3D LINEAMENT RECONSTRUCTION FROM MULTISPECTRAL REMOTELY SENSED DATA IN UNITED ARAB EMIRATES (UAE)

Maged Marghany and Mazlan Hashim
Department of Remote Sensing
Faculty of Geoinformation Science and Engineering
Universiti Teknologi Malaysia
81310 UTM, Skudai, Johore Bahru, Malaysia
Email: magedutm.my
:magedupm@hotmail.com

Abstract
At present, there is no study has been uitlized multi spectral remote sensing to reconstruct 3D lineaments mapping in UAE. In this context, image enhancement contrast, stretching and linear enhancement were applied to acquire an excellent visualization. In addition, automatic detection algorithm of Canny is performed to extract linear features in multispectral remote sensing data e.g. lineaments, fractures. Uncertainties DEM model was performed by using Fuzzy B-spline algorithm to map spatial lineaments variation in 3D.
Keywords: Lineament, 3D visualizations, DEM, Multispectral remotely sensed data.

1.0 Introduction

Approximately 90 % of United Arab Emirate (UAE) is experiencing scarcely of underground water. In fact, highly complex topography features exist in eastern side of UAE which contains huge numbers of liniments and fractures. The discontinuities of groundwater, rainfall recharge and salinity intrusions are recurred due to liniments and fractures. Furthermore, lineaments play an important role in structural controls of groundwater vertical and lateral flow along fault and bedding plans. In this context lineaments are located in the mountainous eastern part of UAE consists of fault zones, fractures influences ground water recharge especially the area directly adjacent to Oman mountain. In addition, drainage lines in terms of water flow gradually changes direction from eastward to westward and northwest direction around the Bahays, Fayah and Mellihah mountains belt is due to existence of foredeep thrusting front fault zone which extends 75 Km parallel to Oman mountain from north AL Ain city to the north passing through the Al Fayah range Thus underground water discharge into in land sand dunes and Arabian gulf . In this manner, UEA economic might be influenced due to water shortages (Semere and Ghebreab 2006).

Lineament identifications from remotely sensed data are required standard procedures. Conventional methods, however, is challenge task due to Earth complex topography. In this context, visual interpretation is imperfect method for liniment extractions from satellite data. Thus researchers and scientists have developed computer packages to acquire precisely liniment features from remotely sensed data. In referring to Katsuaki et al., (1995); Moore et al., (1998); Walsh (2000) liniment information extractions in satellite images can be divided broadly into three categories: (i) lineament enhancement and lineament extraction for characterization of geologic structure;(ii) image classification to perform geologic mapping or to locate spectrally anomalous zones attributable to mineralization (Mostafa et al., 1995; Süzen and Toprak 1998); and (iii) superposition of satellite images and multiple data such as geological, geochemical, and geophysical data in a geographical information system (Novak and Soulakellis 2000; Semere and Ghebreab 2006). Furthermore, remote sensing data assimilation in real time could be a bulk tool for geological features extraction and mapping. In this context, several investigations currently underway on the assimilation of both passive and active remotely sensed data into automatic detection of significant geological features i.e. liniments. Edge automatic detection algorithms such as Laplacian, Sobel, and Canny are the major geomatica tool for liniment investigation in remotely sensed data. In this study there is integration of different automatic detection algorithms to develop a new approach for lineament detection and mapping. This work hypothesized that lineament features can be reconstructed in three dimensional (3D) visualization. In this context, a Canny algorithm can be used as semiautomatic tool to discriminate between lineament and surrounding geological features in optical remotely sensed satellite data. In addition, Uncertainties DEM model was performed by using Fuzzy B-spline algorithm to map spatial lineaments variation in 3D.

2.0 Study Area

The study area is located in Sharjah Emirate about 70 Km from Sharjah city. It is considered in the alluvium plain for central area of UAE and covers an Area of 1800 Km^2 (60 km x 30 km) within boundaries of latitude 25º 00’N - 25º.20'N and 55º.50'E- 56º 10' E (Figure 1). The northern part of UAE (Plates 1 and 2) is composed of the Oman mountains and the marginal hills extends from the base of the mountains and (alluvium plain) to the south western sand dunes. Land geomorphology is consisted of structural form, fluvial, and Aeolian forms(sand dunes). According to JIACA (1997) structural form is broad of the Oman mountains and Jabal Fayah which are folded structure due collusion of oceanic crust and Arabian plate (continental plate).

Furthermore, the mountain is raised higher than 400 m above sea level and exhibit parallel ridges and high–tilted beds. Many valleys are cut down the mountains, forming narrow clefts and there are also intermittent basins caused by differential erosion. In addition, the Valley bases are formed small caves. The fluvial forms are consisted of streams channels which are flowed from Oman mountains have and spread out into several braided channels at the base of the mountains from the Bahada and Playa plains. Stream channels have been diverted to the southwest and they deposited silt in the tongue –shaped playa plain which lies between the dunes. Further, Aeolian forms are extended westwards from the Bahada plain, where liner dunes run towards north-southwest in parallel branching pattern. Their relative heights are more than 50 meters. Nevertheless, the heights are decreased towards the southeast due to a decrease in sand supply and erosion caused by water occasionally flowing from the Oman mountains. Moreover, some of the linear dunes are quite complex due to the development of rows of star dunes along the top of their axes. Additionally, inter dunes areas are covered by fluvial material which are laid down in the playas formed at the margins of the Bahadas plain near the coastline. The dunes changes their forms to low flats of marine origin and their components are also dominated by bioclastics and quartz sands.

