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TREND SURFACE ANALYSIS: A NEW TOOL FOR EDUCATORS

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SUMMARY

This paper deals with the general concepts of trend surface analysis and its application to education.

INTRODUCTION

Trend surfaces are basically a representation of the relationship between geographic location and a criterion variable. Trend surfaces can be considered as response surfaces from which aspects of origin or process can be inferred (Box, 1953). The computation of trend surface is the computation of a multivariate curvilinear regression, and is quite similar to the least squares fit of a regression line. Trend surface techniques, when used in conjunction with mapping procedures provide an opportunity to view the data.

Just as the geologist or meteorologist is interested in geographic visual trends of elevations or barometric pressure gradients, so also is the educator interested in general trends of educational, political, and socio-economic attributes across a geographic surface. Contour maps expressing these continuous attributes across a surface provide a visual image capable of transmitting much more usable information than would a series of tables. Applying these depictions over time and across variables it is possible to provide a graphic illustration over time. This paper will deal with the general concepts of trend surface analysis and its application to education.

The trend surface and contour mapping techniques presented in this paper are an adaptation of methods developed by Donald B. McIntyre of Pomona College* and Donald N. McIsaac of the University of Wisconsin. These routines have been added to and adapted to the computing facilities available at the University of Florida.

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*D. B. McIntyre, Program for computation of trend surfaces and residuals 1 through 8, Claremont: Pomona College, Department of Geology, 1963.

TREND SURFACE ANALYSIS

The computation of a trend surface is quite similar to the least squares fit of a regression line. Instead of using a single predictor variable and a single criterion variable to fit a regression line, trend surface uses two predictor variables and a single criterion

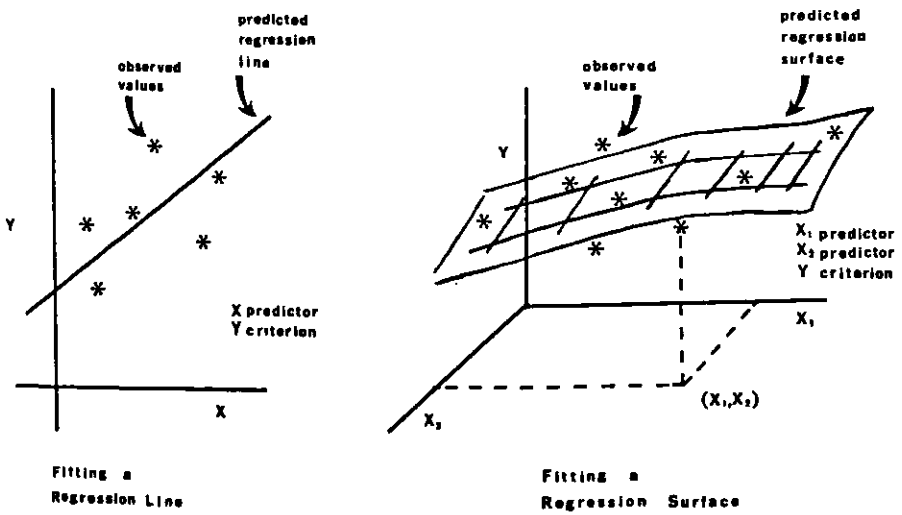

FIGURE 1

variable and is concerned with fitting a regression surface. This results in a three dimensional coordinate system where the two predictor variables serve as locational rectangular coordinates and the criterion variable as a surface point in three dimensional space as opposed to a two-dimensional coordinate system in the regression line problem. Applying the least squares fit technique, which provides a mathematical model of best fit for a set of points by minimizing the squared deviations between the observed criterion variable and the predicted criterion variable, the trend surface will result in a regression surface of best fit to a set of points rather than a regression line. An illustrative comparison is presented in Figure 1.

In computing the regression surface of best fit, the program computes the coefficients for 1 to 8 degree regression surfaces along with an analysis of residuals for each fit. The equation for the regression surface of best fit may then be employed to produce a set of rectangularly spaced grid points which permits the application of contouring techniques to draw out a visual graphical representation of the points.

CONTOUR MAPPING

The purpose of contour mapping is to provide a visual image across a surface of a grid matrix of points. The contour program uses the grid points from the trend surface program and generates a contour map that can be plotted by way of a Calcomp Digital Plotter.* Communication from the trend surface program to the contour mapping program is accomplished by magnetic tape.

