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Investigation of lineaments in Tehran province on the basis of remote sensing techniques

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ABSTRACT

Since the latest 1990s within the rapid development of earth observing, field application has been continuing to expand and deepen ceaselessly. Remote sensing technique is the most efficient scientific tool in conjunction with ground truth and toposheet for collection of spatial information and very useful in identification and mapping of the Lineaments of an area. The main objective of the present investigation was to examine Landsat ETM$^+$ of the study area by ENVI.4.0, ER Mapper 7.0, and applying Sobel 2 and sun angel filters to identify new lineaments. The extracted map indicated several new lineaments in the Tehran Province.

Keywords: Lineaments, Remote sensing, Geological map, Tehran Province

1. Introduction

RS technology was integrated as an American scholar in 1960 (Chen, 1990). Rapid development of space made RS technology and application field continue to expand and deepen ceaselessly since the 90s. This technology in geological survey, mineral exploration, geological evaluation, disaster monitoring and basic geological research has played an increasingly major role (Chang, 2004).

Satellite images and aerial photographs are extensively used to extract lineament for different purposes. Satellite images are considered as better tools to discriminate the lineaments to produce better information than conventional aerial photographs, since They are obtained from varying wavelength interval of the electromagnetic spectrum (Myneni, et.al., 2002).

Linear feature on the earth surface has been used as theme of study since the early years of the last century (Hobbs, 1904,). Lineaments have been defined as linear surface features, which differ distinctly from the patterns of adjacent features and presumably reflect subsurface phenomena (O' Leary et al., 1976). Also they usually appear as straight lines or "edges" on the image that in all cases they are contributed by the tonal difference within the surface material.

Knowledge and experience are considered as the key point to identify the lineaments and particularly to connect the broken segments in to a longer lineament (Wange et al.,1990). The importance of Tehran in Iran necessitates conducted studies about it. The present research indicates the map production of lineaments in GIS by Remote Sensing to introduce the lineaments with equivalent faults. The ETM image used in this study is composed of 6 VNIR and SWIR bands with a resolution of 30 m, and the panchromatic band 8 with a resolution of 15 m.

2. Methods of indicating lineaments

Landsat ETM^{+} imagery is used to improve the quality of lineament map by its spectral and resolution properties. Lineaments have been extracted from satellite image by both interactive visual interpretation (manual) and automated extraction techniques. The images were resized to the exact coordinates of the study area by a subset from the original scenes. The Landsat ETM^{+} image was a subset from an original scene of a path 128 and row 045 and acquired on 14/8/2010. The processing is developed based on the geological map scale of 1/50.000.

2.1 The study area

The study area covers Tehran province that is one of the thirty provinces of Iran. The area under study lies between 50˚ 10′ and 53˚ 8′ North latitudes and 35˚ 1′and 36˚ 20′ East longitude.

