

# Making Different Topographic Maps with the Surfer Package

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## ABSTRACT

The main objective of this study is to describe the preparation of topographic maps using the Surfer software. A total of 159 regularly distributed Ground Control Points (GCPs) were collected with the use of the Differential Global Positioning System (DGPS). Seven methods (Contour Map, Post Map, 3D Surface Map, 3D Wireframe Maps, Grid Vector-1 Map, Color Relief Map, and Shaded Relief Maps) at the Surfer environment were used to prepare the topographic maps at the Mukhtar Village near the Al-Fallujah City. Contour lines with other features were superimposed on the DEM layer, which refers to the topography of the terrain inside this study area. The accuracy of the database's results was estimated, essential maps were given, and the results were efficient and effective. The most appropriate method to represent topographic maps was proposed, each of these techniques has been enough to provide us with a general understanding of the subject area.

*Keywords-topographic map; GCPs; contour map; 3D surface map; Surfer software*

## I. INTRODUCTION

The topographic map is one of the most often utilized maps. Contours are employed to depict the form and height of the land, including both natural and manufactured features such as valleys, hills, plains, streams, boundaries, and significant buildings [1]. A topographic map accurately depicts the geographical characteristics of an area, such as rivers, lakes, paths, railways, power lines, elevations, and contours. Topographical maps are a useful planning aid and information source [2, 3]. Authors in [4] located the research region using Google Earth, DEM, and satellite pictures together with geological and topographical maps. Techniques of geographic information systems were utilized to compute the major large study's area of coverage and geometrical factors [4].

Digital mapping is a way of compiling and formatting a collection of geographical data from an actual location into a virtual representation. The main purpose of this technology is to create maps that accurately depict a given location while also highlighting all the interesting elements that would be useful to a user. The surfer program supports map projections and selects a map to display from an endless list of projections [5]. The term Digital Elevation Model (DEM) refers to raster files that contain elevation information for each raster cell. DEMs are employed in a variety of applications because knowledge of the slope of the ground is useful for explaining phenomena on the surface and in general understanding the way the terrain works [6]. A DEM is a three-dimensional representation of the earth's surface devoid of any plants and structures. The Digital Surface Model (DSM) is a representation of the entire earth's surface, including all its components. Briefly, all the collected satellite data form first a DSM [7, 8].

Geographic Information Systems (GISs) frequently make use of DEMs, which are also the most frequently utilized foundation for digitally created relief maps. DSM may be helpful for 3D digital city deployments, visualization applications, and landscape modeling [9, 10]. DTM is frequently necessary for geological applications, land-use studies, flood or drainage models, and other uses [11-13]. Traditional survey methods, like leveling as well as total stations, are used to generate DEMs with high accuracy for civil engineering projects, although they are more expensive than other methods. Depending on the length of baselines, geodetic GPS receivers are known to be utilized for locating with centimeter- or millimeter-level accuracy [14, 15]. Land-based GPS is intended to give 3-D location, navigation, and velocity data. Satellites make up the space segment of GPS, while ground-based tracking and monitoring spots and user-based receivers make up the control and user portions. The distances between the reception antenna and the satellites in view are measured by a ground-based static or roaming GPS receiver, which is merely a range measurement device. The location is then calculated from the range vectors' adjusted intersections [16]. In the field of geodetic surveying, the GPS is a highly developed technique. The GPS method is significantly more effective than more similar methods, including total station, level, and theodolite, in terms of the number of users, effective cost, inter-visibility, and accuracy [17-20]. Authors in [21] proved that produced DEM using DGPS data are more effective than DEM produced using contour separation or SRTM data. Authors in [22] utilized RTK-DGPS data gathering for leveling, local study, and the application of 2D polynomial models and Earth Gravitational Models (EGM2008, EGM96), dictated by geoid undulation. When the

data do not entirely cover the study domain, interpolation may be utilized. This situation might occur to illustrate changes in the height of the land surface (DEMs) [23]. There are different interpolation principles for the interpolation methods, and each of them may produce different results. Some of these methods include linear interpolation, kriging, triangulation, natural neighbor, Inverse Distance Weighting (IDW), and polynomial regression [24, 25]. In [17], various surface modeling techniques were employed, including nearest neighbor, natural neighbor, and IDW.

