Contouring using different software packages

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An overall study of different programs of contouring is performed. Each program aims to be well suited for accurate fitting of irregular contours and provides a direct control over the density of solved points, which reliably yield smooth computer plotted contour. This paper does not aim to explain the included programs or how they are working, but it aims to make a comparison of their results and accuracy. Accuracy requirement adopted for each program is performed. The external appearance of actual feature and its execution are of great importance before using software.

هذا البحث يهتم بالبرامج الجاهزة المتداولة عند استخدامها لرسم الخرائط الكنتورية من الميزانية الشبكية أو من النقط العشوائية التى تمثل سطح الأرض عند أماكن التغير فى المنسوب. وقد استخدم فى هذا البحث أربعة برامج مختلفة أشهرها وأكثرها تداولا بين المهندسين برنامج سرفر (Surfer) بالإضافة إلى برنامج ADCADD-DTM وبرنامج ACAD ADDONS والبرنامج المساحي المتخصص SDR. وقد تم إجراء البحث على منطقة معروف مسبقا الشكل الطبوغرافى لها ثم تم تعميم البرامج على مناطق مختلفة بأشكال مختلفة للوصول إلى أحسن البرامج التى تعطى نتائج تتوافق مع الشكل الموجود بالطبيعة. وقد وجد أن استخدام البرنامج الأول سرفر (Surfer) مباشرة يعطى خرائط كنتورية غير مطابقة للواقع فى حين أن البرامج الأخرى تعطى نتائج مطابقة للواقع. لذلك فإن استكشاف الموقع قبل بداية العمل بهذه البرامج يعتبر من أهم العوامل التى تحدد مقدار المعالجة المطلوبة قبل استخدام البرامج كذلك فإنه كلما صغرت المسافة بين النقط فى الشبكة كلما أدى ذلك إلى دقة إنتاج الخرائط الكنتورية. كما أوضح البحث ضرورة تحديد أماكن التغير المفاجئ فى المناسيب حيث توضيح ذلك يقلل من المناسيب الغير متوقعة عند استخدام البرامج. من هذا البحث نجد أنه من المهم جدا قبل عمل الخرائط الكنتورية بواسطة البرامج الجاهزة أن تكون لدينا فكرة مسبقة عن طبيعة المنطقة المرفوعة حتى لا يحدث هناك خلط فى إنتاج خرائط كنتورية غير مطابقة للواقع.

Keyword: Leveling, Contouring, Computer software

1. Introduction

A topographic surface, which is usually irregular, containing hills, depressions and ground surface undulations, can be represented on a map by several methods. A contour map is one of the best methods adopted to represent the configuration of the topographic surface [1]. With the wide range of using computer in engineering applications, it is found that it is necessary to introduce a simple study for one of these applications, namely contour map production or contouring. The aim of this study is to perform a comparative study among some computer programs of contour map production. The process of contour map production by different programs included in the study is not explained.

This study aims also to clarify the characteristics of the different programs, especially those that can be considered as short in them.

The varieties of computer programs were taken into consideration. The most available and famous programs were used. One of them runs under DOS operating system. The rest run under Windows operating system. One of them runs independently i.e. during operation and printing, while the rest are linked with another program.

2. Programs used in study

1. Surfer (win 32) version 6.01 [2]. This program runs under Windows operating system. It is a stand-alone program i.e. not linked with other programs during running or printing.

2. ADCADD - DTM - 12.12, [3]. This program runs under DOS operating system. It is linked with AutoCAD version 12 under dos in both operating and printing.

3. ACAD ADDONS - Civil and Surveying, version 14 [4]. This program run under Windows operating system, also it is a linked

program with AutoCAD version 14 in both operating and printing.

4. *SDR Mapping & Design version 6.00, [5].* This program runs under Windows operating system. It is a stand-alone program i.e. not linked with other programs during running or printing.

3. Programs computation

In this study a leveling map (model) is used to produce a contour map using the different programs which were discussed before. Each point in the model is entered using three-dimensional coordinate system. Data are manipulated according to each program and results are obtained for each program run as follows:

3.1. Surfer (win 32) version 6.01. Surface mapping system

In table 1 below, the list of the three-dimension coordinates of the area of land, which is considered to be the sample of the study.