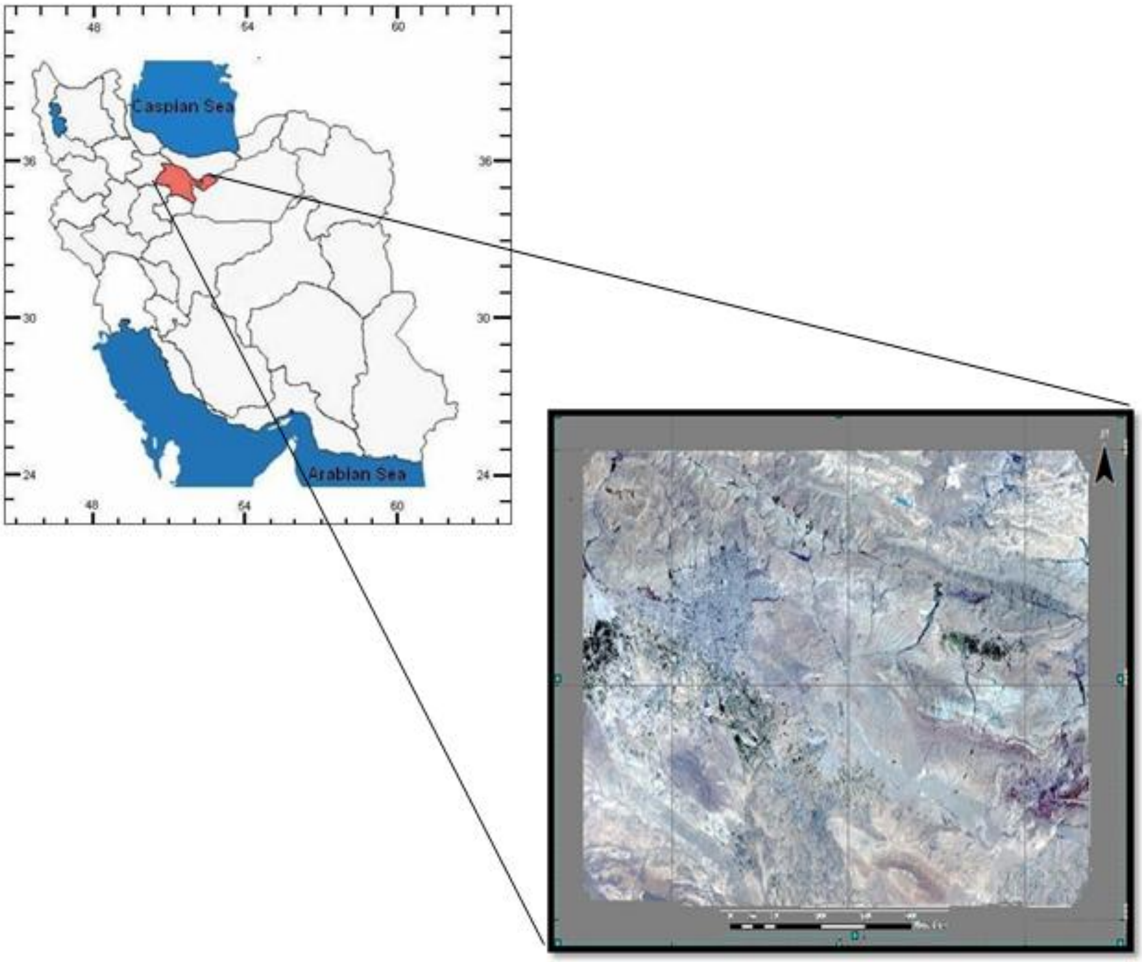

Figure 1: Location map of the study area

The study area is located to the north of the central plateau of Iran. The province of Tehran has over 12,000,000 inhabitants and is Iran's most densely populated region. Approximately 84.15% population resides in urban areas and 15.85% in rural areas of the province.

The highest point of the province is mount Damavand situated at an elevation of 5,678 m and the lowest point of the province in the plains of Varamin, 790 m above sea level.

The research area is located in the central Alborz Mountain and Tehran plain. Geographically speaking the study area is located, in a microscopic view, in the depression surrounded by areas of the great Alborz mountain massif, west Zagros highlands and western part of the Kavir salt desert, specified by altitude ranging from 800 m to 4300 m above mean sea level. The highest recorded summer temperature in study area has been 42o centigrade while the lowest has been registered at -8o centigrade.

The climate of the area is Mediterranean with air mass brought from west in winter and from east in summer. Pluvial air mass visits the area from west or north with humidity which gives precipitation on the way when crossing Azerbaijan, Zagros and Alborz mountains, loosing its influence as it advances further towards east and south. For this reason intensity and amount of precipitation of the area is controlled by latitude and altitude. The area receives 700mm or more rainfall in the western and northern highlands and 100 mm or less in the southern and eastern border near the Kavir salt desert (Figure 1).

2.2 Manual methods

Lineaments have been extracted from satellite image. Manual lineament extraction in visual interpretation and lineaments mapping are considered as techniques to connect lines and edges which are collinear and broken in to series of segment (Wang and Howarth, 1990). Several image enhancement techniques are contributed to manual lineament extraction. Filtering operations among these techniques (Suzen and Toprak, 1998;Chang et al,1998; Mah et al,1995) indicates that each process generates a GIS layer in which is linked to other layers. Using these techniques 17722 lineaments were extracted from Landsat ETM^{+} image data (figure2).