Golden Software provides two products: Grapher TM for 2D and 3D graphing and Surfer for gridding, contouring, and 3D surface mapping. Surfer is strong contouring, gridding, and surface mapping software for scientists, engineers, teachers, and anybody else who wants to create maps quickly and efficiently. The grid-based mapping tool Surfer interpolates randomly spaced Cartesian data into a grid with uniform spacing. The grid is used to create a variety of maps, like contour, color relief, and 3D surface maps [26]. With Surfer, numerous map kinds can be produced, altered, and presented. These maps come in a variety of formats, including base, contour, post, classified post, 3D surface, 3-D wireframe, color relief, grids values, peak and depressions, pointed cloud, watershed, and view shed maps [27-29].

II. STUDY AREA

Information was gathered using a Differential GPS (DGPS) survey carried out in Mukhtar Village near Al-Fallujah City as illustrated in Figure. A total of 159 Ground Control's Points were observed using DGPS technology (Topcon GR3/Hipper II). These observed points are included in Appendix A and can be seen in Figure 1 as contour lines. The purpose of the study is to create a topographical map by using the Surfer package in order to know the terrain and the areas of elevation.



Fig. 1. Study area.

III. RESULT: MAP TYPES

Different topographic maps can be created, modified, and displayed with Surfer software for comparative analysis. After the topographic map representation was done, the Contour Map was found as more suitable, as shown in Figures 2-8.

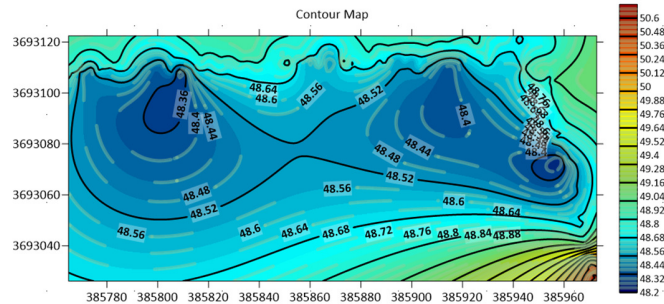


Fig. 2. Contour Map.

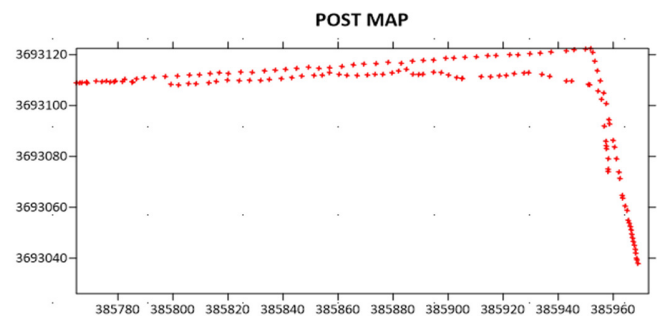


Fig. 3. Post Map.

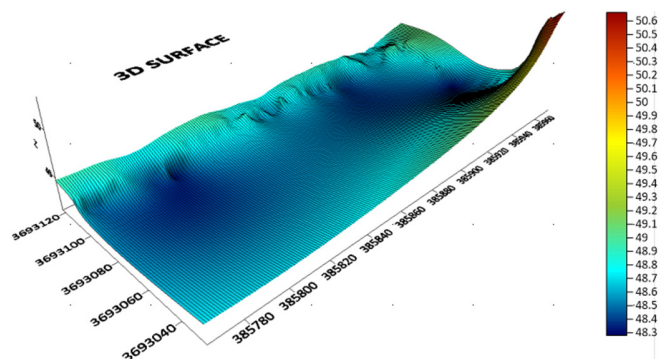


Fig. 4. 3D Surface Map.