Table 1
Coordinate of points of the sample area as input data (X,Y, and Z coordinates)

0,0,7.1	0,20,6.1	0,40,6.5	0,60,6.1
30,0,5.2	30,20,7.8	30,40,7.1	30,60,6.5
60,0,7.8	60,20,5.4	60,40,6.2	60,60,7.9
90,0,7.4	90,20,7.7	90,40,6.4	90,60,7.9

It is noticed that the coordinates are written as X, Y, Z axes respectively, and the X-axis is towards the eastern direction, the Y-axis is due to the north direction, and the Z-axis represents the level of the mentioned point. Fig. 1 represents the contour map production and the following are the most important remarks.

a- There is a point with level (7.90) on line (7A-8A),in the meanwhile the level of point (7A) is (7.80) and the level of point (10A) is (7.40). This point must be closer to point (10A) where the difference in elevation is (0.10), than to point (7A) where the difference in elevation is (0.30).

b- Contour line (6.50) between lines (3G-4G) and (1B-1C) must pass through point (4G) with the same level. The same can be said about contour line (6.50) between lines (1D-1E) which must pass through point (1E) with level of (6.50).

c- Point (7G) with (7.980) level has the same level as point (10G), so contour lines (7.50), (7.25), and (7.00) must be parallel to line (7G-10G).

d- A point with level (7.50) on line (10A-10B) is incorrect because it is far from point (10A) with level (7.40) by (0.10) and from point (10C) with level (7.70) with (0.20).

e- The program assumed that the area around point (2B) is in the range of (6.50) and (6.25), but this is not clear from the basic data of the contour map because of long distances between Graticule in the vertical direction (north-south direction) which achieved to (0.30) and in the horizontal direction (east-west direction) which equal to (020).

f-The same notice in the previous point can be applied for the area around point (5F) and for the same reasons.

If a Graticule of 10 m. in both directions (east west and north south) and a simple interpolation is assumed, which is the main feature of this program, the following notes can be observed:

i. On line (1G-2G) there is a point with level (6.25); the correct point must lay on the line (2G-3G) because it is (0.15) far from point (4G) with (6.5) level.

ii- On line (8E-9E) there is a point with level (6.50), while the level of point (7E) is (6.20) and the level of point (10E) is (6,40).

iii- A point with level (6.50) is laid on the line (9E-10E), meanwhile the level of the point (7E) is (6.20) and the level of point (10E) is (6.40).

iv- A point with level (7.55) is laid on the line (9G-10G), meanwhile the level of the point (7G) is (7.90) and the level of point (10G) is (7.90).

v- A point with level (7.75) is laid on the line (7G-8G), meanwhile the level of the point (7G) is (7.90) and the level of point (10G) is (7.90).

3.2. ADCADD-DTM-12.12

Table 2 represents the list of the three dimension coordinates of the same area of land, which is considered to be the model of study.

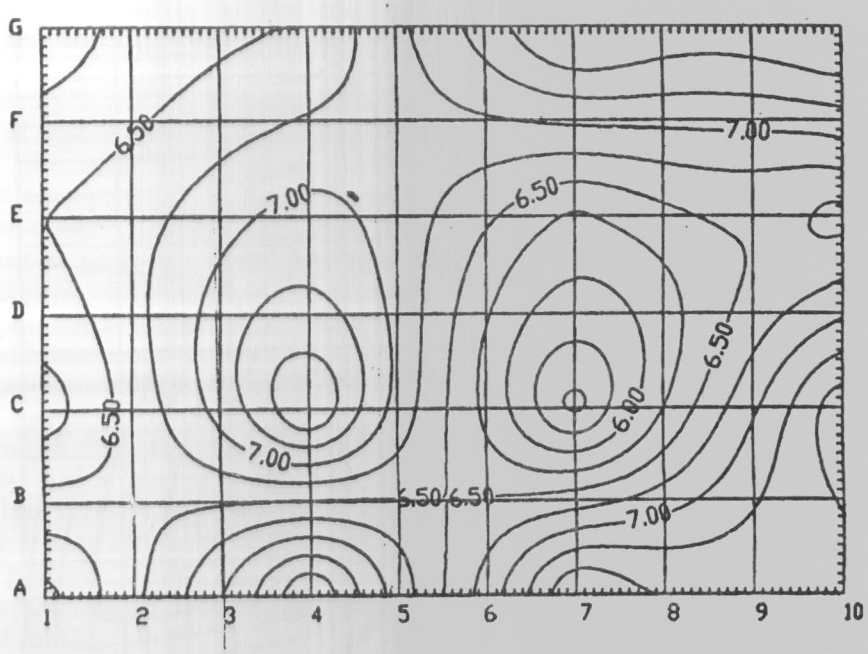

Fig. 1. Contour map using Surfer program.