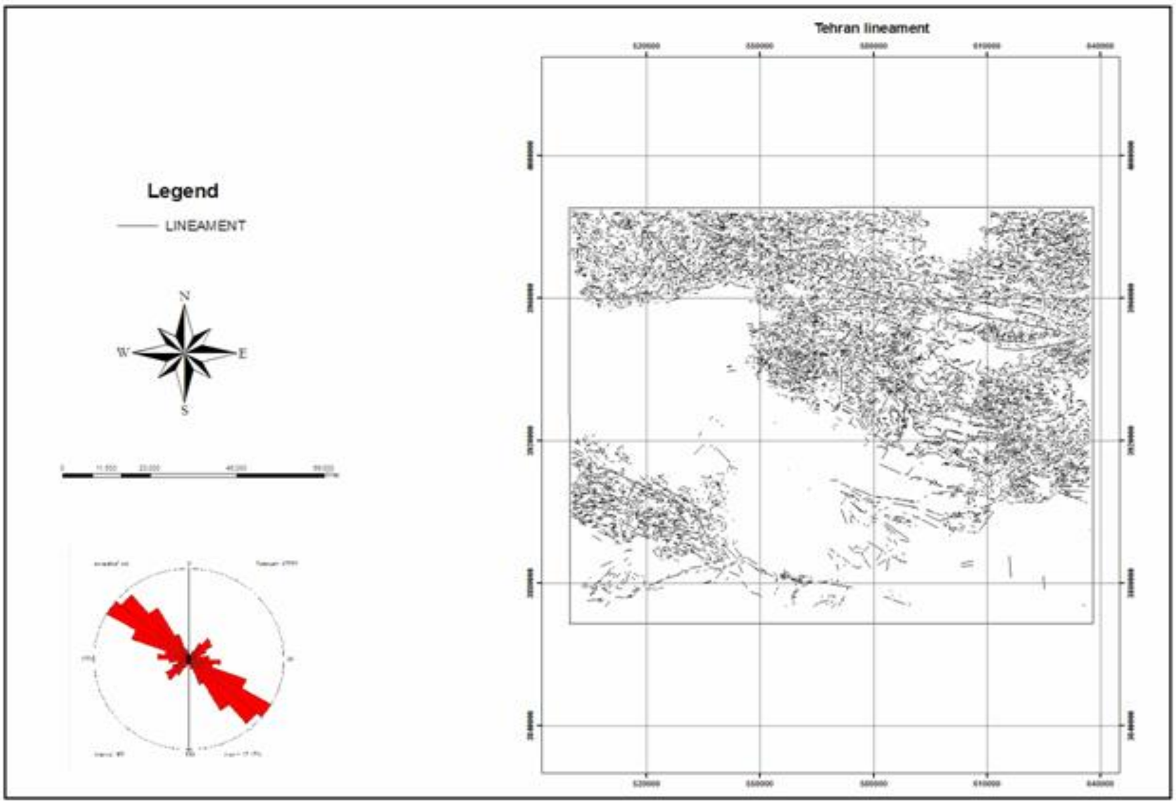

Figure 2: The 17722 extracted lineaments through the manual methods.

2.3 Automatic methods

Automatic detection was done by using automatic edge detection Soble2 algorithm. Prior to implementations of automatic edge detection processing, LANDSAT ETM data are enhanced and then geometrically corrected. The advantage of the method is that results can be obtained in a less time. Line Module in PCI Geomatica is applied to identify Lineaments.

Line algorithm consists of three parts:

1. Detecting the edge while the image has been filtered and the size of the filter determined by RADI parameter.
2. The obtained binary image shows the edge by the Threshold value.
3. Lineaments are defined by the threshold value of the previous image.

$$\begin{bmatrix} 0 & -1 & -1 \\ 1 & 0 & -1 \\ 1 & 1 & 0 \end{bmatrix}$$

2.4 Geometric correction of the satellite image

The geometric correction of satellite image was done by ENVI 4.0. Geological map with 1:50:000 scale from Tehran, Garmsar, Varamin, Robat Karim and Damavand, common maps and satellite images were geometrically corrected in registration option of the software.

2.5 satellite image filtering

Satellite images have been directionally filtered by ER Mapper. . In the present study lineaments with North West-South East direction have been created by Sobel2 in ER Mapper.

Sobel filtering is a three step process. Two 3×3 filters (often called kernels) are applied separately and independently. Besides, Sun angel filter was chosen for the directions of sun radiation in order to clarify other lineaments. Then the North West-South East lineaments have been analyzed by North-East filter (figure 3).

$$\begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{bmatrix}$$

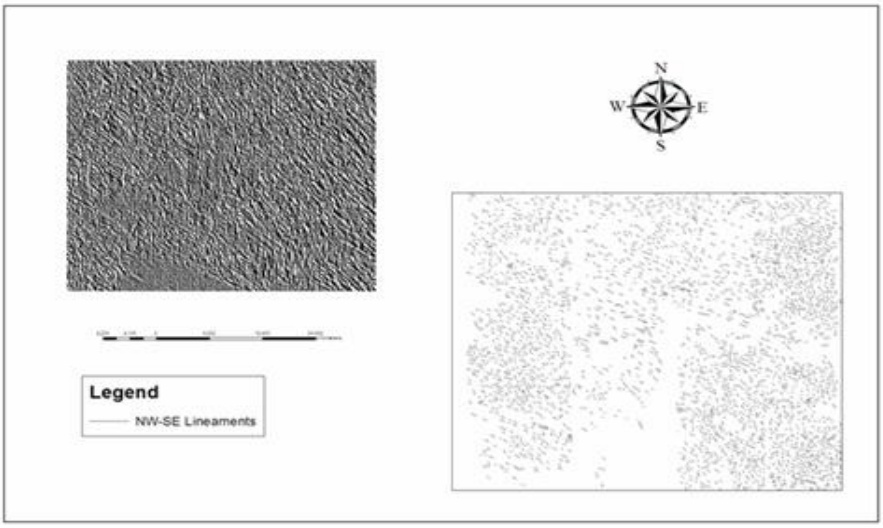

Figure 3: Drawing NW-SE lineaments in a part of area under investigating by using North-East filter