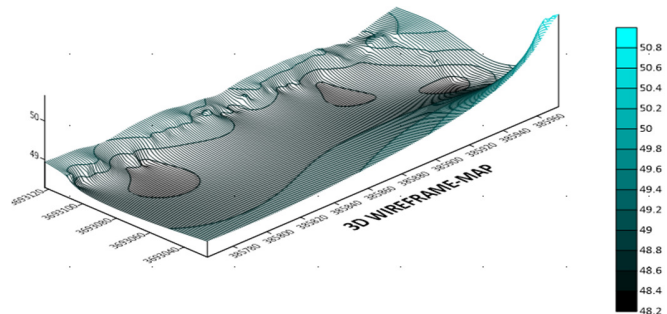


Fig. 5. 3D Wireframe Map.

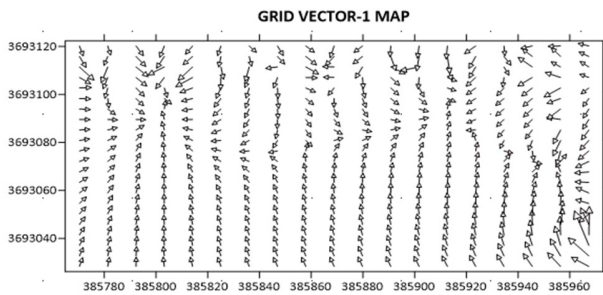


Fig. 6. Grid Vector Map.

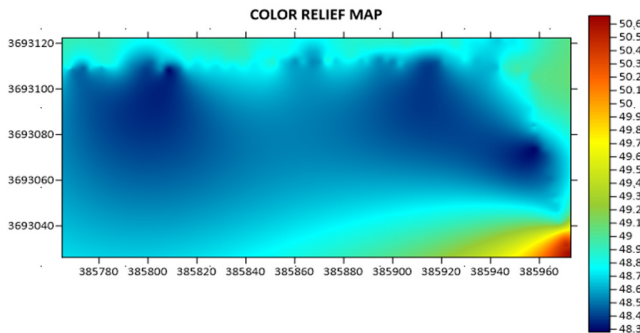


Fig. 7. Color Relief Map.

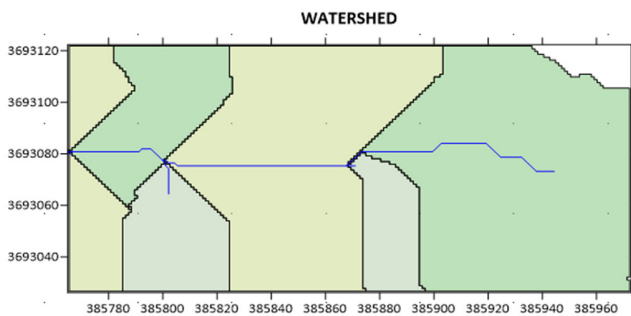


Fig. 8. Shaded Relief Map.

The surfer can conduct volumetric calculations quickly. Cross-sectional profiles can be computed and exported as well. Figure 9 shows the mass haul diagram for the road that passes throughout at a minimum elevation of 48.3 m and a maximum elevation of 50.7 m. The report for the Grid Volumetric Computations results that Volume [Cut]  $\approx$  666.962 m<sup>3</sup>, and Volume [fill]  $\approx$  5026.602 m<sup>3</sup>. According to the Grid Data Report, the contour map had the lowest possible error value whereas the Grid Vectors Map had the highest, as shown in Table I. The error values for each type of map are not considered a criterion for choosing the type of map representation due to the existence of limitations, such as the purpose of the map and the number of points. Authors in [23, 30] mentioned that the topographic maps and their calculation can be performed quickly in Surfer. The gridding files for each map can be edited, combined, filtered, sliced, queried, and mathematically transformed. There is no difference in opinion with previous works. The results of this study encourage the expansion of applied ideas in the future by integrating with other programs and result comparison.

