A Statistical Model Inspired by the National Map Accuracy Standard

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Abstract

This work proposes a statistical model inspired by the National Map Accuracy Standard pass/fail philosophy. The model is formulated as the composition of a statistical Binomial model on other statistical base models (parametric or nonparametric). This formulation allows adapting of the pass/fail philosophy of the NMAS *to any desired statistical base model, tolerance, percentage of points in error, and risks. The main contribution of this proposal is a common framework for dealing with sampling and risks with independence of the underlying base model (parametric or nonparametric). The use of nonparametric base models is explained and exemplified for the 1D case. For 2D and 3D, the Gaussian base model has been adopted. The Gaussian models allow the combining of error components by means of the Chi Squared and the Gamma distributions. For the 2D case, different situations have been considered in order to analyze the pass/fail behavior, and producer's and user's risks.*

Introduction

The positional accuracy of geospatial products has always been of great importance. This is, together with logical consistency, the quality element of geographic information most extensively used by the National Mapping Agencies (NMA), and also the more commonly evaluated quality element option (Jakobsson and Vauglin, 2002). Positional accuracy is a matter of renewed interest because of the capabilities offered by the Global Navigation Satellite System (GNSS) and the need of a greater spatial interoperability for supporting the Spatial Data Infrastructures. Different positional behaviors of geographic data sets mean the existence of an inter-product positional distortion and a barrier to interoperation (Church *et al.*, 1998). This barrier exists not only for the positional and geometric aspects, but also for thematic ones which are greatly affected by position (Carmel *et al.*, 2006). For these reasons many NMAS are currently involved in the development of positional accuracy improvement programs (EuroSDR, 2004).

In a Spatial Data Set (SDS) the position of a real world entity is described with values in an appropriate coordinate system. Positional accuracy represents the nearness of those values to the entity's "true" position in that system. The positional accuracy requirements for an SDS are directly related to its intended use(s). Positional accuracy is determined by means of a statistical evaluation of random and systematic errors (DOD, 1990) and specified by means of the Root Mean Squared Error (RMSE) or by the mean value of errors (μ) and their standard deviation (σ). Comparison with an independent source of greater accuracy is the preferred method for assessing positional accuracy (ANSI, 1998).

Since positional accuracy is essential in geospatial production, all NMAS have used statistical methods for its control, which we call here Positional Accuracy Assessment Methodologies (PAAMs). Many of these have been established as national or international standards and can be used for specifying spatial data products but also the resultant positional accuracy assessment compliance criteria. Standards should be taken into account when seeking an economic optimization of the quality of geographic information (Krek and Frank, 1999): with a quality standard the producer provides the product according to the known specification and characteristics, as defined in the standard. This assures a certain level of reliability and certainty, allowing the acquirer to avoid excessive measuring of the quality and thus reducing the measuring cost and shortening the decision-making process.

The International Organization for Standardization (ISO) considers positional accuracy to be one of the quantitative quality elements of geographic information as stated in its international standard 19157 (ISO 2012), which is a general framework for describing and reporting the quality of geographic information. This International Standard also proposes a general quality evaluation methodology for geographic information which must be applied to all the quality elements of geographic information (e.g., position, completeness, consistence, thematic accuracy, and so on). This standard is a generic guideline, and there is no specific or preferred method for positional quality assessment. Because this International Standard is a general framework, there is a need to clearly define aspects such as the computation of errors, sample size, and schema, acceptation/rejection criteria, and so on. We believe that the future of positional accuracy assessment must be resolved within ISO standards, but prior to this we need to know about current methods and their improvement possibilities in order to develop appropriate assessment methods for the positional aspect of geographic information.

This work is about the National Map Accuracy Standard (NMAS) (USBB, 1947), a standard of very simple application and broadly used in the entire world from its publication date. We propose a statistical formulation based on well-known statistical models, and given the current interest in controlling 3D positional accuracy (e.g., Cai and Rasdorf, 2009; Li *et al.* 2009), our proposal incorporates the third dimension as a logical extension of the 2D model. We also develop a 1D non-parametric case. The interest of our approach is twofold: first it can be used to better understand past re-

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