North East-South West filter was applied to show North East –South West lineaments (figure 4).

$$\begin{pmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{pmatrix}$$

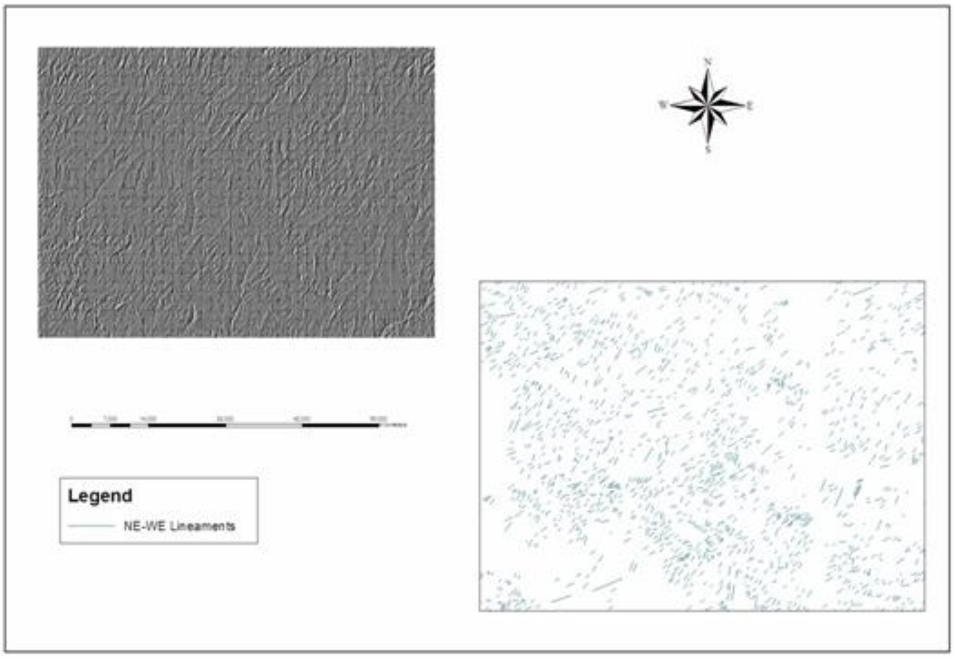

Figure 4: Drawing NE-SW lineaments in a part of area under investigating by using North-West filter

Finally East- West lineaments which have been analyzed by North-South filter (figure 5). All Lineaments were placed in a specific layer by these filters.