It is noticed here that the coordinates of points must be forward as input data by the pervious sequence, any change in it will lead to change in the model area shape, i.e. direction and angle of view.

Fig. 2 represents the contour map production by ADCADD_DTM_12.12 program. The following are the most important remarks, which could be noticed:

Table 2
The three dimension coordinates of the same sample area

No.	X	Y	Z
1	0.000000	00.000000	7.100000
2	0.000000	20.000000	6.100000
3	0.000000	40.000000	6.500000
4	0.000000	60.000000	6.100000
5	30.000000	00.000000	5.200000
6	30.000000	20.000000	7.800000
7	30.000000	40.000000	7.100000
8	30.000000	60.000000	6.500000
9	60.000000	00.000000	7.800000
10	60.000000	20.000000	5.400000
11	60.000000	40.000000	6.200000
12	60.000000	60.000000	7.900000
13	90.000000	00.000000	7.400000
14	90.000000	20.000000	7.700000
15	90.000000	40.000000	6.400000
16	90.000000	60.000000	7.900000

I. Point (1E) has level of (6.50), but contour line (6.50) does not pass through it. The contour line intersects line (1E-2E).

II. Point (5G) has level of (6.5), but contour line with the same level does not pass through it. The contour line intersects line-connecting points (4F-4G).

As in the pervious program if a Graticule of 10 m. in both directions (east west and north south), and a simple interpolation is assumed, the following notes can be observed.

i-A point with level (6.50) is found on line (5F-6F), in spite of by simple interpolation; the level of point (5F) is (6.85) and for point (6F) is (6.95).

ii- A point with level (6.50) is fond on line (8D-8E), in spite of by simple interpolation; the level of point (8D) is (6.20) and for point (8E) is (6.25).

iii- Point (5F) with (6.85) level reached by simple interpolation between point (5.60) with level (6.90) and point (5E) with level (6.80), has passed by contour line (6.50).

iv- After a simple interpolation process, the level of point (6F) is (6.95), and of point (6G) is (7.40), so contour line (7.40) cannot run between them.

will leads to a change in the example area shape, i.e. direction and angle of view.

IV. As this study is not concerning with the features of the different programs, but with the characteristics and accuracy of a contour map production by each one of them, the other functions or jobs they can do such as longitudinal and lateral cross sections, calculation of cut and fill, three dimensions modules, ... etc is not considered here.

V. If a simple interpolation is applied upon the grid system of coordinates before starting contouring, it will be noticed that point (4B) has a level of (6.50) and point (6B) will has level (6.55). The above levels gives an uncertain indication that the distance between these two points is flat and have the same level range between (6.50) and (6.55).

VI. According to the previous assumption, it is impossible to have a contour lines with (6.75) or (7.00) or (7.25) levels crossing the line extends from point (4B) to point (6B).

4. Discussion

1. Any change in contour interval has no effect on the main characteristics of the contour map, so it is neglected in this study.
2. Any change in the contour maps characteristics such as smoothing the curves...etc will not affect the main shape of the contour lines, consequently will not have any effect upon the maps accuracy.
3. Surfer (win32-version 6.01) starts the job by creating a smaller Graticule and making simple interpolation over it before starting contouring process.
4. The other three programs starts contouring process directly according to the input Graticule.
5. By applying a simple interpolation over the grid of Graticule before starting contouring, an uncertain feeling that fig. 1 which is the result of server (win 32-, version 6.01 program, is the best among the studied programs. If no simple interpolation is applied upon the grid system of coordinates before starting contouring, there will be a possibility that there is a change in elevations along the lines ((5B-4B-5B-6B) and around the point (5F), which indicates in fig. 2 or fig. 3 or fig. 4 which are the result of ADCADD-TM-12.12 or ACAD ADDONS version14 or SDR mapping

