IBM

Application Program

1130 Numerical Surface Techniques and Contour Map Plotting Application Description

This manual contains a general description of a set of programs adaptable to application areas that require the quantitative description of surfaces. These programs make numerical or analytical approximations to a set of coordinate values which define a surface, and prepare a display of the geometry of the surface in the form of a plotter contour map.

CONTENTS

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Changes do not affect the content of the manual.

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INTRODUCTION

In practically all of the sciences and fields of engineering there is the need to express a surface of interest analytically by an equation or numerically by a system of data points. In many of these disciplines there is the further need to express the configuration of a surface graphically in the form of contour lines on a map or chart. In order to describe the various types of data on this map or chart, it is desirable to plot symbols, to letter alphabetic data, to post numeric values, to provide headings, and to draw various types of boundary lines.

This set of programs provides these functions in such a way that they may be carried out singly or in various combinations, with no necessity for intermediate card output. The programs included in the set perform functions in the areas of:

1. Surface Determination
   - Numerical and analytic representation of surfaces

2. Operations on and between Surfaces
   - Smoothing of surfaces, arithmetic operations between two surfaces, adjustment of the boundaries of a surface, numerical integration of volumes and areas

3. Graphic Display
   - Presentation of surfaces in contour form on a display device, annotation of indicative information

4. Utility Routines
   - Routines for the preparation and input of data

SURFACE DETERMINATION

Quantitative surface representations may be used for such diverse purposes as to provide a graphic display of the configuration of a surface, to provide a mathematical model for controlling a process, to describe some physical object to be fabricated, or simply to provide a means for further analysis of the surface. Techniques for surface approximation require that the surface of interest be defined by a set of measured coordinate values. These values, commonly termed control points, usually are irregularly spaced and are limited in number by considerations of time and economy. The problem, then, in developing an automatic technique for surface determination is to provide a satisfactory representation of the surface in a short time from a limited amount of input data for control.

A commonly used approach is to make a surface fit of an assumed mathematical function to the observed control points by some sort of regression analysis. There are two main objections to this approach: (1) the selection of a particular function introduces a bias, and (2) it is usually not possible to achieve a good fit to the input data in all areas of the surface and, at the same time, avoid unreasonable shaping where there is no control. These objections can be overcome to some extent

by piecewise fitting, in which different functions are fitted to several sections of the surface, but this is only a partial solution. This set of programs implements two new techniques which offer the user greatly improved ways to overcome these problems.

Surface Representation by a Square Grid

This set of programs includes an original technique of surface determination which interpolates irregularly spaced data onto a square grid of arbitrary mesh size. The basic program develops numeric values at the mesh-points of a square grid system superimposed over the input data and provides a very accurate approximation to the surface. The technique avoids the objections mentioned above by an extreme form of piecewise surface fitting in which the control used to establish the surface is different at each mesh-point. The technique is flexible enough to fit almost exactly any input data no matter how undulatory, and yet is constrained to give smooth and reasonable values in the areas of sparse control. The output is in a form suitable for further numerical analysis techniques and for the preparation of a contour map.

Surface Fitting with an Analytic Function

In a field such as process control, it may be desirable to obtain a mathematical model by surface fitting to a set of data. An analytic expression for a surface can be easily obtained from the grid values by an orthogonal polynomial surface fitting program, which makes a least-squares fit to a set of orthogonal polynomials. This procedure avoids the objections to surface fitting mentioned above, because the voids in the data distribution have been filled. The program can also accept the original input data for fitting. Additional programs provide the capability to evaluate the polynomials over a square grid.

OPERATIONS ON AND BETWEEN SURFACES

Programs in this category are employed to smooth surface irregularities, if desirable, to perform arithmetic operations between surfaces, to compute areas and volumes by techniques of numerical integration, and to reduce grid size for smoother contouring.