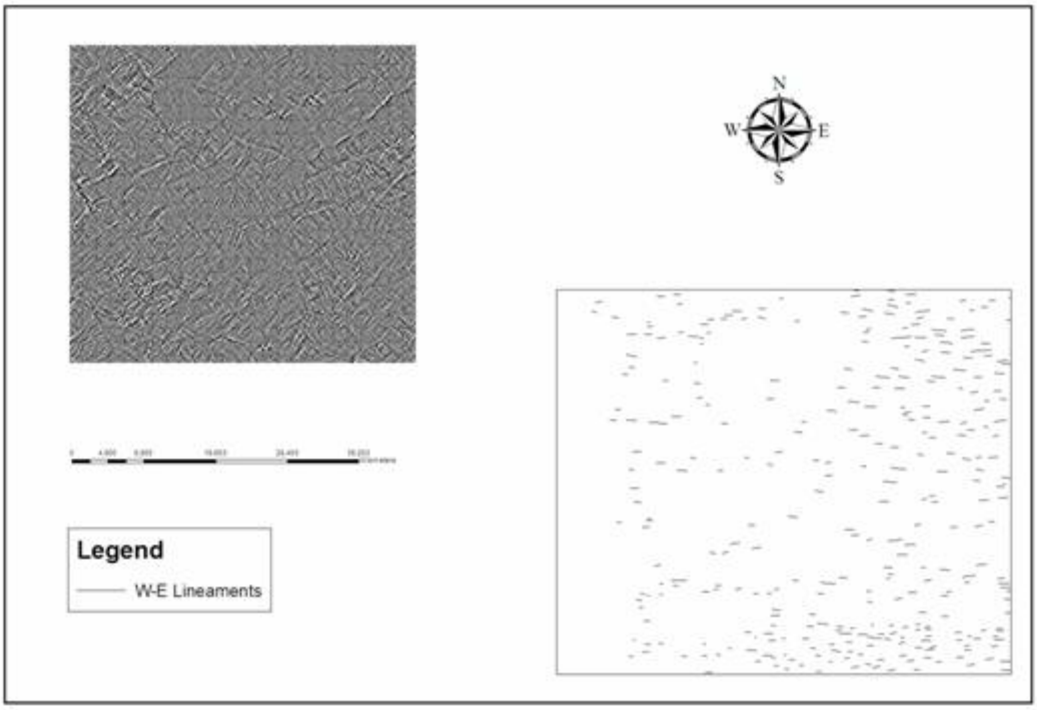

Figure 5: Drawing W-E lineaments in a part of area under investigating by using North- South filter

2.6 Rose diagram

The imported Lineaments layers in Arc GIS software indicated the Azimuth, Length of the lineaments in Perimeter and Length Calculated line trend option. Lineaments are commonly analyzed by using frequency or length against Azimuth histogram (Mostafa and Zakir,1996; Zakir et al, 1999). Rose diagram is created in Tectonics FP software. The Faults map of Tehran has been digitized in Arc GIS 9.2 (figure 6) and the Rose diagram of Tehran's Faults has been created by Tectonics FP (figure 7).The long Lineaments was drawn by perusing the Lineaments in same direction (figure 8, 9).

The Azimuth of the long Lineaments is presented in table 1.

Here, the Rose diagram chart is considered to indicate the following facts:

1. The dominate trend of Lineaments is NW-SE
2. The transverse Lineaments are second maximum in the area investigated with NW-SW trend.
3. The last trend interpreted was the East-West which increased by moving toward East.

The map of Lineaments and the Faults are compared with some Lineaments found without any equivalent Faults.

Lineaments and equivalent faults are:

L14 Lineament equivalent Emamzade David Fault
L33 Lineament equivalent Meygon Fault
L3 Lineament equivalent Mosha Fault
L4 Lineament equivalent Ghasre Firoze Fault