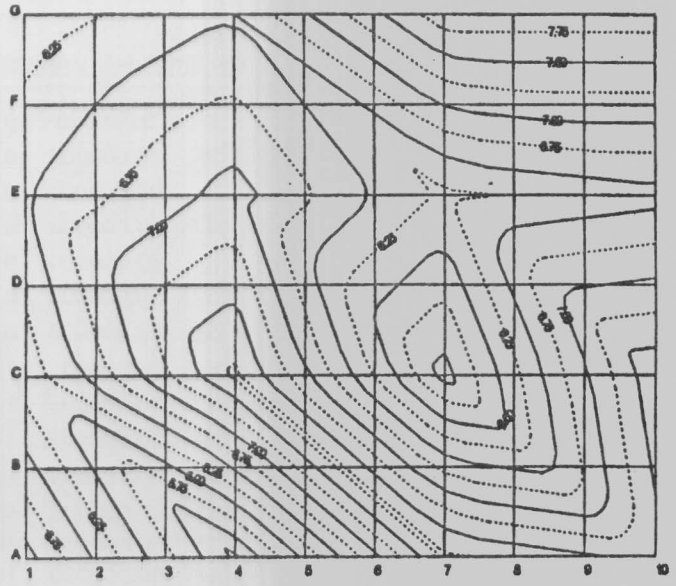

Fig. 3. Contour map using ACAD – ADDONS program.

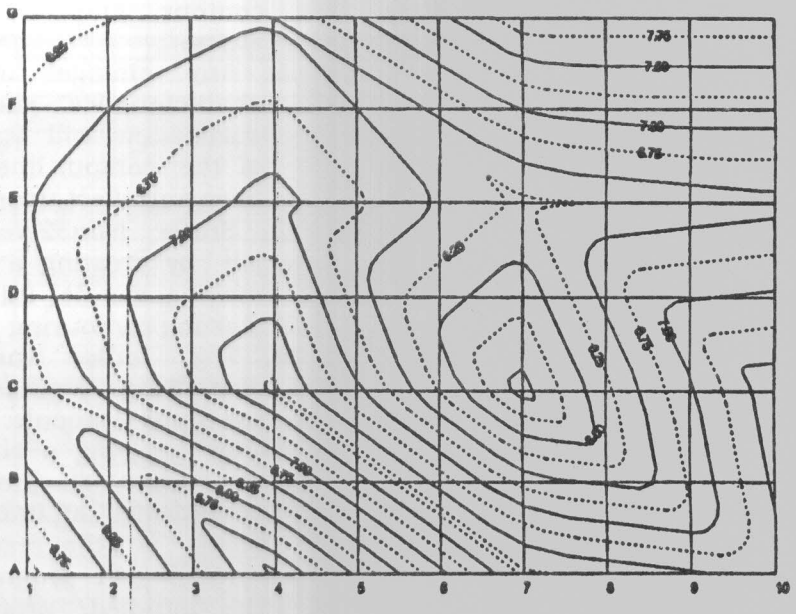

Fig. 4. Contour map using SDR program.

And Design version 6.00 program, which is the best among the studied programs.

It seems that there is no rule that can control applying; or not; interpolation upon graticule before starting contour operation.

To determine which contour map is the most accurate the following precaution and steps may be suggested:

- Exploration of the site to be contoured before work starting is a must. This will give the surveying engineer an idea about the features of the site, and can be considered as the human rule in the process.
- Minimizing the graticule distances during leveling of the site. The shorter the distances between points of graticule, the more accurate contour map production. In the same time the economical factor must be considered during the Graticule distances determination.
- As a basic matter in contouring field operations, an elevation must be defined at every change in the nature level. This will eliminate unexpected levels if a simple interpolation is applied upon a new smaller Graticule before contouring process.

6. It is difficult to judge on the last three contour maps efficiency and also it's hard to determine which one of the used contouring programs is the more accurate and more precise than the others.

7. To prove previous conclusions a manual simple interpolation is applied upon a Graticule of 10 m. performed for the same field data. The results are introduced as input data to programs number (2,3 and 4). The contour map produced by any of these programs is identical with that produced by program number (1).

8. The input data are shown in table 3 and the contour map is shown in fig. 5

Table 3
The input data using programs 2, 3 and 4

No.	X	Y	Z
1	0.000000	0.000000	8.100000
2	10.000000	0.000000	7.100000
3	20.000000	0.000000	6.100000
4	30.000000	0.000000	6.300000
5	40.000000	0.000000	6.500000
6	50.000000	0.000000	6.300000
7	60.000000	0.000000	6.100000
8	0.000000	10.000000	7.120000
9	10.000000	10.000000	6.900000
10	20.000000	10.000000	6.700000
11	30.000000	10.000000	6.700000
12	40.000000	10.000000	6.700000
13	50.000000	10.000000	6.460000
14	60.000000	10.000000	6.230000
15	0.000000	20.000000	6.160000

Table 3. (Cont.)

