

T_EX Plotter – a program for creating 2D and 3D pictures

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Abstract

The MS DOS program which creates 2D and 3D T_EX pictures for the plots of functions of two variables $f(x, y)$ is described. In comparison with GNUPLOT this program enables to plot the equilines (2D view) and the surface (3D view) pictures correctly and without memory overflow even for complex cases. The input is the ASCII file which contains the data points (X_{ij}, Y_{ij}, Z_{ij}) of the function $z = f(x, y)$ calculated over non-regular quadrangular mesh. The output is the ASCII file which contains the required picture in T_EX format. The program has a flexible menu driven user interface and enables to create and to preview the output pictures with a variety of styles. At the time being the program supports L^AT_EX commands, EPIC/EEPIC macros and emT_EX specials. In future the program should support T_EX graphical tools like MFPI_C, PiCT_EX and EPS-files.

1 Introduction

The development of this program was induced by the fact that the well known program GNUPLOT *cannot* draw properly the equilines for functions of two variables. For example, Figure 1 demonstrates equilines of function

$$f(x, y) = x^2 + y^2 - \cos(18x) - \cos(18y)$$

created by GNUPLOT 3.5 for the region $x \in [-1, +1]$, $y \in [-1, +1]$. As it can be seen this picture is wrong: it does not reflect the symmetry $x \longleftrightarrow y$ of the function. Figure 2 shows the plot of the function $f(t) = t^2 - \cos(18t)$, and the correct plot of equilines is shown on Figure 3.

There are also other drawbacks during the processing of 2D function with the help of GNUPLOT: "out of memory" messages, no possibility to draw something over the plot

of equilines, no possibility to mark the points over the plot and to supply it with some text, restricted set of line styles as compared with $\text{\TeX}/\text{\LaTeX}$ possibilities, etc. Since our work is mostly related with calculation of electrostatic and magnetostatic fields, the equiline plots are the pictures which are indispensable. For this reason we decided to develop our own program which creates the output 2D and 3D plots compatible with \TeX in the way we like (and without such errors as shown on Figure 1). The result is the program \TeX Plotter, the preliminary version of which is described here.

2 Principal algorithms

It seems that the decision done by the designers of GNUPLOT to calculate and to store the whole equiline in advance results to most problems with 2D and 3D plots created by this program. This approach enables to smooth and to process the whole equiline before plotting, but simultaneously it results to memory problems and the errors like shown on Figure 1.

We selected the different approach which does not enable good smoothing of individual equilines as well as correct plotting with dotted and dashed equilines, but which causes no memory problems and conserves the symmetry of input data. Using this algorithm the function values are calculated at the nodes of non-regular quadrangular mesh, and the equilines inside each quadrangle are processed separately. Although the equilines inside different quadrangles are calculated independently, the pieces of equilines inside neighbouring quadrangles are connected smoothly if the approximation of the function is smooth in the whole region.

Let us consider the quadrangular mesh which is characterized by the node coordinates (x_{ij}, y_{ij}) , $i = 1 \dots N_x$, $j = 1 \dots N_y$. The neighbouring nodes (x_{ij}, y_{ij}) , $(x_{i+1,j}, y_{i+1,j})$, $(x_{i,j+1}, y_{i,j+1})$, $(x_{i+1,j+1}, y_{i+1,j+1})$ forms the quadrangular mesh cell, and the value of the function $z = f(x, y)$ at the node point (x_{ij}, y_{ij}) is equal to z_{ij} .

The coordinates (x, y) can be considered as the pair of parametric functions $X(p, q)$, $Y(p, q)$, which transforms the rectangular region (p, q) into curvilinear region (X, Y) so that the nodes (p_i, q_j) of the rectangular mesh are transformed into the points (x_{ij}, y_{ij}) of the quadrangular mesh. Analogously the function $z = f(x, y)$ is considered as the parametric function $z = Z(p, q)$ which has the value z_{ij} for the point (p_i, q_j) .