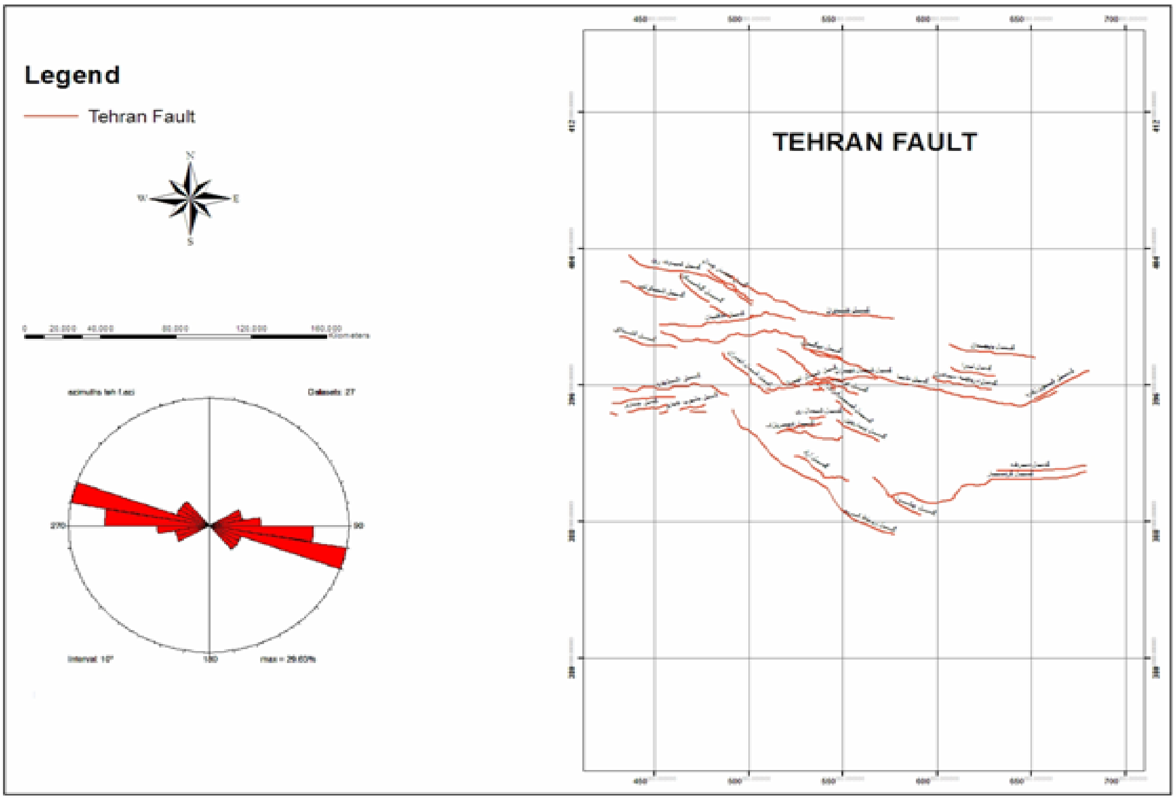

Figure 6: Faults map of Tehran was digitized in Arc Gis9.2

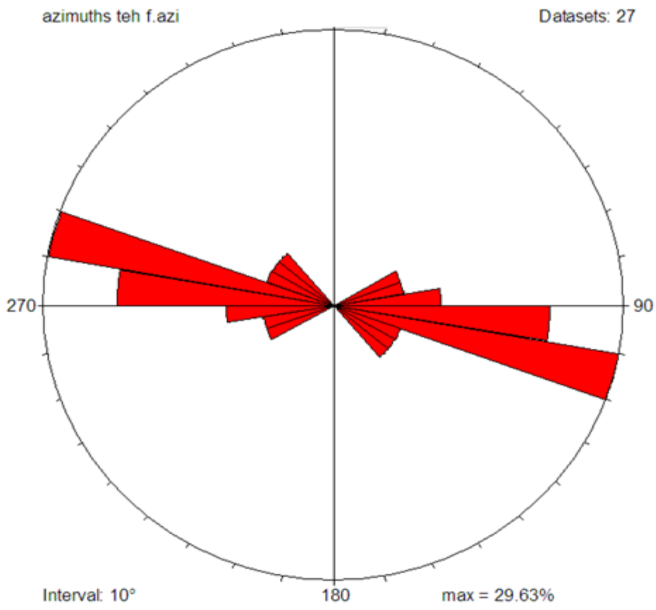

Figure 7: Rose diagram of Tehran faults

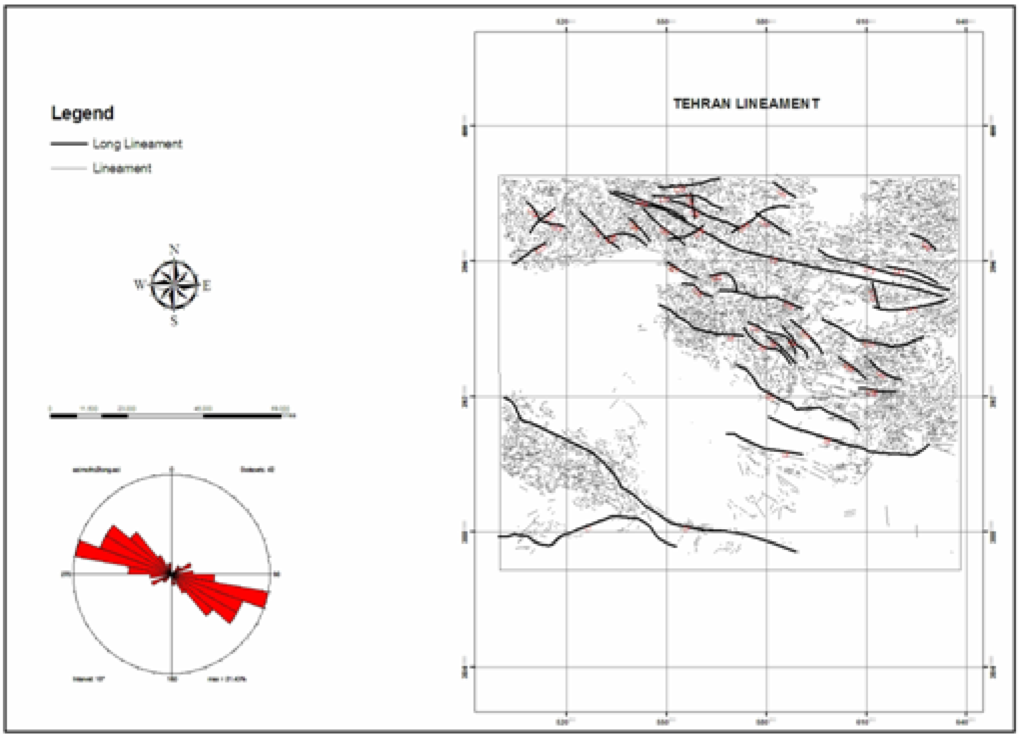

Figure 8: Long lineaments by pursuing the lineaments in same direction

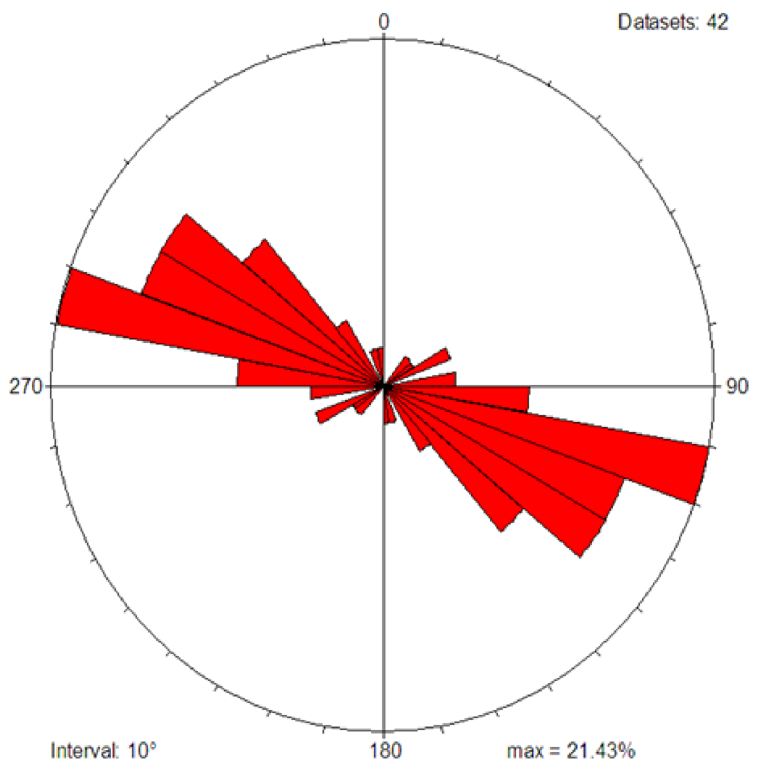

Figure 9: Rose diagram of long lineaments

Table 1: The Azimute and length of the long lineaments

AZIMUTH	LENGTH(M)	Name	AZIMUTH	LENGTH(M)	Name
92.99	59632.959	L1	117.57	10442.562	L21
117.49	103111.258	L2	117.61	11842.486	L22
107.10	105145.623	L3	58.67	12155.912	L23
109.81	27966.225	L4	143.64	6606.393	L24
128.14	18445.565	L5	45.12	11010.854	L25
134.33	11879.866	L6	103.24	7760.681	L26
140.63	12505.610	L7	98.31	14229.453	L27
104.81	23820.409	L8	137.96	9248.127	L28
99.42	51043.463	L9	69.15	11782.784	L29
100.27	32869.713	L10	131.07	16739.966	L30
84.48	22752.389	L11	100.35	21837.765	L31
165.05	7707.365	L12	82.01	18739.043	L32
106.82	41734.980	L13	110.91	23112.250	L33
132.35	16104.449	L14	66.22	19777.654	L34
171.75	7836.600	L15	122.99	12577.666	L35
111.50	22336.858	L16	123.30	8092.971	L36
123.62	18340.523	L17	135.92	13909.345	L37
112.88	9982.315	L18	95.36	11404.008	L38
102.27	25942.962	L19	128.50	10827.900	L39
117.67	43508.744	L20			

2.7 Automatic methods

The automatic lineaments are created by PCI Geomatica software. The concept of lineaments extraction from digital satellite image has been treated by several authors (Podwysocki et al., 1975)(Burdick and Speirer, 1980) and (Baumgartner et al., 1999).

2.7.1 Short lineaments production

Short lineament is produced by following parameter (figure 10, 11).