No.	X	Y	Z
16	10.000000	20.000000	6.700000
17	20.000000	20.000000	7.250000
18	30.000000	20.000000	7.070000
19	40.000000	20.000000	6.900000
20	50.000000	20.000000	6.630000
21	60.000000	20.000000	6.360000
22	0.000000	30.000000	5.200000
23	10.000000	30.000000	6.500000
24	20.000000	30.000000	7.800000
25	30.000000	30.000000	7.450000
26	40.000000	30.000000	7.100000
27	50.000000	30.000000	6.800000
28	60.000000	30.000000	6.500000
29	0.000000	40.000000	6.060000
30	10.000000	40.000000	6.535000
31	20.000000	40.000000	7.000000
32	30.000000	40.000000	6.900000
33	40.000000	40.000000	6.800000
34	50.000000	40.000000	6.880000
35	60.000000	40.000000	6.970000
36	0.000000	50.000000	6.920000
37	10.000000	50.000000	6.570000
38	20.000000	50.000000	6.200000
39	30.000000	50.000000	6.350000
40	40.000000	50.000000	6.500000
41	50.000000	50.000000	6.970000
42	60.000000	50.000000	7.440000

Table 3. (Cont.)

No.	X	Y	Z
43	0.000000	60.000000	7.800000
44	10.000000	60.000000	6.600000
45	20.000000	60.000000	5.400000
46	30.000000	60.000000	6.800000
47	40.000000	60.000000	6.200000
48	50.000000	60.000000	7.050000
49	60.000000	60.000000	7.900000
50	0.000000	70.000000	7.660000
51	10.000000	70.000000	6.920000
52	20.000000	70.000000	6.170000
53	30.000000	70.000000	6.270000
54	40.000000	70.000000	6.230000
55	50.000000	70.000000	7.850000
56	60.000000	70.000000	7.900000
57	0.000000	80.000000	7.530000
58	10.000000	80.000000	7.240000
59	20.000000	80.000000	6.930000
60	30.000000	80.000000	6.680000
61	40.000000	80.000000	6.360000
62	50.000000	80.000000	7.130000
63	60.000000	80.000000	7.900000
64	0.000000	90.000000	7.400000
65	10.000000	90.000000	7.550000
66	20.000000	90.000000	7.700000
67	30.000000	90.000000	7.050000
68	40.000000	90.000000	6.400000
69	50.000000	90.000000	7.150000
70	60.000000	90.000000	7.900000

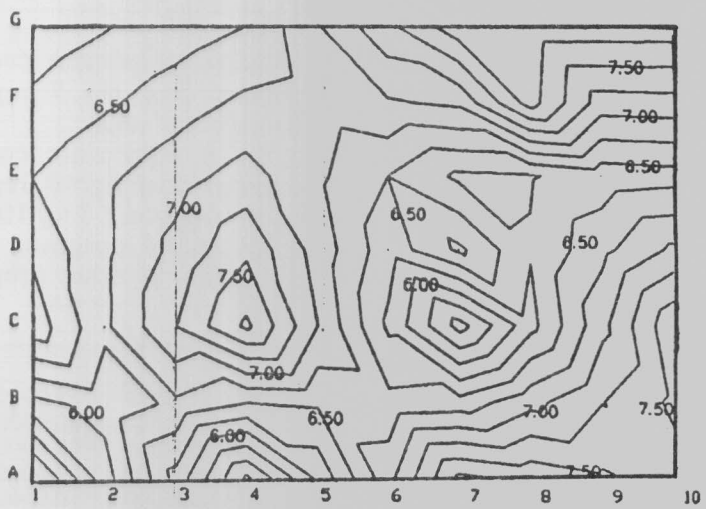

Fig. 5. Contour map after interpolation.

It is noticed here that the coordinates of points must be forward as input data by the pervious sequence, any change in it will leads to change in the example area shape, i.e. direction and angle of view. The programs used are applied on another real areas and results are given in appendix.

Conclusions

Several examples were provided to demonstrate the practical use and efficiency of each program use for contour production.

The smoothing interpolation procedure is a reliable and efficient means for the computer approximation and display of discretely sampled unknown contour lines on condition that:

The shorter the length of the Graticule the more accurate the resulting contour maps.

A level at every change in the elevation at site must be recorded. Full dependence on computer programs may lead to inaccurate results, i.e. the examination and observation of nature of topographic feature is a must.

Appendix

To prove what is previously mentioned in the discussion and conclusion, all the programs applied three more examples. It is noticed that the results of last three programs are identical, and a slight difference in curve smoothing between them and the first program, so two drawings are quite enough for each example.