GRAPHIC DISPLAY

Although a surface may be well defined by numeric grid values, it is very often desirable to express the surface in graphic form for ease of communication and to aid in locating important features. The most useful form of graphic display is the contour map because of the amount of quantitative information which may be indicated thereon. Contour maps are necessary tools in such widely diverse fields as meteorology, mineral exploration and production, civil engineering, and oceanography, to mention only a few. Contour maps are frequently annotated to show basic data and other indicative information. With the advent of the computer and associated output devices, such as plotters, it has become economically practical to create maps by automatic methods. The contouring program accepts as input the grid values developed by a

surface determination program and creates a contour map which is displayed on the IBM 1627 Plotter. (This input grid may be plotted if desired.) The original input data is, thus, the same as would be used in drawing the map by hand, and the complete set of programs provides the techniques which are consciously or unconsciously employed in hand contouring. The contour interval and scale are specified by the user.

The input data may be spotted to scale on the map, along with other information, by a map annotation program. Sample contour maps are shown in Figures 1 and 2.

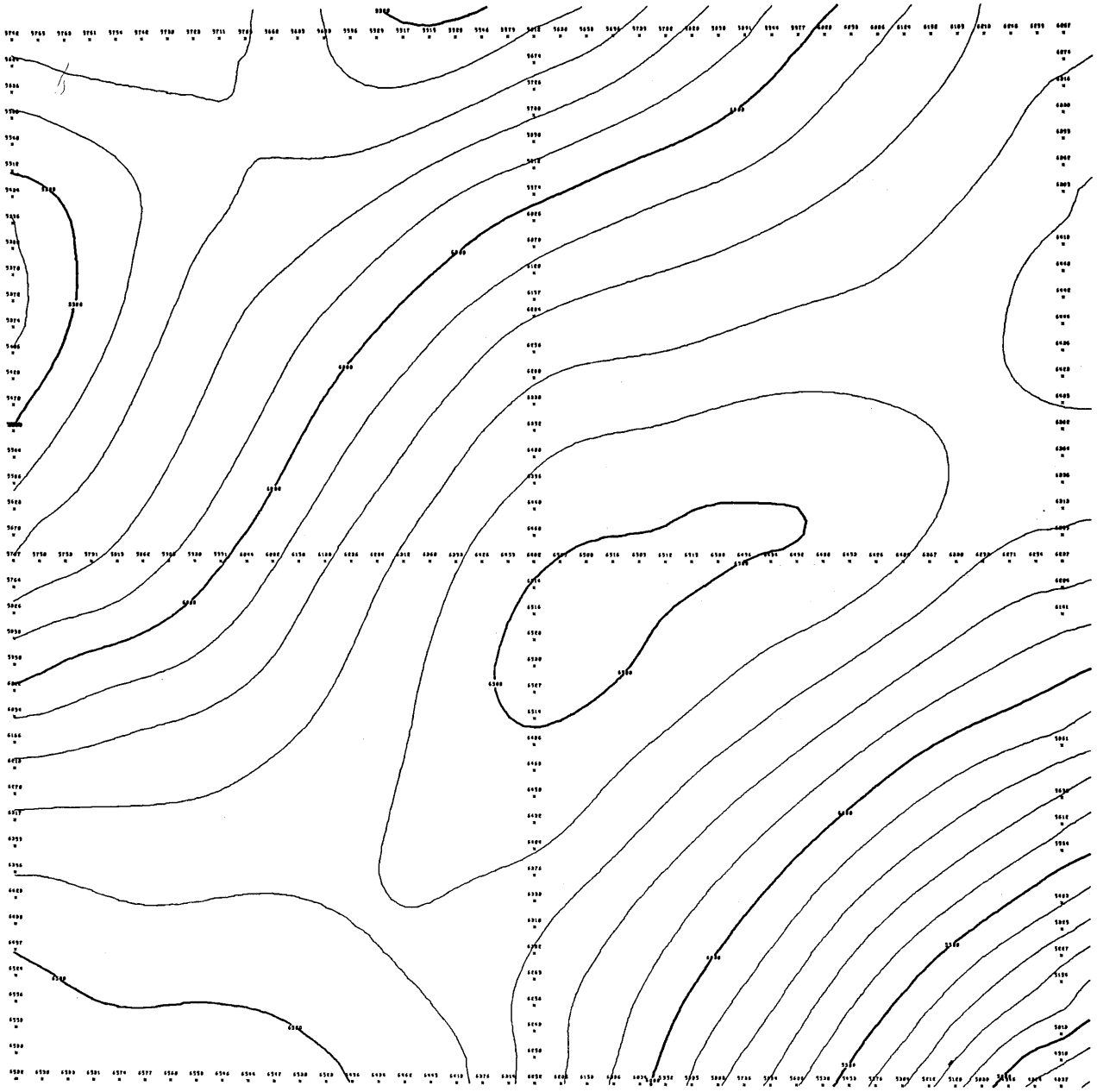

Figure 1. Contour map of geophysical data

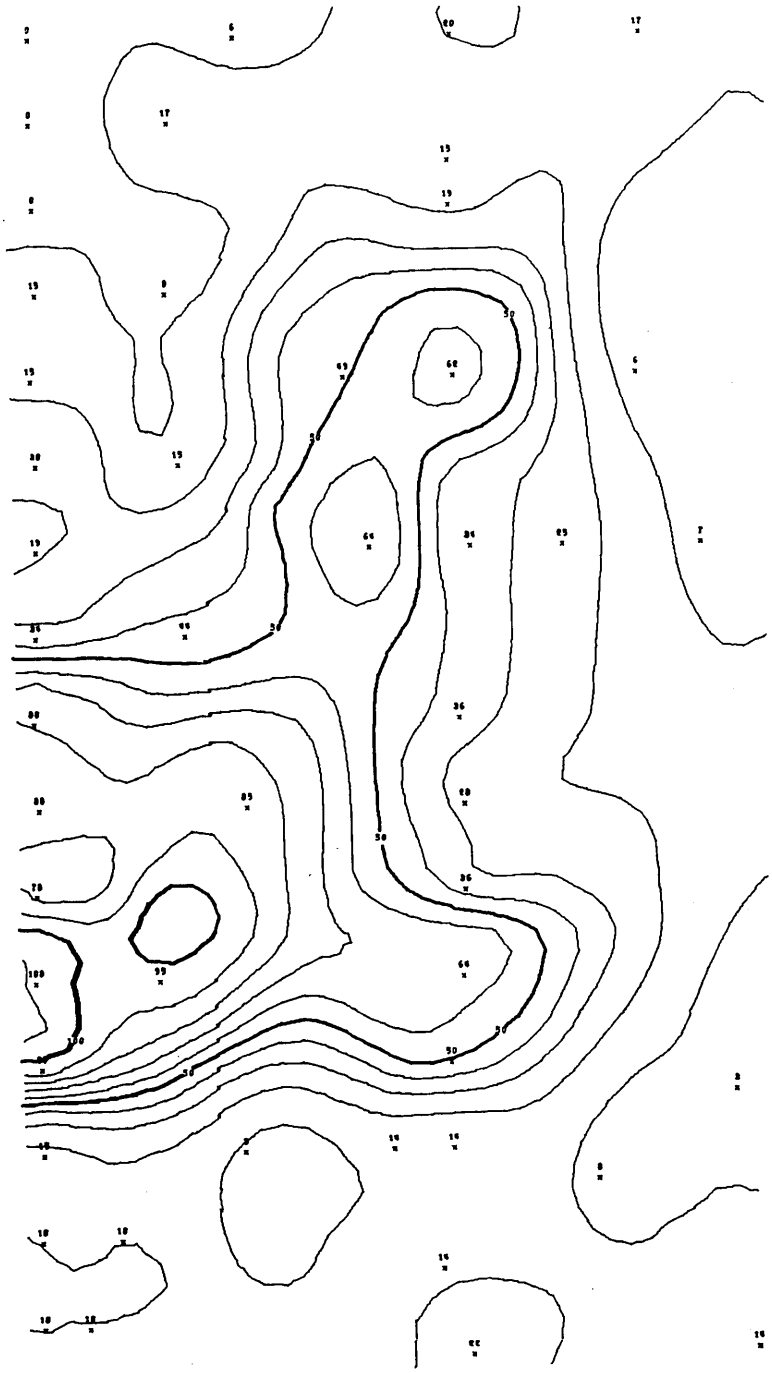

Figure 2. Contour map of copper thickness, Granduc Area, British Columbia.
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UTILITY ROUTINES

To promote input flexibility and obviate repeated reading of basic data, an input program is provided for loading card data onto disk. Additional routines may be written by the user and incorporated into the program package.

GENERAL SYSTEM FLOW