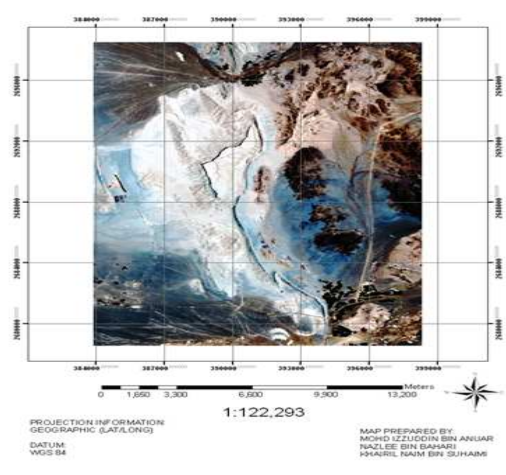


Figure 1. Location of Study Area.

Plate 1. Geological Fault Feature

Plate 2. Dune Forms on Oman Mountain Base.

3.0 Methdology

3.1 Data Set

In study, there are two sort of data have been used. First is satellite data which is involved LANDSAT Enhanced Thematic Mapper (ETM) image with pixel resolution of 30 m Second is ancillary data which are contained digital topographic, geological maps, well logs and finally ground water data. These data are obtained from UAE ministry of agricultures and UAE University, Department of Geology, respectively. Furthermore, ancillary data such as topography map of scale 1: 122,293 used to generate Digital Elevation Model (DEM) of selected area.

3.2 Lineament Extraction Procedures

This section describes the procedures have been used to extract lineaments and drainage pattern from LANDSAT ETM satellite image. In this context, image enhancement contrast, stretching and linear enhancement were applied to acquire an excellent visualization. In addition, automatic detection algorithm Canny are performed to acquire excellent accuracy of lineament extraction (Maged 2002). Two procedures have involved to extract lineaments from LANDSAT ETM data. First is automatic detection by using automatic edge detection algorithm of Canny algorithm. Prior to implementations of automatic edge detection processing, LANDSAT ETM data are enhanced and then geometrically corrected. Second is implementing fuzzy B-spline was adopted from Maged et al., (2007) to reconstruct 3D liniment visualization from LANDSAT ETM satellite data.

3.2.1 Fuzzy B-spline

The fuzzy B-splines (FBS) are introduced allowing fuzzy numbers instead of intervals in the definition of the B-splines. According to Maged et al., (2007), in computer graphics, two objective quality definitions for fuzzy B-splines are used: triangle-based criteria and edge-based criteria. A fuzzy number is defined using interval analysis. There are two basic notions that we combine together: confidence interval and presumption level. A confidence interval is a real values interval which provides the sharpest enclosing range for topography elevation gradients. An assumption level μ -level is an estimated truth value in the [0,1] interval on our knowledge level of topography elevation gradients (Anile 1997). The 0 value corresponds to minimum knowledge of topography elevation gradients, and 1 to the maximum topography elevation gradients. A fuzzy number is then prearranged in the confidence interval set, each one related to an assumption level $\mu \in [0,1]$. Moreover, the following must hold for each pair of confidence intervals which define a number: $\mu \succ \mu' \Rightarrow h \succ h'$. The construction begins with the same pre-processing aimed at the reduction of measured topography elevation values into a uniformly spaced grid of cells. Among all the fuzzy numbers falling within a kernel window size, a fuzzy number is defined whose range is given by the minimum and maximum values of topography elevation gradients along each kernel window size.

Furthermore, the identification of a fuzzy number is acquired to summarize the estimated topography elevation data in a cell and it is characterized by a suitable membership function. The choice of the most appropriate membership is based on a triangular number whose support is the range of water depth data in the cell and whose vertex is the median value of topography elevation (Anile et al. 1997).

4.0 Result and Discussions

Figure 2 illustrates a clear appearance of lineament features in LANDSAT ETM satellite image. In fact, Canny algorithm is able to extract linear features from image as it produces thresholding hysteresis which allowed any pixel in an edge list to have greater gradient values than threshold. This procedure classes the edge pixel as valid edge point. On other words, any pixels connected to valid edge points that have a gradient value above the lower threshold value are classes as edge points which can be presented as vector layers (Mostafa and Bishta 2005).

