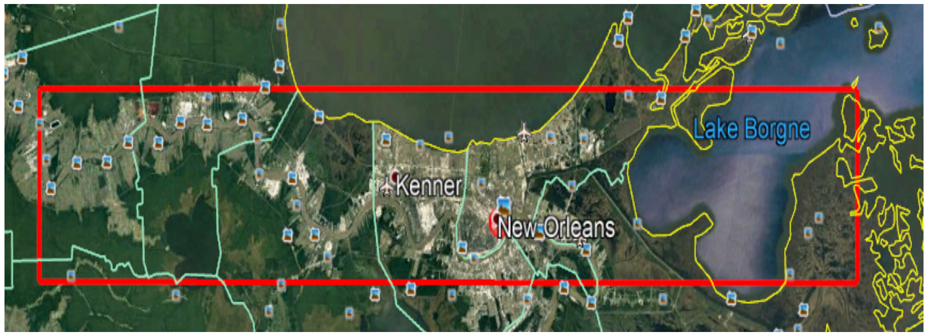

Figure 2. KML file of UAVSAR data on google earth

ROI are selected samples of a raster, such as areas of water that are identified for a particular purpose [4]. After creating ROI in polygon shape, we sub set the data and mask the pixels outside the ROI with value 0 by using an image detection software. Equalization filter and Contrast up to 70% are applied to have a better image detection. ROI masking pixels outside region is a polygon which covers the runway, as shown in the figure 3.

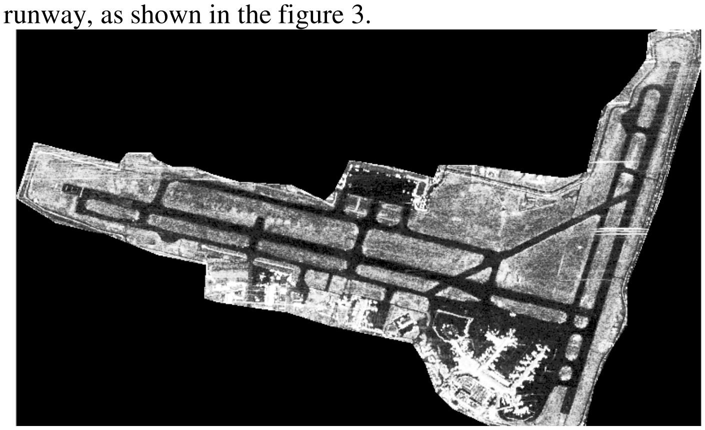

Figure 3: Region of Interest

2.3 K-MEANS CLUSTERING

K-means is a clustering method that aims to find the positions of the clusters that minimize the distance from the data points to the cluster [5]. Let X = {x_i}, I = 1, . . . , n be the set of n d-dimensional points to be clustered into a set of K clusters, C = {c_k, k = 1, . . . , K}. K-means algorithm finds a partition such that the squared error between the empirical mean of a cluster and the points in the cluster is minimized. Let μ_k be the mean of cluster c_k. The squared error between μ_k and the points in cluster c_k is defined as

$$J(c_k) = \sum_{x_i \epsilon c_k} \|x_i - \mu_k\|^2$$

K-means will minimize the sum of the squared error over all the K clusters resulting,

$$J(C) = \sum_{k=1}^{K} \sum_{x_i \epsilon c_k} \|x_i - \mu_k\|^2 \quad [6]$$

The reason for choosing K-means algorithm is due to its popularity for the following reasons:

1. Its time complexity is O(nkl), where n is the number of patterns, k is the number of clusters, l is the number of iterations taken by the algorithm to converge [7].

2. If variables are huge, K-means is faster computationally, then hierarchical clustering, keeping k small [8].

3. K-means produces tighter clusters than hierarchical clustering [8].

3. RESULTS AND DISCUSSION

The goal of this research is to detect the runway of the airport using polarimetric SAR data by applying K-means clustering with different classes and iterations. Detecting the runways from satellite and aerial images is a complicated task, but this data can be analyzed by clustering. The runways are uniform, they have a gray level and this valid feature is used to distinguish runways from other landforms.

In this research, we will define number of classes, number of iterations, and set the threshold value to 5, the change threshold is used to end the iterative process when the number of pixels in each class changes by less than the threshold. K-means unsupervised classification calculates initial class means evenly distributed in the data space, then iteratively clusters the pixels into the nearest class using a minimum distance technique. Each iteration recalculates class means and reclassifies pixels with respect to the new means. All pixels are classified to the nearest class unless a standard deviation or distance threshold is specified, as we set threshold to 5, this process continues until the number of pixels in each class changes by less than the selected pixel change threshold that is 5 or the number of iterations is reached [4]. The following figures show how we used K-means in detection of Runway, using different classes and iterations: Figure 4 shows K-means classification with 5 class and with (a) Iterations 1 (b) Iterations 10 (c) Iterations 100 (d) Iterations 1000. Figure 5 shows K-means classification with 7 class and with (a) Iterations 1 (b) Iterations 10 (c) Iterations 100 (d) Iterations 1000. Figure 6 shows K-means classification with 9 class (a) Iterations 1 (b) Iterations 10 (c) Iterations 100 (d) Iterations 1000. The image of 9 class with 10 iterations shows clear runway, and gives the good detection compared to 5 class and 7 class. Figure 7 shows K-means classification with 11 class (a) Iterations 1 (b) Iterations 10 (c) Iterations 100 (d) Iterations 1000. 11 class with iterations 10 shows good runway detection along with 9 class with iterations 10.

