STATISTIC AND ANALYTIC COMPATIBILITY TO JOINT CATALOGUES WITH A SET OF COMMON ICRF DEFINING SOURCES

F.J. MARCO[1], M.J. MARTINEZ[2]

[1] Universidad Jaume I
Dept. Matematicas, Institut de Matematiques I Aplicacions de Castello, Castellon, Spain
e-mail: marco@mat.uji.es

[2] Universidad Politecnica de Valencia
Dept. Matematica Aplicada, Valencia, Spain
e-mail: mjmartin@mat.upv.es

ABSTRACT. The construction of quasar catalogs from other catalogs containing few reference points but including a significant number of ICRF defining sources represents an interesting way to obtain an increasingly extended and accurate catalog (see [1], [3] and [5]). There are several questions that should be taken into account to reach this aim. For example, each catalogue should have its residuals normally distributed and this property should be also transferred to the final catalog. In addition, after the correction, the defining sources from each individual catalog should be related with the ones belonging to the other catalogs only by means of infinitesimal rotations, as usual. Also, the total residuals in the final catalog should not decrease while the variance increases too much, in order to avoid the introduction of excessive deformations.

There are several ways to correct catalogs. Roughly speaking we can classify the different methods in parametric and non-parametric. The parametric methods subdivide in geometrical (including corrections for rotation or rotation+deformation) and analytical (which consider developments in different sets of functions, such as spherical harmonics or Legendre-Fourier functions). All the parametrical methods make apriori suppositions about the function of residuals, in order to assure that this function belongs to a certain functional space. On the other hand, non-parametrical methods do not need to make any supposition about the functional expression of the function of residual, because they build on the statistical properties of the data. Our method uses both techniques (parametrical and non-parametrical) in order to obtain the best possible properties because some problems arise when we improperly apply the parametrical methods. We would like to remark that the application of the usual discrete least squares method, in order to obtain a functional continuous representation of the residuals, might provide erroneous results due to different causes (more details in [2]), such as:

1. Analytical causes: a lack of homogeneity in the data causes that the functional orthogonality of the set of functions employed in the adjustment is not necessarily preserved and thus the coefficients in the development would not be accurate.
2. Statistical causes: The hypothesis of the Gauss-Markov theorem should be fulfilled in order to assure that the least squares method provides the least variance estimator in the class of unbiased estimators.

All the former problems could be avoided if we use a non-parametrical method as an intermediary. In this case, a good method is to compute a estimation of the function over fiducial points homogeneously distributed over the celestial sphere. This procedure has additional advantages: each coefficient of a harmonic development can be computed independently as a quotient of the integral inner products from the Hilbert functional space. Such integrals can be approximated with precision as high as required. In these integrals each function has been approximated using a kernel non-parametrical method that requires the use of a bandwidth [4] whose length is very important in order to obtain the required accuracy. Altogether there is an additional advantage, because we can select a different bandwidth according to the order of each one of the coefficients which is being calculated and to the statistical properties of the

data.

1. CONDITIONS TO BE FULFILLED TO OBTAIN A CATALOG FROM INPUT CATALOGS WITH COMMON ICRF DEFINING SOURCES

We propose two main conditions in order to assure the compilation of an improved catalogue from other source catalogs:

1. First Condition (for each individual input catalog): previous study of the properties of each catalogue that is going to be used in the improvement process. We demand that the distribution of the residuals obtained through the comparison with the ICRF2 acts as a normal random variable before and after the correction.
2. Second Condition (for the combined final catalog): the differences between the final positions (after the correction) and the initial ones (before the correction) must behave as a normal random variable and not as a sum of Gaussians, in order to avoid the introduction of deformations.

It is possible that we should previously remove those positions clearly bad determined in order to fulfill these conditions. The inclusion of these positions could have a negative influence in the adjustment.

2. STEPS TO BUILD AN IMPROVED CATALOG

STEP 1: Selection of each individual catalogue to be used in the adjustment, taking into account that they should verify the First Condition. Then, we will make a non-parametrical adjustment over the defining sources of each selected catalog and then we obtain the geometrical transformation rotation+deformation for each one. At this stage, we will consider only the rotation computed using the catalog whose residuals have the minimum variance and we will disregard the deformation, which will be absorbed in the next step. Each catalog will provide a different rotation, thus all of them should be transformed into the same system. To this aim, we should apply to each catalog its own rotation and the inverse of the selected rotation (the one from the catalog with minimum variance). Notice that at the end of the first step, we have removed the geometric systematics.

STEP 2: We apply to the remaining individual residuals of each catalog a new non-parametrical adjustment to obtain the approximations over the selected fiducial points (over the whole sphere) and over all the sources selected for the adjustment. The inverse of the obtained variances are used as weights to built the final catalogue.

STEP 3: Test of the Second Condition given in the 1st section. This is to verify that the final errors are Gaussian, but do not form a Gaussian mixture distribution. This property should be seriously taken into account, because there is the risk of inhomogeneities in the final catalog if it is not fulfilled. A particular case is the sum of two Gaussians with the same (or nearly the same) centers and different variances. To detect this undesirable case, we have a developed a special method, out of the scope of this extended abstract and which is now under review.

Acknowledgements: Part of this work was supported by grant P1-1B2009-07 from Fundacio Caixa Castello BANCAIXA.

REFERENCES

[1] Malkin, Z. A&A. 474, 665-670. 2007
[2] Marco F.J., Martinez M.J. and Lopez J.A. A&A. 418. 1159-1170. 2004.
[3] Sokolova, Ju & Malkin, Z. A&A. 474, 665-670. 2007
[4] Wand M.P. & Jones M.C. Kernel Smoothing. Ed. Chapman & Hall.1995.
[5] Yatskiv, Y. & Malkin, Z. Journes systmes de rference spatio- temporels. 2007