Example 1

No.	X	Y	Z
1	0.000000	0.000000	7.380000
2	7.500000	0.000000	7.040000
3	15.000000	0.000000	6.410000
4	22.500000	0.000000	5.510000
5	30.000000	0.000000	5.280000
6	37.500000	0.000000	5.620000
7	45.000000	0.000000	5.680000
8	0.000000	10.000000	7.200000
9	7.500000	10.000000	6.420000
10	15.000000	10.000000	4.980000
11	22.500000	10.000000	4.570000
12	30.000000	10.000000	4.650000
13	37.500000	10.000000	3.460000
14	45.000000	10.000000	4.310000
15	0.000000	20.000000	6.500000
16	7.500000	20.000000	5.460000
17	15.000000	20.000000	3.520000
18	22.500000	20.000000	3.560000
19	30.000000	20.000000	3.060000
20	37.500000	20.000000	2.810000
21	45.000000	20.000000	2.570000
22	0.000000	30.000000	5.720000
23	7.500000	30.000000	5.150000
24	15.000000	30.000000	5.300000
25	22.500000	30.000000	4.050000
26	30.000000	30.000000	2.620000
27	37.500000	30.000000	2.620000
28	45.000000	30.000000	2.540000
29	0.000000	40.000000	4.780000
30	7.500000	40.000000	4.460000
31	15.000000	40.000000	3.910000
32	22.500000	40.000000	3.890000
33	30.000000	40.000000	3.740000
34	37.500000	40.000000	3.610000
35	45.000000	40.000000	3.230000
36	0.000000	50.000000	3.840000
37	7.500000	50.000000	3.550000
38	15.000000	50.000000	3.620000
39	22.500000	50.000000	3.080000
40	30.000000	50.000000	2.910000
41	37.500000	50.000000	2.630000
42	45.000000	50.000000	2.150000

Fig. 6 represents contouring using Surfer program and fig. 7 represent contouring by other programs.

Fig. 8 represents contouring using surfer program and fig. 9 represents contouring by other programs. Fig. 10 represents contouring using surfer program and fig. 11 represent contouring by other programs.

Example 2

No.	X	Y	Z
1	0.000000	0.000000	4.920000
2	20.000000	0.000000	5.100000
3	40.000000	0.000000	7.500000
4	60.000000	0.000000	8.100000
5	80.000000	0.000000	8.500000
6	100.000000	0.000000	8.700000

Example 2 (Cont.)

No.	X	Y	Z
7	120.000000	0.000000	7.900000
8	140.000000	0.000000	7.500000
9	160.000000	0.000000	6.900000
10	180.000000	0.000000	5.200000
11	0.000000	20.000000	5.400000
12	20.000000	20.000000	5.900000
13	40.000000	20.000000	7.130000
14	60.000000	20.000000	7.210000
15	80.000000	20.000000	8.000000
16	100.000000	20.000000	7.350000
17	120.000000	20.000000	7.800000
18	140.000000	20.000000	7.400000
19	160.000000	20.000000	6.000000
20	180.000000	20.000000	5.220000
21	0.000000	40.000000	5.600000
22	20.000000	40.000000	6.200000
23	40.000000	40.000000	9.300000
24	60.000000	40.000000	9.200000
25	80.000000	40.000000	9.250000
26	100.000000	40.000000	9.350000
27	120.000000	40.000000	9.400000
28	140.000000	40.000000	9.070000
29	160.000000	40.000000	8.920000
30	180.000000	40.000000	5.700000
31	0.000000	60.000000	5.350000
32	20.000000	60.000000	5.400000
33	40.000000	60.000000	5.450000

Example 2 (Cont.)

No.	X	Y	Z
34	60.000000	60.000000	5.920000
35	80.000000	60.000000	5.550000
36	100.000000	60.000000	5.500000
37	120.000000	60.000000	5.350000
38	140.000000	60.000000	5.700000
39	160.000000	60.000000	5.700000
40	180.000000	60.000000	5.600000
41	0.000000	80.000000	5.310000
42	20.000000	80.000000	5.150000
43	40.000000	80.000000	5.200000
44	60.000000	80.000000	5.220000
45	0.000000	80.000000	5.160000
46	100.000000	80.000000	5.030000
47	120.000000	80.000000	5.050000
48	140.000000	80.000000	5.010000
49	160.000000	80.000000	5.020000
50	180.000000	80.000000	5.200000
51	0.000000	100.000000	5.390000
52	20.000000	100.000000	5.300000
53	40.000000	100.000000	5.250000
54	60.000000	100.000000	5.150000
55	80.000000	100.000000	5.120000
56	100.000000	100.000000	5.000000
57	120.000000	100.000000	5.040000
58	140.000000	100.000000	5.020000
59	160.000000	100.000000	5.030000
60	180.000000	100.000000	5.050000

