

MAPS CREATION BY INTERPOLATION USING SPLINE FUNCTIONS IN SCILAB

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Abstract. In this paper the author is solving, using Scilab, a problem proposed by Octavian Cira [3], concerning: the creation of a map by interpolation based on spline functions. No software like ARC GIS was used here.

1. INTRODUCTION

Nowadays the maps -and the GIS applications too – sometimes carried on portable devices - become of more and more interest. In this years, due to the climate changes some maps may become more important than the others: the maps of water resources and the maps of possible flooded areas are such examples. Since some resources are difficult to spot under the ground and more drilling implies supplementary costs, some maps – especially of some resources which are situated under the surface of the soil are very important. Such maps provide valuable information for inhabitants of some regions, especially remote regions , which are not included in the usual nets.

In fact, there exist requests from private individuals asking for good maps of water resources in some places in Bacău's area.

2. SOME TECHNICAL ASPECTS

2.1. The selected software : Scilab

We have selected Scilab, which is an European product made in France by INRIA, DIGITEO and others, here being included the authors of mathematical methods and a support from Intel. Scilab is:

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a) very similar with Matlab (being a sort of free clone of Matlab) with some small drawbacks – which are normals for a cloned product.

b) gifted with a good set of functions and algorithms for plotting : surface, mesh, plot2d, plot3d, polarplot, hisplot etc.

c) programable in a language which is accessible (structured programming with some O.O.P. elements).

d) available in source and binary formats for all major platforms and operating systems for free.

There is also a small drawback: when using Scilab on some specific hardware configuration, the buttons and controls forming the GUI (graphic user interface) can not be placed in the graphic windows (where the plots, curves and surfaces are pictured) but they can be placed in some neighbour windows. So multi-windows solutions are some how encouraged by Scilab.

Due to the popularity of Matlab, his clone Scilab is nowadays used in a set of projects including areas like: Multicore Embedied Systems [6], Matrix Structural Analysis of Plane Frames [1].

Modeling and Simulation in Scilab/Scicos [2], Graphics, Vector operations, Matrices and Linear algebra [7]. It was also used by the team of the R Projects in the field of Bioinformatics [8]. Only one book concerning Scilab was available from the The MatrixRom Publishing House [5].

Usually maps are created with specialized tools as ARC GIS [4] but maps can easily be seen as applied mathematics objects and treated as it using Scilab which is a multi-purpose tool.

Some tricks of use concerning Scilab can lead the reader to consult more how-tos and papers, including [7].

2.2. Back to maps creation

Due to its facilities, price, costs and usability (based on user's previous knowledge on Matlab), Scilab seems a promising software for maps creation. The folowing experiment was designed to reengineer a small application which draws a map from MathCad to Scilab. Let's remark the fact that before collecting potentially unusable data we wanted to deal with the last phase of maps creation process: we wanted to see Scilab creating maps in the lab. The experiment had consisted in recreating a map which was previously built using MathCad. The datase was borrowed, as hypothesis of the test, from [3]. We have planned to compare our results with those from [3].

So the problem is : given a set of data, the surface of the map (in fact, its approximation) should be created by interpolation using spline functions and plotted as a 2D map with contours or as a 3D (mesh or surf) surface.

The data set used in the first experiment was (in Scilab's notations, where triple dots "..." means that it will continue on the next line):

```

Mz = ...
[ ...
895 877 856 844 888 901 ; ...
906 901 913 922 934 955 ; ...
901 878 857 845 866 879 ; ...
880 899 876 868 843 838 ; ...
875 888 899 881 885 873 ; ...
900 903 907 912 915 922 ];

```

We quoted this matrix from [3] due to the need to quickly visually compare the results ; but similar sets can be even quicker created for example using the `rand()` function of Scilab which can be used as a random n -dimensional vector generator. This `rand()` function works, of course, as a matrix generator, too. The reader may want to rerun the program using different sets. For example, here is a new, (pseudo) randomly produced, one:

```

-->1000*rand(6,6)
ans

211.90304 406.20248 589.61773 922.28987 499.34938 627.40931
112.13547 409.48255 685.39797 948.81843 263.85784 760.84326
685.6896 878.41258 890.62247 343.53372 525.35631 48.55662
153.12167 113.83597 504.22128 376.01187 537.62298 672.39497
697.08506 199.83377 349.36154 734.09406 119.99255 201.71727
841.55184 561.86607 387.37788 261.57615 225.63035 391.15739
or an other :
-->400*rand(6,6)+600
ans =

932.01266 714.21457 996.92764 625.70587 622.75712 995.41631
835.14881 944.30059 620.01679 931.16332 823.83747 895.82626
793.16717 939.76407 899.42026 970.49375 649.97361 601.48692
689.3146 810.28243 764.16236 826.68845 891.16889 836.02291
936.03543 997.2484 843.38105 828.46556 707.11066 723.85869
648.23984 859.54251 941.76844 926.40442 818.6134 702.08823
-->

