STATISTICAL METHODS IN APPLICATION TO ASTROMETRY

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ABSTRACT

Various important problems in astrometry require algorithmic solutions and statistical modeling. As a matter of fact, it is known that efficient methods for small-scale problems do not necesseraly translate into efficient methods in the large-scale setting and conversely. In this contribution, we present various recent statistical methods that can be exploited when solving estimation problems. They will be examplified in different astrometrical situations.

EXPLORATORY MULTIVARIATE DATA and PROJECTION PURSUIT METHODS

Exploratory Multivariate Analysis is usually based on the hope that a part of the data is redundant. Several statistical methods could be performed and acted efficiently in this context. Introduced by Friedman and Tukey (1974), the "Projection pursuit techniques" intend to select low-dimensional orthogonal projections of the data under modeling, in order to reduce dimensionality for computational purposes. Several methods belong to such approach.

Recall that, in the family of Principal Components Methods, the index of interestingness of a selected projection is the *proportion of variance related to the projected data.* These techniques are said *essentially algebraic "second order"* methods since they are based on the *Singular Value Decomposition* (SVD) of a specific data matrix, as stated by Jones and Sibson (1987, J. Royal Stat. Soc., vol 150-1, p1-36).

In astrometry, such tools may be quite relevant in data analysis, depending on the context. To examplify each approach, we present below, different fields in which they have been applied and can work efficiently in the future.

- APPLICATION 1) *Least Squares Fit Under Multicollinearity* Observations of minor planets are of importance to determine corrections to astronomical parameters between reference frames. Due to collinearities, a direct least squares fit is potentially misleading. Based on Hipparcos minor planet data, *principal component regressions* were successfully performed. The main references are:

  Bec-Borsenberger A., Bange J.F, Bougeard M.L., 1995, Hipparcos minor planets, *Astr. Astroph, 304,p176-181*

  Bange J., Bec-Borsenberger A., Bougeard M.L., Caquineau C., 1996, Lien entre referentiel dynamique et ICRS-Hipparcos, in:*Journées Systèmes de Référence spatio-temporels 1996*

  Bougeard M.L., Bange J., Bec-Borsenberger A., 1999, Singular Statistical Analysis of astrometric measurements with application to Hipparcos Minor Planet Observations, Pulkovo ed

- APPLICATION 2) *SMART and Projection Pursuit Regression, PPR, to estimate how approximated is the use of a linear model*

  For details on this nonparametric method, for which computational efficient procedures are now available, and for an example of application to ground-based astrometrical observations, we refer to:

  Bougeard M.L., 1990, L'ajustement statistique par Directions Revelatrices. Applications en astrometrie, *Journées JRS 1990, Paris-Observatory ed.*

- APPLICATION 3) *Singular Spectrum Analysis SSA and Application to Polar Motion series*

  In the context of SSA modeling, the PCA method is adapted to lessen the effects of possible irrelevant noises in order to separate the signal into "interpretable" components. In this context, the matrix under consideration is a M-lag covariance matrix. The most difficulty is that the consistency of the selected model mainly depends on the choice of the tuning parameter M.

  For application to the determination of episodic terms in the 1999-2000 Polar motion series, the reader is referred, for instance, to the paper below and the references therein.

  Bougeard M.L., Rouveyrollis N., Gambis D., 2001, EOP-SSA deteremination of episodic terms in the 1999-2000 Polar Motion, *Journées JRS 2001, Bruxelles-Observatory ed.*