The equilines are calculated separately inside each rectangular cell $p_i \leq p \leq p_{i+1}$, $q_j \leq q \leq q_{j+1}$ which results to piecewise presentation of the equilines where the different pieces are not necessarily joined together. As it was already mentioned these pieces are joined together after drawing, and the connection of equilines is continuous for continuous functions $X(p, q)$, $Y(p, q)$ and $Z(p, q)$, and is smooth for smooth functions $X(p, q)$, $Y(p, q)$ and $Z(p, q)$.

The continuous approximation can be constructed as the piecewise bilinear function, and the smooth approximation can be constructed as the piecewise bicubic function using well known numerical algorithms. It is essential that the approximation is *local*,

i.e., depends only on the function values at the mesh nodes next to the considered mesh cell.

The input data for T_EX PLOTTER is the ASCII data file where each line contains the values X_{ij} , Y_{ij} and Z_{ij} corresponding to quadrangular mesh used for plotting. In most cases this quadrangular mesh is actually the rectangular one so that $X_{ij} \equiv X_i$ and $Y_{ij} \equiv Y_j$. The first lines of the input file contain the information about the size of the mesh $N_x \times N_y$, and, may be, the parametrization (p_i, q_j) which can be selected as the uniform by default. The symbolic expressions for plotted functions are not supported: it is assumed that the User can create small program using his favourite computer language which produces the ASCII file with the function data. Instead of it in future versions of T_EX PLOTTER more attention will be paid to filtering, smoothing and fitting procedures.

3 Style options

The menu driven user interface enables to specify the input data file as well as all the parameters which define the style of the output plot. It is possible to vary the position and the size of the plot, the title and text captions and their position, font style and size, numbering and drawing of the axis, etc. The preview menu item enables to see the whole plot or its fragment using suitable magnification.

The output of T_EX PLOTTER is the ASCII file which describes the 2D or 3D plot using T_EX commands: L^AT_EX `\rule` commands, or E_PI_C/E_EP_IC `\drawline` macros, or e_mT_EX specials `\special{em:moveto}` and `\special{em:lineto}`. It is expected that in future the program will support the output which is compatible with such graphical facilities as M_FP_IC, P_IC_TE_X and Encapsulated PostScript files.

The smoothness of the plot is defined by the bilinear or bicubic approximation of the parametric functions $X(p, q)$, $Y(p, q)$ and $Z(p, q)$ and by the number of subdivisions used to calculate equilines. The plot range and the equiline levels can be selected automatically by the program or can be defined by the User. The equilines corresponding to different levels can be drawn using various line thickness. Dotted and dashed lines are not supported. Although it is possible to organize plotting so that the pieces of dashed and dotted equilines are connected correctly, the present version of T_EX PLOTTER does not realize it.

The preview function draws the text strings with the characters scaled approximately like the T_EX text at the output plot. The preview function does not support *math* mode, the character metric information and ligature/kerning data of the T_EX fonts. In spite of it the results are close to the real output especially as compared with the GNUPLOT previewing.

It is possible to draw over the equiline plot the arbitrary geometrical objects, including straight lines, circles and arcs, point markers and text strings. All such geometrical objects are listed in a separate ASCII file. The essential feature is that all these objects use just the same coordinate system as the input data, and it is very easy to overlap the