```

2.3. The program

This Scilab script, which can be saved as `.sce` or `.sci` file was a part of our experiment:

```

// F0602-harta5.SCI
// Romanian comment: Realizarea unei harti 3D.
// În 36 puncte dintr-o retzea, nu neapărat echidistantă,
// s-au făcut măsurători cu ajutorul unui altimetru a
// altitudinilor în aceste puncte. Aceste valori sunt
// memorate în matricea Mz.
Mz = ...
[ ...
895 877 856 844 888 901 ; ...

```

```
906 901 913 922 934 955 ; ...
901 878 857 845 866 879 ; ...
880 899 876 868 843 838 ; ...
875 888 899 881 885 873 ; ...
900 903 907 912 915 922 ];
```

```
x=linspace(10,60,6) // 6 values from 10 to 60
y=x;
```

```
clf();           // Clear the graphic window
```

```
subplot(221);
mesh(Mz);
subplot(222);
surf(Mz);
```

```
subplot(223);
plot3d(x,y,Mz);
```

```
subplot(224);
plot3d1(x,y,Mz)
```

```
// Interpolation / Extrapolation using spline2d function(s)
// Computing using interp2d folowing the example from Scilab's Help
```

```
C = splin2d(x,y, Mz(x/10,y/10));
```

```
m = 80; // The number of computations – dimension of the grid
xx = linspace(0,70,m); yy = xx; // [10 60] -> [0 70]
[XX,YY] = ndgrid(xx,yy);
```

```
// Varios types of interpolations / extrapolations can be used:
```

```
zz1 = interp2d(XX,YY, x, y, C, "C0");
zz2 = interp2d(XX,YY, x, y, C, "by_zero");
zz3 = interp2d(XX,YY, x, y, C, "periodic");
zz4 = interp2d(XX,YY, x, y, C, "natural");
```

```
xclick();           .. // waiting for a click of the mouse
clf();
subplot(2,2,1)
plot3d(xx, yy, zz1, flag=[2 6 4])
xtitle("interpolare in modul numit C0 ") // Romanian titles
subplot(2,2,2)
plot3d(xx, yy, zz2, flag=[2 6 4])
xtitle("interpolare/extrapolare in exterior cu zerouri")
subplot(2,2,3)
plot3d(xx, yy, zz3, flag=[2 6 4])
xtitle("interpolare/extrapolare in mod periodic ")
subplot(2,2,4)
```

```

plot3d(xx, yy, zz4, flag=[2 6 4])
xtitle("interpolare in modul natural")
show_window()

// Scilab is using splin2d not cspline as MathCad users did.
// (this code by Dan Popa is solving a problem offered by Ovidiu Cira.)

scf();
//-----
f = gcf();
f.color_map = linspace(0,1,64)*ones(1,3);

subplot(221);
Sgrayplot(xx,yy,zz1)      // Smoothed grayplot

// Define and add level curves:
//-----
level = 50 * [1:1:20]
contour2d(xx,yy,zz1,level);

subplot(222);
Sgrayplot(xx,yy,zz2)      // Smoothed grayplot

// Define and add level curves:
//-----
level = 50 * [1:1:20]
contour2d(xx,yy,zz2,level);

subplot(223);
Sgrayplot(xx,yy,zz3)      // Smoothed grayplot

// Define and add level curves:
//-----
level = 50 * [1:1:20]
contour2d(xx,yy,zz3,level);

subplot(224);
Sgrayplot(xx,yy,zz4)      // Smoothed grayplot

// Define and add level curves:
//-----
level = 50 * [1:1:20]
contour2d(xx,yy,zz4,level);
show_window()

```

The programmers benefit from a good set of inspirational examples in Scilab's help. `xclick()` is used to make a pause until the mouse is used, by clicking on it. Pressing the button of the mouse will move you to the next image.

3. THE RESULTS

As we expected, the experiment succeeded: Scilab was able to build the requested surfaces and the map, including the contours. It is able to interpolate and also to extrapolate the dataset.

Let's remark that the user should be less confident in the informations resulted by extrapolation than by interpolation, due to the increased distance to the points where the measurements were actually made.