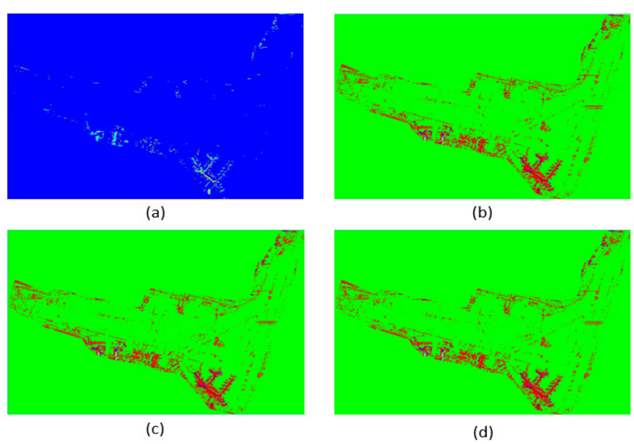

Figure:4 K-means classification with 5 classes, with Iterations: (a) 1 (b) 7 10 (c) 7 100 (d) 1000

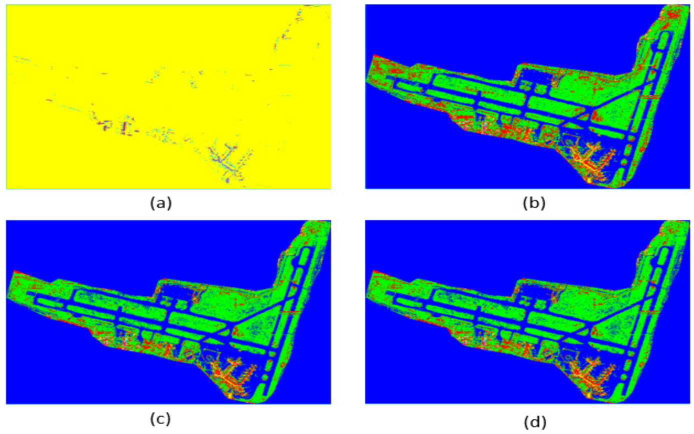

Figure:5 K-means classification with 7 classes, with iterations: (a) 1 (b) 7 10 (c) 7 100 (d) 1000

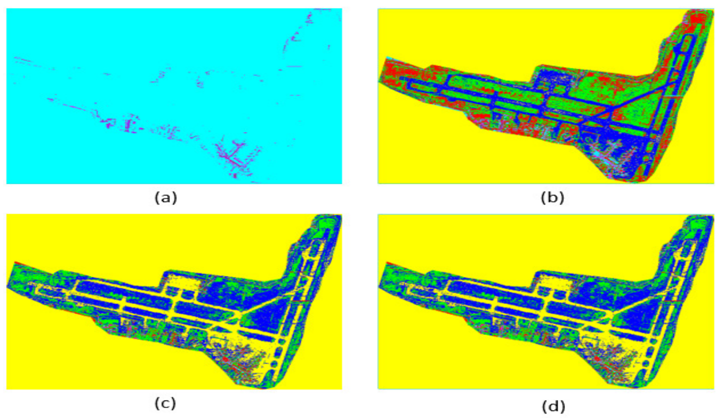

Figure:6 K-means classification with 9 classes, with iterations: (a) 1 (b) 7 10 (c) 7 100 (d) 1000

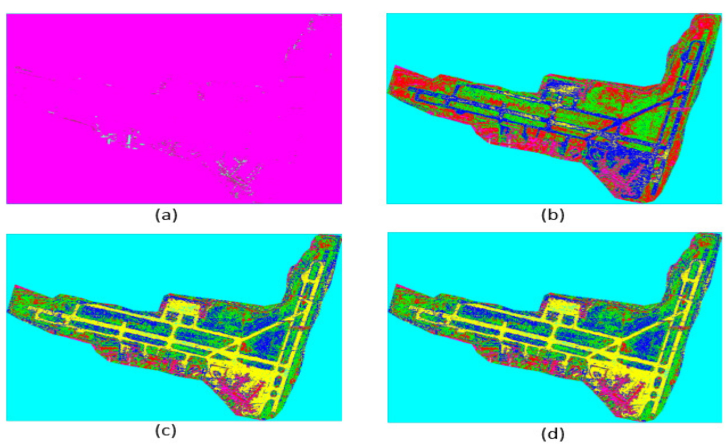

Figure:7 K-means classification with 11 classes, with iterations: (a) 1 (b) 7 10 (c) 7 100 (d) 1000

We have experimented with classes ranging from 5 to 11 and with iterations 1, 10, 100 and 1000. For each class varying the iterations, we observed that the image is better analyzed (has good resolution) when the iterations is equal to 10, for iterations below and above 10, clustering is not that great. And especially for 9 & 11 classes, with iterations 10, gives the best image showing the runway of the airport.

4. CONCLUSION

This paper explains an approach for runway detection using remote sensing images by implementing K-means clustering classification. The K-means algorithm has been implemented on quad polarimetric L-band polSAR image from NAS JPL's UAVSAR. The study area is Louis Armstrong New Orleans International Airport, Louisiana, USA. We worked with classes 5, 7, 9 and 11, and with iterations from 1, 10, 100 and 1000.The obtained results show that, we have better detection of runways when we take 9 & 11 classes and iterations as 10. For iterations equals to 1, we observed that classification ends after 1 iteration, irrespective of the threshold value taken. And for iterations 100 and 1000, we observed the increased number of pixels reaching the threshold value and only the pixels that do not reach the threshold value continues until number of iterations is reached or until the number of iterations is completed.

ACKNOWLEDGEMENT

We thank our team and colleagues for their suggestions and advices. We also thank Alaska Satellite Facility (ASF) and NASA Jet Propulsion Laboratory for imagery.

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