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Report Jan 2020 – Attempts at parameterising an empirical AUF

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ABSTRACT

Given the depths that LSST will reach, we possibly require a different approach than previously undertaken to compute the perturbation component of the Astrometric Uncertainty Function (AUF) for probabilistic photometric catalogue cross-matching. We document here an attempt to derive this AUF – along with any other non-statistical AUF component, such as proper motions or binary reflex motion – from the data themselves, creating in-situ AUFs which do not rely on simulation.

1 INTRODUCTION

The Astrometric Uncertainty Function (AUF) is the probability density function (PDF) describing the probability of a source being detected at some position given its true location. The probability of two sources being the same intrinsic object detected twice given their respective locations – or the distance between their given positions – is the convolution of their respective AUFs. Each AUF is, itself, a convolution of the individual components describing its offset from its "true" location. The first of these, and typically the only component used, is its statistical component, in which Poisson noise in a photometric image causes the centroiding of a source imperfectly.

A second critical component in crowded regions, or in photometric surveys which probe significant depths relative to the length scale of the survey PSF (of which LSST and *WISE* are both subject), is the perturbation from blended sources. These objects, while hidden beneath the flux from a brighter source, contaminant the central object by both adding additional flux, and by tugging on the center-of-light of the composite object. Thus, in this simple two-component model, the AUF is

$$h(\mathbf{x}) = (f_{\mathrm{stat}} * f_{\mathrm{blend}})(\mathbf{x}) \tag{1}$$

where the notation $(f * g)(x)$ denotes a convolution.

Previously, Wilson & Naylor (2018) produced f_{blend} by a Monte Carlo simulation, via Galactic stellar densities from a TRILEGAL simulation (Girardi et al. 2005). However, the limiting magnitude of these simulations – via the public API – is 32nd magnitude; this was fine for *WISE* where we still had access to stars 10 magnitudes fainter than the limit of the survey (necessary for probing the faintest flux ratios and sufficiently small flux weighted astrometric perturbations), being brighter than $W1 = 32$. However, the limiting magnitude of LSST is about 27th magnitude, and thus the magnitude limit is out of the range of the TRILEGAL simulations.

2 IN SITU AUF

Thus the need for deriving empirical AUFs was born.

REFERENCES

Girardi L., Groenewegen M. A. T., Hatziminaoglou E., da Costa L., 2005, A&A, 436, 895

Wilson T. J., Naylor T., 2018, MNRAS, 481, 2148