Here are some images we got, during the experiments:

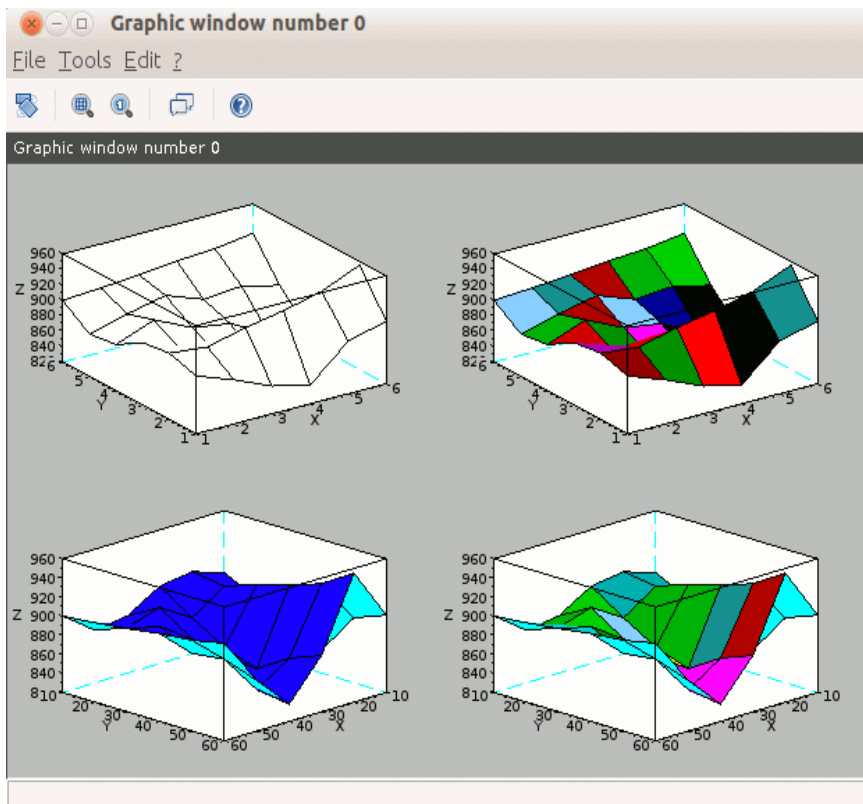


Figure 1. The initial dataset (no interpolation) as a 3D representation

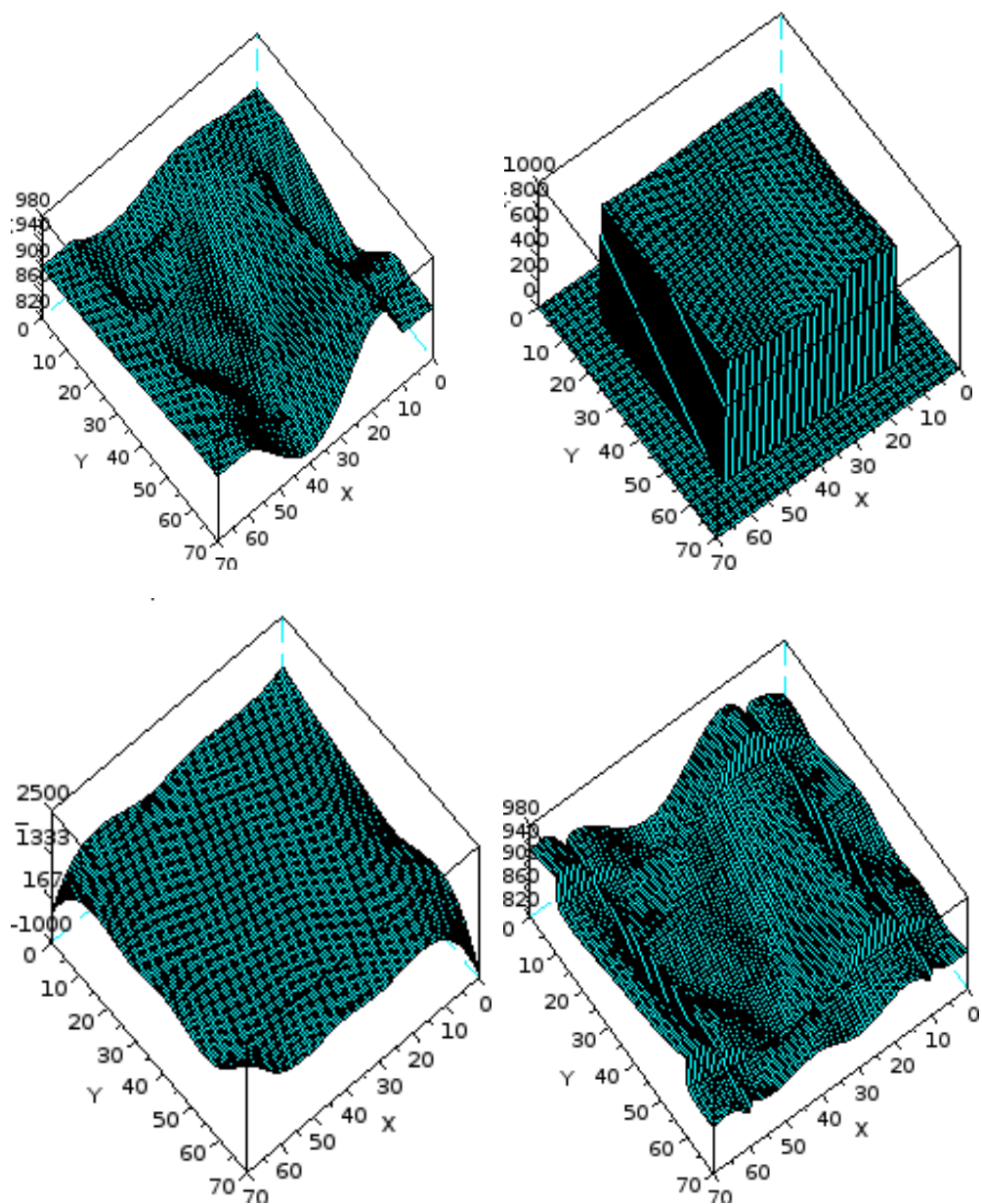


Figure 2. Interpolations (in fact the border is made by extrapolation)

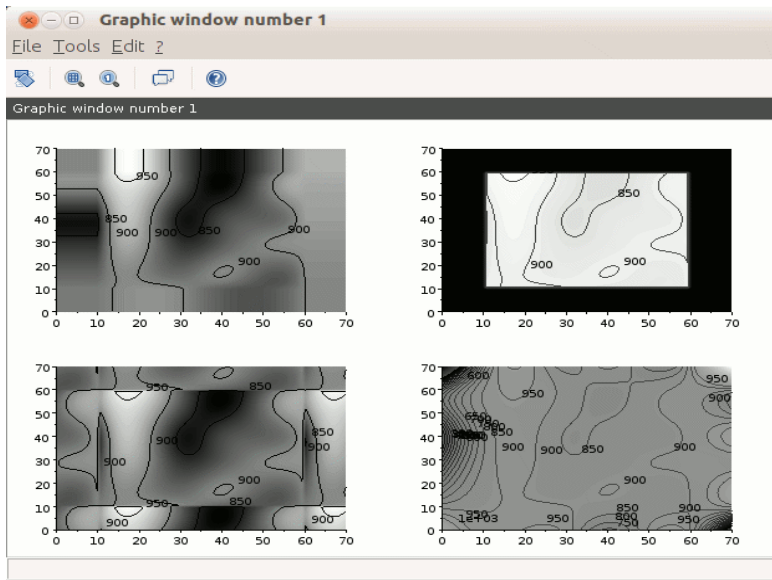


Figure 3. 2D maps produced from the initial dataset from [3]

Remarks: In Figure 2, the extrapolation is made by using zeroes, which explains the aspect of the image, and in the third one, the method uses periodicity to extrapolate. The pictures from Figure 2 was supplementary rotated, too, using the mouse.

4. CONCLUSIONS

Scilab, which is a sort of Free Software Matlab clone, can be used by service providers (persons or companies or administration) to create maps by interpolating data using spline functions. A good example is to use it to draw the maps of underground water resources. Some little problems should also be considered – but they are unrelated to Scilab software itself:

P1) When collecting data from the field, the device which will be used should be carefully built, in order to provide usable data.

P2) The domain of values offered by the sensor should be consistent with the domain of values from the field.

P3) To avoid manually entering the data into the computer a specific board for data acquisition may be used. This extension board or device should be able to be used with a laptop

P4) Of course, the equipment and power sources should be portable (a request that is easy to fulfill nowadays).

5. VERSIONS AND PLATFORMS

We used Scilab 5.3.3. for Linux, running on the Ubuntu 12.04 and then 12.10 systems. At the time being, both software providers are offering (on line) new versions: Ubuntu 13.04 and Scilab 5.4.1. The above program could be run on this new combination of software and operating system or on any other platforms (there is also a port on Solaris) .



**Figure 4. Scilab 5.3.3 running on Ubuntu 12.10 Linux.
(The Help About Window.)**

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