The graphic depiction of a criterion variable is displayed in a fashion illustrating the general geographic regional trends. An illustrative graph is presented in Figure 2. In examining the map, three distinct low achievement areas are identifiable. Only the outlying areas which might correspond to suburban areas are achieving at, or above, grade level.

The contour map is then overlayed on a map of the geographic region for which the trend surface was done. This allows one to identify the precise geographic location of the high and low achievers. Alone the map tells only the regional trend of the criterion variable, but careful analysis and comparison of similar depictions across variables and over time would show dynamic change in the criterion variable as related to geographic location.

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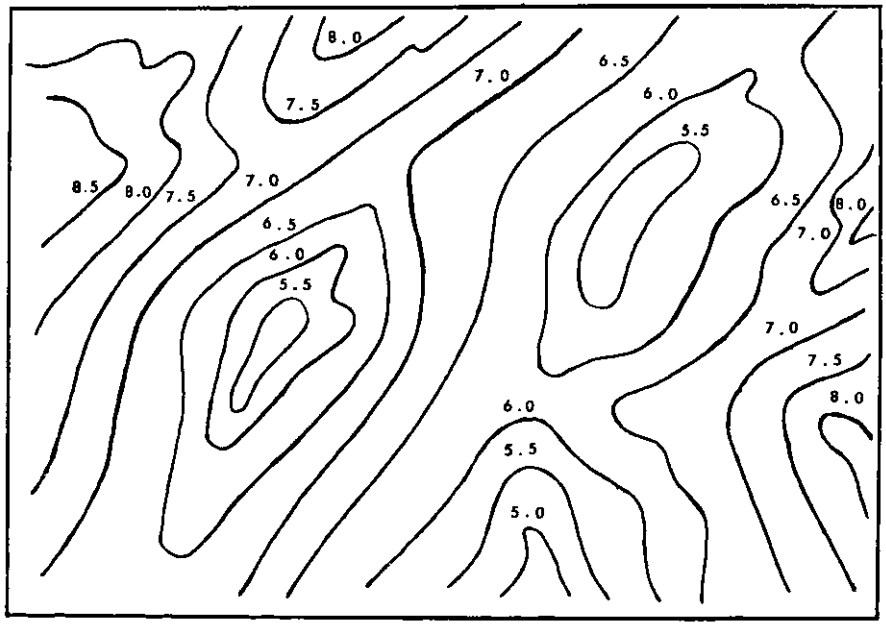
*The Calcomp Digital Plotter is an incremental line plotter and is on line to a 1401. The plotter is model 563.



Contour Map of 7th Grade
Reading Achievement

FIGURE 2

APPLICATION

For many years, geologists and meteorologists have used the contour map as a tool for expressing the trend of continuous variables across a specified surface. Just as the geologists and meteorologists are interested in visual regional trends and in changes in these trends, over a relatively short period of time; so also is the educator interested in general and regional trends of educational data, and the changes in these data over time.

Only recently, have educators begun to use trend surface analysis as a tool to aid in educational planning and decision making. McIsaac has applied trend surface to student achievement data in St. Louis and Philadelphia and to the analysis of redistricting of schools in Milwaukee. Through such applications, questions can be answered in regard to regional variations in such variables as: (1) achievement and the shifts in achievement variations over time, (2) wealth and how variations in wealth correspond to those in achievement, (3) Title I and whether such dollars are actually reaching their target areas, and (4) race or some other demographic variable and how such a variable relates to the redistricting of schools. This latter application has particular utility in view of the present problem in regard to federal requirements on integration.

The author is presently applying trend surface analysis to select personal income data for the states of Florida and Wisconsin to determine regional trends on such variables as the proportion of low income families, the proportion of high income families, adjusted gross income per pupil and total income tax paid per pupil. The information has potential for redistricting purposes in terms of a more equitable tax base and as a basis for a more equitable distribution of state and federal aid. Other possible applications are in the area of pupil population trends in the home address of students attending a particular institution of higher education or a junior college, voter behavior patterns in school bond elections, and in educational opinion surveys.

The main criteria that must be met before one can apply trend surface analysis is that the data be geographically quantifiable. That is, for each data element in question, it must be possible to represent geographically with X_1 and X_2 units of dimension the location of the data element on a map. This can be done by actually measuring the X_1 and the X_2 distances from a point of origin to the data element or by using a digitizer which would automatically assign an (X_1, X_2) coordinate if held over the selected point. If the data elements were students then the most efficient way to provide the type of information needed for the trend surface would be to have an (X_1, X_2) locational coordinate on each student in the district's student data file. A trend surface could then be performed for any sample of students that the district desired on any variable.