Radius of filter in pixels, RADI=10

Threshold for edge gradient, GTHR=75

Threshold for curve length, LTHR=30

Threshold for line fitting error, FTHR=3

Threshold for angular difference, ATHR=1

Threshold for linking distance, DTHR=40

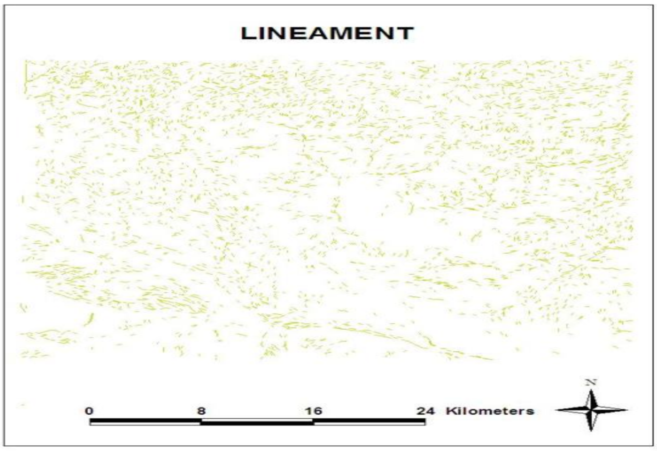

Figure 10: Short Lineaments, producing by Automatic methods

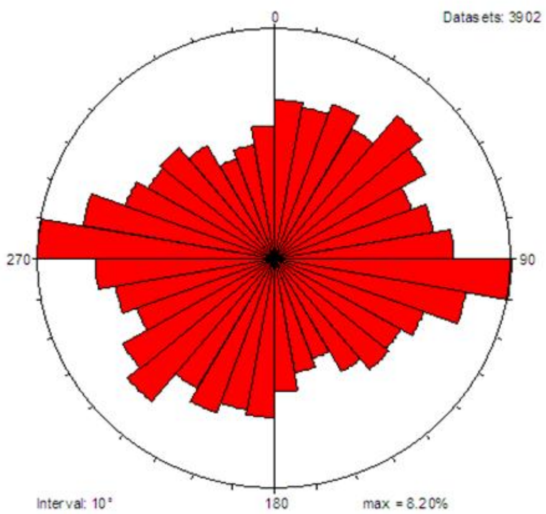

Figure 11: Rose diagram of short lineaments, producing by Automatic methods

2.7.2 Long lineaments production

Following parameter is applied to produce long lineament (figure 12,13).

Radius of filter in pixels, RADI=11

Threshold for edge gradient, GTHR=25

Threshold for curve length, LTHR=90

Threshold for line fitting error, FTHR=4

Threshold for angular difference, ATHR=15

Threshold for linking distance, DTHR=200

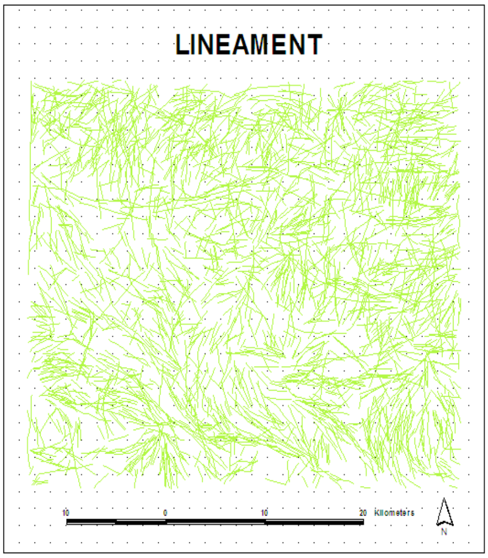

Figure 12: Long Lineaments, producing by automatic methods

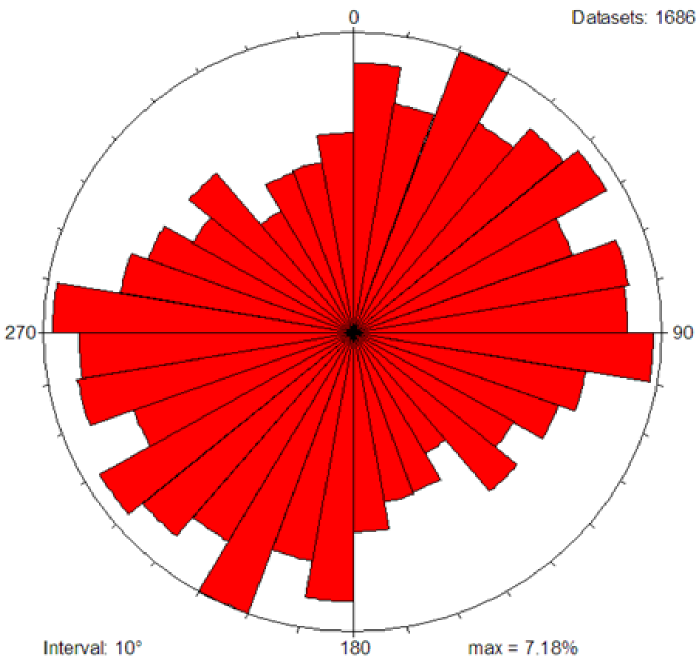

Figure 13: Rose diagram of long lineaments, producing by Automatic methods

3. Conclusion

It is indicated that the accuracy of the manual method is higher because the non- geological lineaments may be specified.

From the results obtained, some lineaments do not have any equivalent faults (table1), and new lineaments can be recognized within field work, so removing hazard of them might be very crucial in Tehran if they are verified as faults.

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