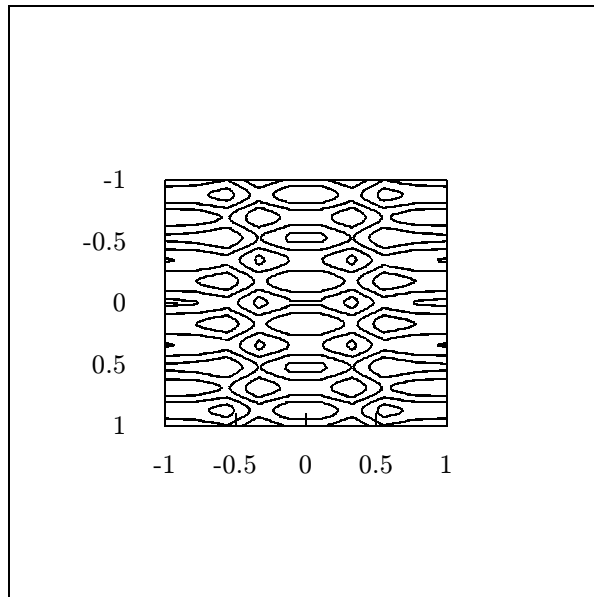


Figure 1: Equilines for the function $f(x, y) = x^2 + y^2 - \cos(18x) - \cos(18y)$ in a region $x \in [-1, +1]$, $y \in [-1, +1]$ as calculated by GNUPLOT 3.5.

equiline plot with external markers and drawings. The output $\text{T}_{\text{E}}\text{X}$ -file contains comments emphasizing the logical pieces of the plot so that the manual corrections of the picture can be introduced if necessary.

4 Conclusion

The program $\text{T}_{\text{E}}\text{X PLOTTER}$ is written in *Borland Pascal* using the *User's Window Tools* interface library. It works under MS DOS 3.3 and higher, does not require extended memory and can be used even on 286 computers although 386/486/586 are preferable. The program is distributed "as it is" in executable form without source code to eliminate the problems with intermediate versions and mutant source codes. It is planned to distribute the final version of the program with the source code, but the present version is far from it. The suggestions, corrections and noticed errors are welcomed.

5 Acknowledgements

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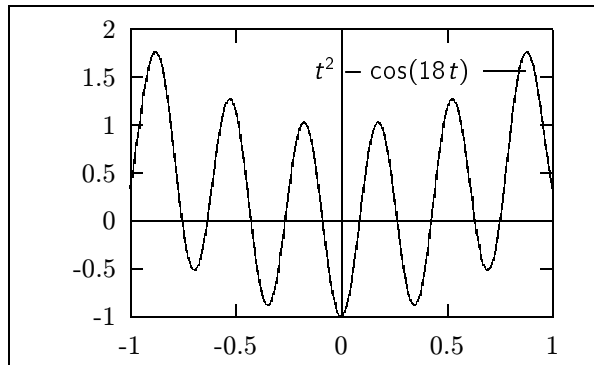


Figure 2: Function $f(t) = t^2 - \cos(18t)$ in a region $[-1, +1]$ (calculated by GNUPLOT 3.5).

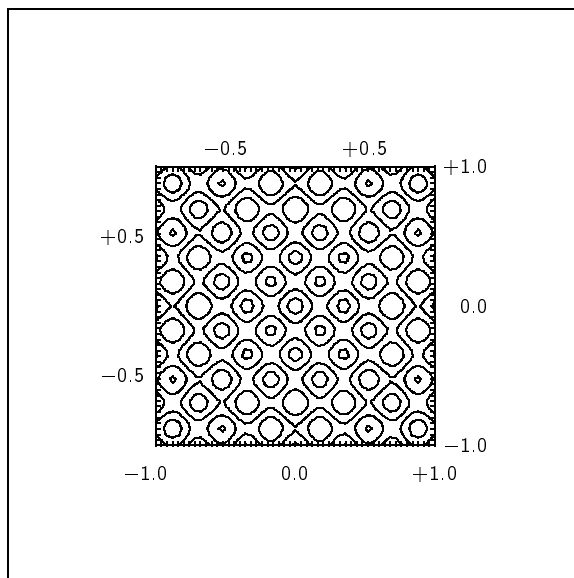


Figure 3: Equilines for the function $f(x, y) = x^2 + y^2 - \cos(18x) - \cos(18y)$ in a region $x \in [-1, +1]$, $y \in [-1, +1]$ (calculated by TEX PLOTTER.)