CONTOURING TRIVARIATE DATA

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ABSTRACT

In many applications, the data consist of discrete 3-D points at which one or more parameters are given. To display contours, the data are represented by a continuous function which is evaluated at any point as needed for contouring. We present contouring results applicable both to artitrarily spaced data and to data which lie on a topologically rectangular three-dimensional grid. We assume that the contours are to be described by 3-D display lists for viewing on a dynamic color graphics device; that is, they will not simply be projected into 2-D and viewed as a static image on a frame buffer. Dynamic viewing of color contours may be essential to the proper interpretation of results.

We assume that the gridded data lie on a topologically rectangular grid although two or more nodes may be the same point. This type of gridded data is common in computational fluid dynamics. Parametric tensor product methods may be used to fit the gridded data and to generate the contours. Rectangular elements are convenient but not necessary. For example, there are other methods [1] which are effective for contouring over tetrahedral elements.

Various types of contours are helpful in interpreting trivariate data. Since we are interested in displays which can be viewed dynamically, we define contours as 3-D polygons, which are shaded by using polygon fill, or as 3-D vectors. Cross sections through the grid can be contoured using vectors or polygons (Figure 1). Contours over all grid layers are computed as vectors (Figure 2) or polygons (Figure 3). By combining adjoining grid cells into one cell, the amount of display list data needed to define the contours can be reduced. This can either speed up the dynamics or allow more contours (or other data) to be displayed. If a static picture is sufficient, the polygons can be scan-line rendered with transparency (Figure 3). An unusual feature that we developed consists of drawing the contours for one parameter onto the shape of a contour of a different parameter (Figure 4). In Figure 4, the shape is the 0.1 contour of a tricubic function and the gray bands indicate the derivative with respect to x of the tricubic function.

Multistage methods [2,3] for arbitrarily spaced trivariate data allow for efficient computation of contours. In these methods, an interpolant or approximant is fit to the arbitrarily spaced data and then evaluated at the nodes of a rectangular grid. The gridded data are then contoured as discussed above. One area where multistage methods have been applied is in geology, where the data consist of pollen counts at various depths in cores drilled in the earth. An analogous example occurs in well log data from an oil field in which various parameters are measured at many depths in each oil well. A similar application occurs in experimental fluid dynamics where pressure is recorded at various points on an

aircraft body during wind tunnel tests. Since these data occur along a surface, rather than throughout a volume, different representation methods are required, but the same display techniques are relevant.

REFERENCES

1. Peterson, C. S., Contours of Three and Four Dimensional Surfaces. Masters Thesis, Dept. of Math., Univ. of Utah, 1983.

2. Barnhill, R. E., and Stead, S. E., Multistage Trivariate Surfaces. Rocky Mountain J. of Math., vol. 14, no. 1, winter 1984, pp. 103-118.

3. Stead, S. E., Smooth Multistage Multivariate Approximation. Ph.D. Thesis, Div. of Appl. Math., Brown Univ., Providence, RI, 1983.

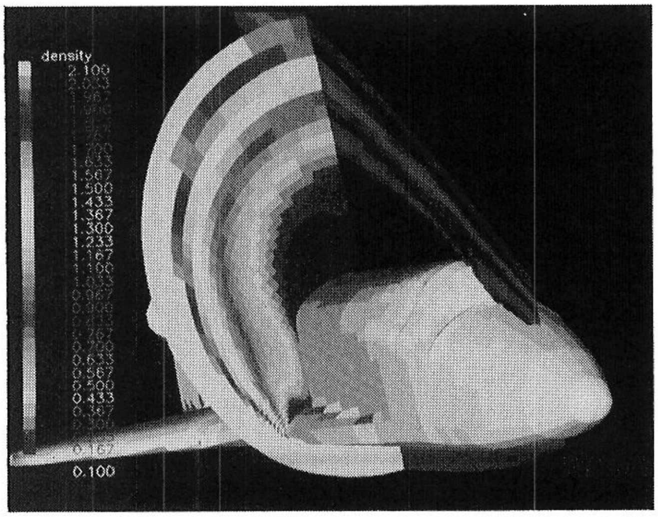

Figure 1. Density contours on two cross sections.

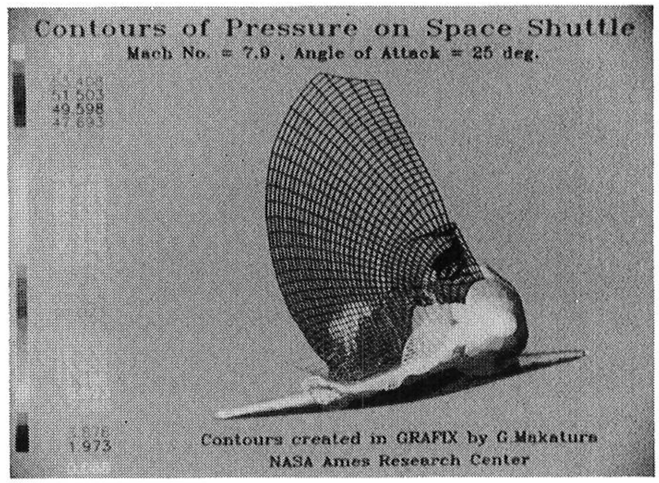

Figure 2. Pressure contours.

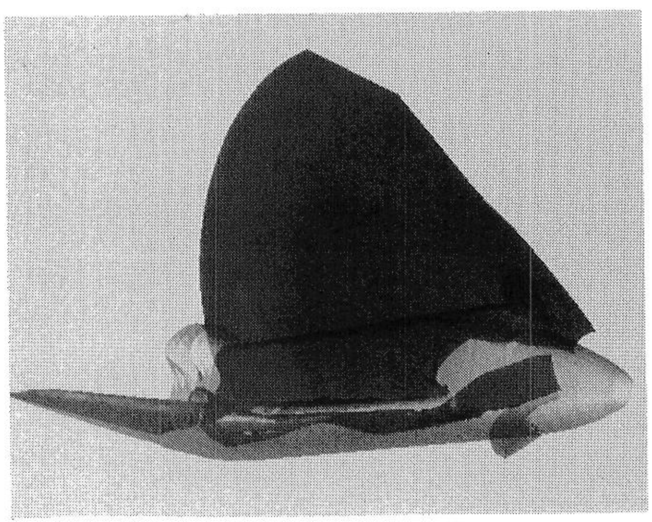

Figure 3. Pressure contours using transparent polygons.

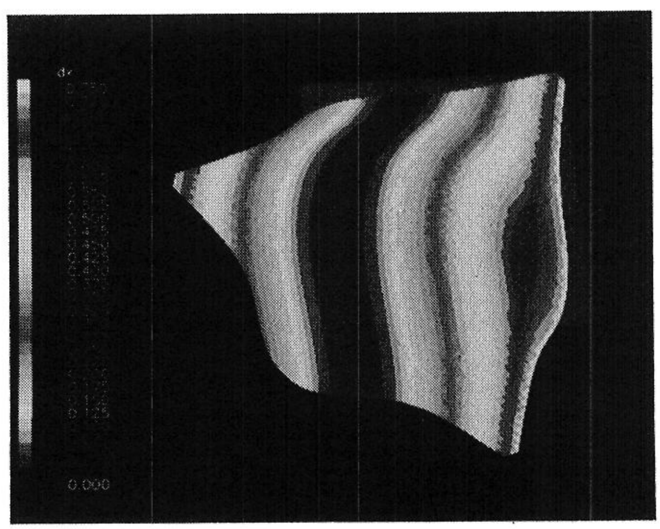

Figure 4. Contouring on a contour.