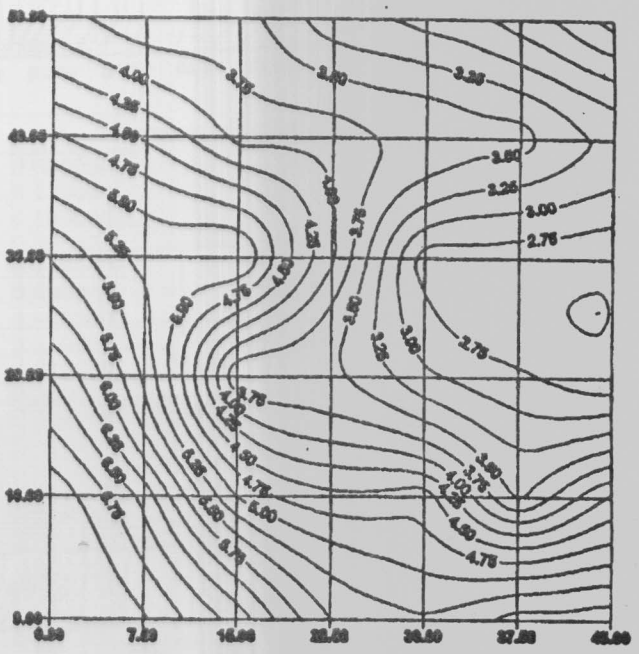

Fig. 6 Contouring using Surfer program.

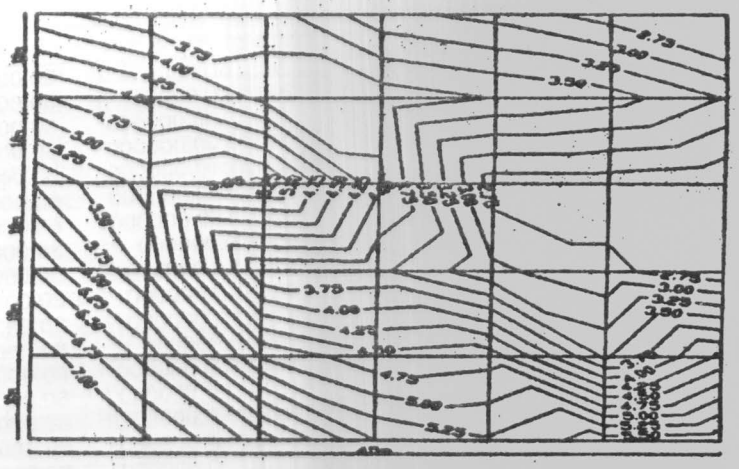

Fig. 7 Contouring using other programs.

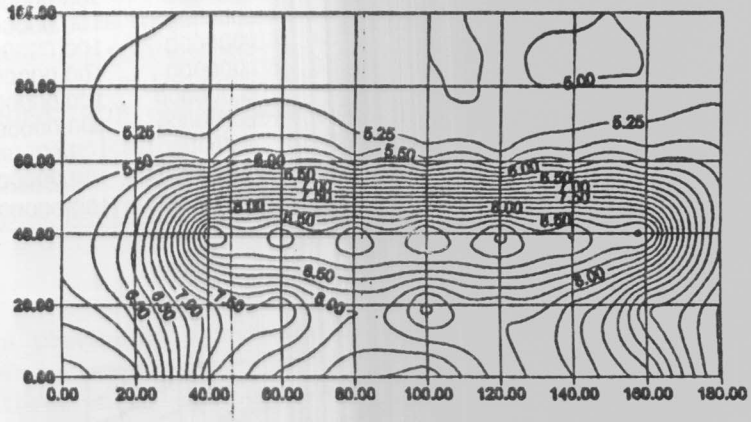

Fig. 8 Contouring using Surfer program.

