II.5 Estimates of variance in visual field data

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Abstract

Local or generalized increases in variance of multiple threshold determinations may indicate abnormality. If variance could be reliably estimated from a visual field in which threshold was determined only once, considerable test time could be saved. Meridional threshold data from 40 patients and 18 normals was used to test empirically various methods of estimating variance.

A variety of time-series analyses, including combinations of moving average methods, differencing, autoregression models, and forecasting techniques were applied. A modification of the Holt-Winters forecasting algorithm was developed which produced variance estimates which correlated well with standard mean square calculations. Increases in variance attributed to subject fatigue were observed at the end of a 60 minutes test session in normal subjects.

Introduction

Multiple determinations of threshold at a single point in the visual field will yield a set of values distributed about a mean. While the mean represents a reasonable estimate of the true threshold at that point, the degree to which the multiple determinations differ from the mean is expressed as a variance. In perimetry, the variance is dependent upon many factors, including the probability of seeing the stimulus, the strategy used to arrive at a threshold value, various patient factors including cooperation and attentiveness, and whether the tested point is abnormal or not [6]. If the multiple determinations are made in different test sessions, the variance increases further.

The variance for many tested points can be pooled to provide a variance estimate for the field as a whole. The square root of the variance of a single visual field test is referred to as the root mean square (RMS) and has been called the short-term fluctuation (SF) by Bebie, Fankhauser and Spahr [1]. SF is a useful...
statistic since it provides information about the visual field which is not readily available by perusal of the numeric or graphic charts. Low values of SF, under 2 dB, indicate excellent patient cooperation and make determinations of visual field change over time more reliable. High values of SF, on the other hand, may occur in abnormal fields and confound determinations of progression. SF has also been used by Flammer and his co-workers [5] in the calculation of the corrected loss variance (CLV) visual field index.

Of course, the true SF of a visual field can only be estimated. Fortunately, many threshold determinations at each point are not required to obtain meaningful estimates of SF. Double determinations are performed at each point in the full Octopus program, or at 10 points in the standard Octopus 31 and 32 programs. As Bebie, Fankhauser, and Spahr showed, the estimated SF has a probability of 0.68 of lying within ± 22% of the true SF, and probability of 0.95 of lying within ± 44% of the true SF [1]. For coarse uses such as allocations of subject reliability into three classes, ten double determinations are enough, but for more sophisticated uses such as calculation of CLV, a more accurate estimate requiring significant extra testing time is necessary. If SF could be estimated reliably without determining threshold twice at each point, significant time savings could be realized. The attempt to obtain a good SF estimate through mathematical manipulations of single threshold determinations forms the basis for this report. Our calculations were performed on estimates of variance (which is the square of S.F.).

However, the task is made difficult by the fact that there is a definite interrelationship among the threshold determinations of the various points in an individual visual field test. This relationship prevents their use as replicated independent observations in calculations of variance. It is therefore necessary to remove the intercorrelation by data manipulation.

Differential light sensitivity decreases with increasing distance from fixation. While the trend is obvious when plotted graphically, the average curve seems to have many changes of slope. In addition, changes in stimulus size, background intensity, and direction of the meridian tested change the shape of the curve [4]. It is difficult to describe this curve mathematically since it varies a great deal among individuals. Accordingly, it is necessary first to remove the trend from the data by empirical methods in order to produce a stationary series, i.e. a series of observations with a constant mean and covariance structure. A method must then be found to estimate the variance from the stationary series. Several techniques of detrending and of variance estimation were tried on data from patients and normal volunteers.