The flowchart in Figure 3 indicates the flow of data among the programs in the set and some of the different options available to the user. The original data read in through the card reader consists of a set of measured coordinate values in three dimensions. A variety of formats for this data are acceptable. The output from each routine serves as

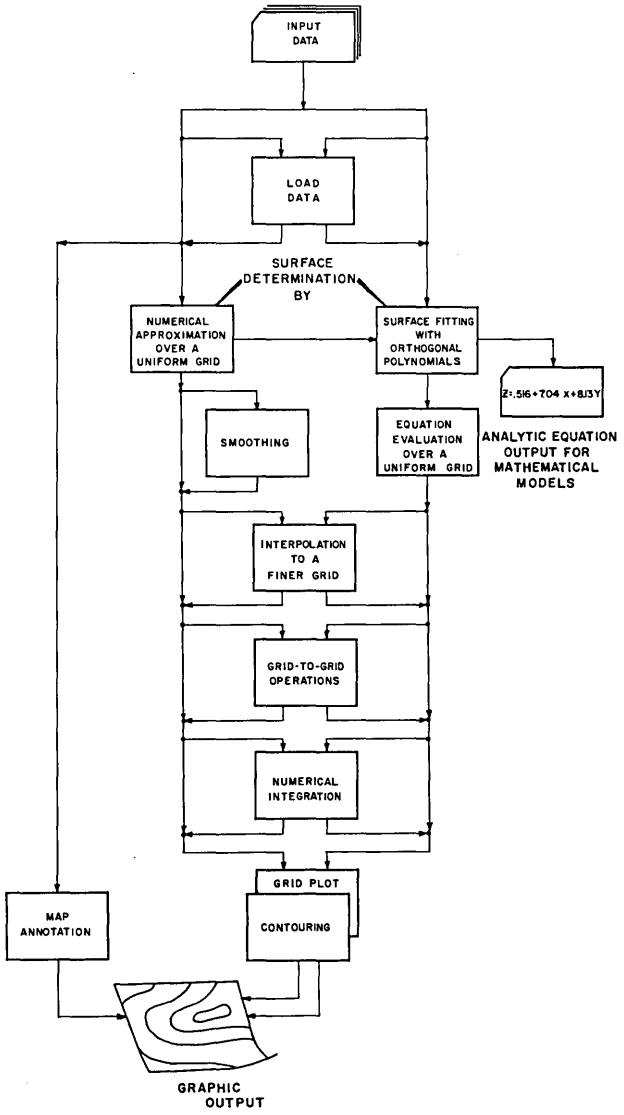

Figure 3. Data flowchart showing different program options

input to the succeeding program as indicated on the chart. This intermediate data is stored in disk and may be punched into cards if desired. Users may write their own programs to either generate or operate upon this intermediate data.

SOURCE LANGUAGE

1130 Assembler Language

MINIMUM CONFIGURATION

1131 Processor, Model II, with 8K core storage
1442 Card Read Punch
1627 Plotter, either Model 1 for a 12-inch-wide chart or Model 2 for a 30-inch-wide chart

REFERENCE

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