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ELSEVIER Applied Mathematics and Computation 172 (2006) 963–970
APPLIED MATHEMATICS AND COMPUTATION
www.elsevier.com/locate/amc

Analysis of three-dimensional grids: The four-point cube

G.L. Silver

Los Alamos National Laboratory,[1] *P.O. Box 1663, MS E517, Los Alamos, NM 87545, USA*

Abstract

Methods for analyzing the four-point cube are not commonly encountered. This paper illustrates the estimation of quadratic-term coefficients on four monotonic data in prismatic array. The analysis depends on the sequential application of interpolating equations for the four-point diamond and eight-point prismatic arrays. The estimates are often within an order-of-magnitude of the true values if the data do not suggest steep or rapidly changing gradients. The method is not strictly limited by the requirement that the data form a monotonic sequence.

Keywords: Interpolation; Operational equations; Response surfaces; Curvature coefficients; Extrapolation

[1] Los Alamos National Laboratory is operated for the US Department of Energy by the University of California under contract no. W-7405-ENG-36.

E-mail address: gsilver@lanl.gov

0096-3003/$ - see front matter
doi:10.1016/j.amc.2005.02.038

1. Introduction

The cost of laboratory work requires the economical use of resources. Traditional approaches for estimating curvature coefficients on three parameters may require as many as eight experiments. This paper describes the estimation of quadratic-term coefficients using only four data in cubical array. The methods supplement a recently described procedure for the same purpose [1]. Both approaches rely on operational interpolating equations [2–4]. The economy inherent in the four-point methods, as well as their accuracy on typical monotonic data, may be sufficient to interest experimentalists.

2. Two equations for the A, D, G, H design

Let the data reside at prism vertices A, D, G, and H as illustrated in Fig. 1. A method for estimating linear-term coefficients turns on Eq. (1).

$$R = E + (xc)x + (yc)y + (zc)z, \tag{1}$$

Eq. (1) can be substituted with the measurements (taken as R) at vertices A, D, G, and H, and the coordinates of those measurements, thus forming four numeric equations. The set of equations can be solved for the four coefficients E, xc, yc, and zc. This process renders estimates of the center point response, E, and the three linear-term coefficients xc, yc, and zc. Eq. (1), commonly used in the $-1,\ldots,1$ coordinate system, is not useful for estimating quadratic-term coefficients.

A second method for the same purpose uses Eqs. (2)–(5).

$$R = (P)J^{(x+1)}K^{(y+1)}L^{(z+1)}, \tag{2}$$

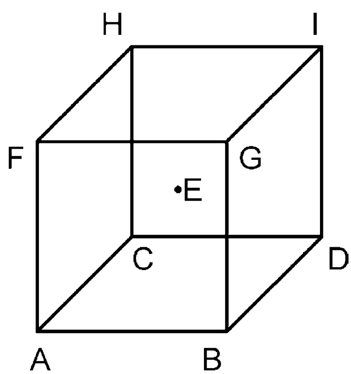

Fig. 1. The eight-point cube. Center point E is not used in the eight-point methods.