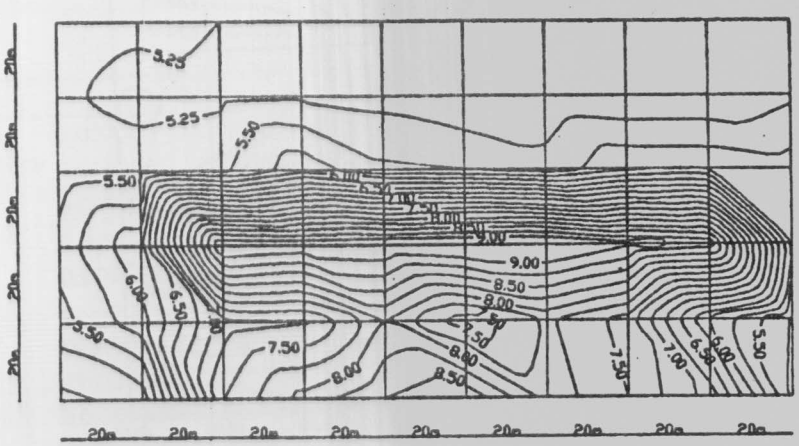

Fig. 9. Contouring using other programs.

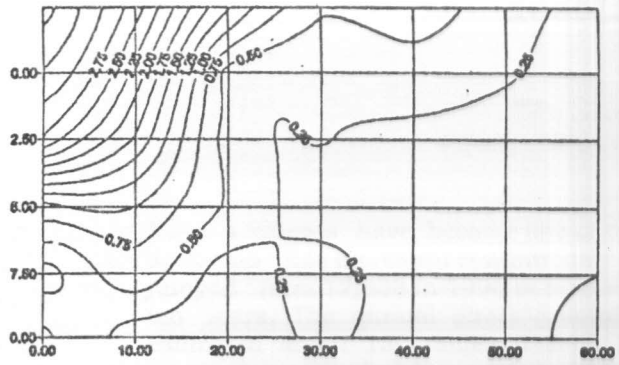

Fig. 10 Contouring using Surfer programs.

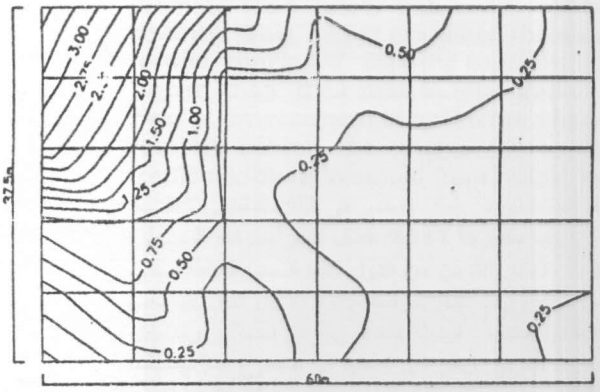

Fig. 11. Contouring using other programs.

Example 3

No.	X	Y	Z
1	0.000000	0.000000	0.580000
2	10.000000	0.000000	0.130000
3	20.000000	0.000000	0.100000
4	30.000000	0.000000	0.300000
5	40.000000	0.000000	0.110000
6	50.000000	0.000000	0.090000
7	60.000000	0.000000	0.420000
8	0.000000	7.500000	0.110000
9	10.000000	7.500000	0.710000
10	20.000000	7.500000	0.100000
11	30.000000	7.500000	0.400000
12	40.000000	7.500000	0.120000
13	50.000000	7.500000	0.130000
14	60.000000	7.500000	0.250000
15	0.000000	15.000000	0.900000
16	10.000000	15.000000	1.000000
17	20.000000	15.000000	0.470000
18	30.000000	15.000000	0.140000

Example 3 (Cont.)

No.	X	Y	Z
19	40.000000	15.000000	0.010000
20	50.000000	15.000000	0.060000
21	60.000000	15.000000	0.070000
22	0.000000	22.500000	2.720000
23	10.000000	22.500000	1.720000
24	20.000000	22.500000	0.380000
25	30.000000	22.500000	0.270000
26	40.000000	22.500000	0.160000
27	50.000000	22.500000	0.100000
28	60.000000	22.500000	0.020000
29	0.000000	30.000000	3.230000
30	10.000000	30.000000	2.150000
31	20.000000	30.000000	0.380000
32	30.000000	30.000000	0.340000
33	40.000000	30.000000	0.440000
34	50.000000	30.000000	0.290000
35	60.000000	30.000000	0.100000
36	0.000000	37.500000	3.610000
37	10.000000	37.500000	2.630000
38	20.000000	37.500000	1.290000
39	30.000000	37.500000	0.530000
40	40.000000	37.500000	0.610000
41	50.000000	37.500000	0.380000
42	60.000000	37.500000	0.110000

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