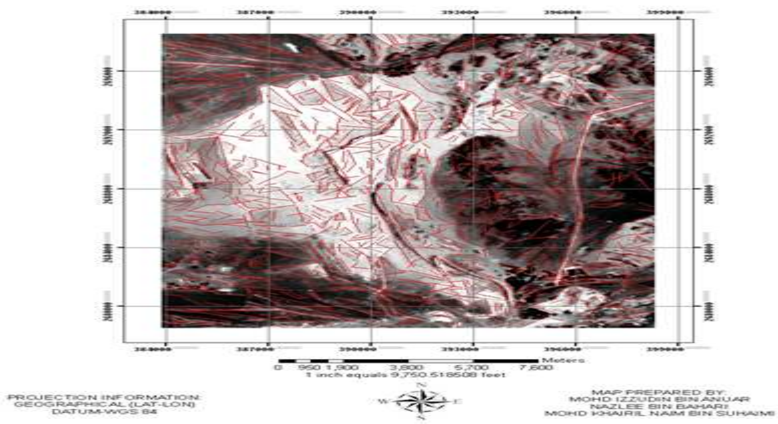


Figure 2. Lineament extraction by using Canny algorithm

Figure 3 shows DEM variation over the study area. DEM varies between 319 to 929 m. Maximum elevation is found in north-east direction of UAE. The high density of lineaments are found in north-west direction in Alluvial plan (Figure 3). It is clear that area adjacent to the mountainous area from Manamh (northward), Flili village in the (southward) has high density of lineaments due to the westward compressive force between the oceanic crust and Arabian plate, such as fractures and faults and drainage pattern that running in the buried fault plains (filled weathered materials coming from Oman mountains).

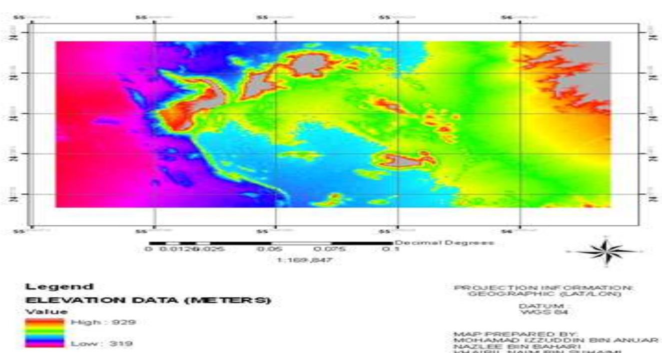
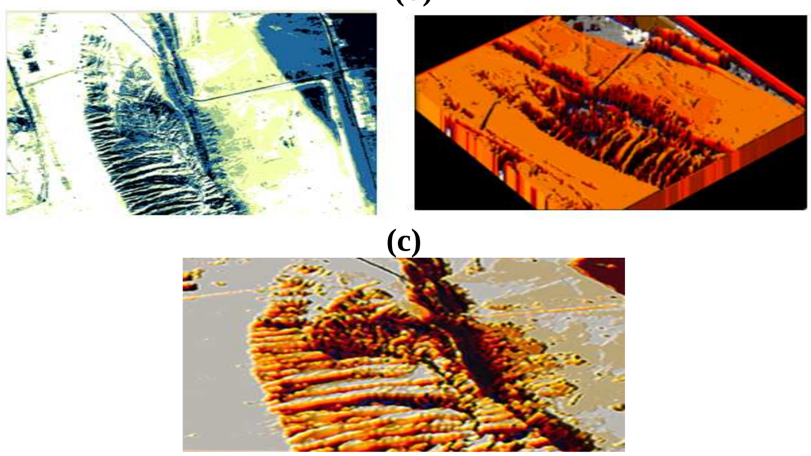


Figure 3. DEM extracted from LANDSAT ETM satellite image based on topography map

Figure 4 shows the result acquires by using fuzzy B-spline algorithm. It is clear that the 3D visualization discriminates between different geological features. It can be noticed the faults, lineament and infrastructures clearly (Figure 4c). This is due to the fact that the fuzzy B-splines considered as deterministic algorithms which are described here optimize a triangulation only locally between two different points (Anile et al 1995; Maged and Mazlan 2006; Maged et al., 2007). This corresponds to the feature of deterministic strategies of finding only sub-optimal solutions usually.The visualization of geological feature is sharp with the LANDSAT ETM satellite image due to the fact that each operation on a fuzzy number becomes a sequence of corresponding operations on the respective μ-levels , and the multiple occurrences of the same fuzzy parameters evaluated as a result of the function on fuzzy variables (Davies, 1990;Anile, 1997; Anile et al., 1997; Maged and Mazlan 2006). It is very easy to distinguish between smooth and jagged bathymetry. Typically, in computer graphics, two objective quality definitions for fuzzy B-splines were used: triangle-based criteria and edge-based criteria. Triangle-based criteria follow the rule of maximization or minimization, respectively, of the angles of each triangle (Fuchs et al 1997). The so-called max-min angle criterion prefers short triangles with obtuse angles. This finding confirms those of Keppel (1975) and Anile (1997).

(a) **(b)**



(c)

Figure 4. (a) LANDSAT ETM satellite data and (b) 3D fuzzy B-spline visualization and (c) zoom area of lineaments and fault .

5.0 Conclusion

It can be said that composite LANDSAT ETM band 1 to band 4 can be used to map the spatial lineament variations. It has been demonstrated that Canny algorithm is appropriate algorithm for automatic lineaments mapping. Integration between Canny algorithm and DEM generated by using fuzzy b-spline could be used as an excellent tool to understand variation of lineament density.

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