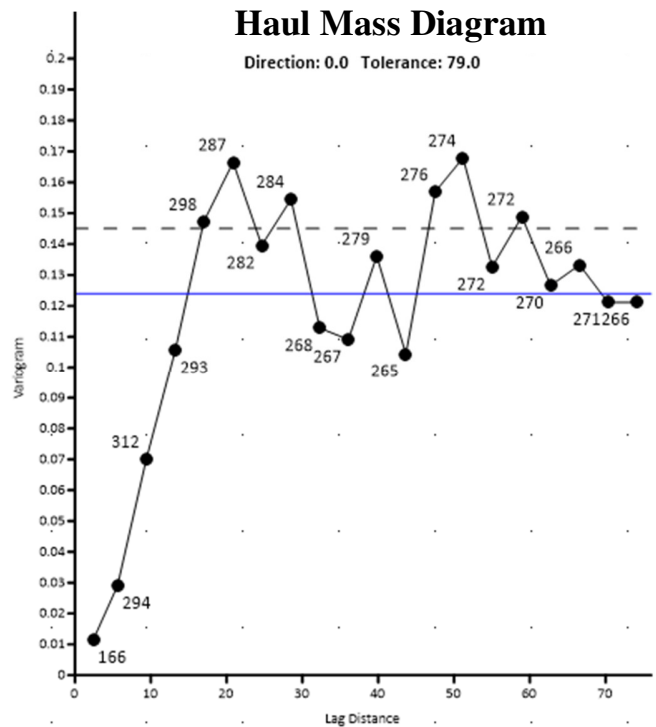


Fig. 9. The surfer volumetric calculations the mass haul diagram.

TABLE I. ERROR VALUE FOR EACH MAP TYPE

Type	No. of points	RMSE
Contour Map	159	0.016~0.025
Post Map	159	0.290~0.297
3D Surface Map	159	0.206~0.213
3D wireframe Map	159	0.283~0.296
Grid vector Map	159	0.355-0.367
Color Relief Map	159	0.295-0.301
Shaded Relief Map	159	0.310-0.322

#### IV. CONCLUSION AND DISCUSSION

In this study, topographic maps of the Mukhtar Village near Al-Fallujah City were drawn. Most of the study area is characterized by roughly equal levels on the right side of the map with a gentle slope on the most part, as the elevations appeared to increase as we go to the left of the map. The produced maps exhibit the accuracy and ease of the Surfer package and its ability to draw many types of topographic maps.

The main contributions of this study is the possibility of using its results in many areas, e.g. the street construction, laying water pipes or sanitary sewers, or being used as a preliminary study of a site when adding or creating a building. The Contour Map is the optimum for usage with the given features on the mapped area.

#### APPENDIX

Some of the data taken from the study site using the DGPS are shown in the following table:

Point	Coordinates		
	East-m	North-m	Elevation-m
1	385972.7	3693026	50.673
2	385972.8	3693026	50.663
3	385972.8	3693026	50.659
4	385972.8	3693026	50.671
5	385972.4	3693027	50.646
6	385971.8	3693027	50.579
7	385971.4	3693029	50.625
8	385971.1	3693030	50.431
9	385970.7	3693032	50.51
10	385970.4	3693033	50.403
11	385970	3693034	50.259
12	385969.7	3693036	50.086
13	385969.3	3693037	49.885
14	385969	3693038	49.616
15	385968.6	3693039	49.363
16	385968.5	3693040	49.238
17	385968.2	3693042	48.9
18	385968	3693044	48.853
19	385967.7	3693045	48.802
20	385967.3	3693047	48.683
21	385967	3693048	48.681
22	385966.7	3693049	48.653
23	385966.5	3693051	48.729
24	385966.2	3693053	48.644
25	385965.8	3693054	48.589
26	385965.4	3693055	48.625
27	385965	3693059	48.551
28	385964.3	3693061	48.49
29	385963.4	3693064	48.499
30	385963.2	3693065	48.482
31	385962.4	3693071	48.423
32	385962	3693074	48.509
33	385961.2	3693079	48.621
34	385960.5	3693084	48.711
35	385959.9	3693086	48.785
36	385958.6	3693093	48.873
37	385958.4	3693094	48.887
38	385957.4	3693101	48.934
39	385956.5	3693105	49.025
40	385955.3	3693110	48.917
41	385954.2	3693114	48.9
42	385953.3	3693117	48.768
43	385952.5	3693121	48.775
44	385951.8	3693122	48.794
45	385949.9	3693122	48.72
46	385945.8	3693122	48.738
47	385942.9	3693122	48.655
48	385937.4	3693121	48.74
49	385933.5	3693121	48.733
50	385929.7	3693120	48.761

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