$\boxed{\mathcal{AIPS}\text{ Memo 103}}$

Weighting data in AIPS

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Abstract

This memo describes the 'correct' calculation of weights for VLA and VLBA data based primarily on phenomological considerations with a light sprinkling of theoretical grounding.

1 Introduction

Weight calibration is important for radio-synthesis data. One commonly weighting scheme is for data weights to reflect the inverse variance of the data points. We have the advantage that modern synthesis radio interferometry is based upon the correlation of millions of digitized signal bits. Large number statistics are on our side.

The unnormalized correlator coefficient is the number of bits correlated $\rho = r$. The *rms* number of bits correlated when there is no signal present is the noise $\sigma = \sqrt{n}$. The normalized correlation coefficient is $\hat{\rho} = \frac{r}{n}$. The normalized noise is $\hat{\sigma} = \frac{\sqrt{n}}{n}$. So, the normalized weight $\hat{w} = \frac{1}{\hat{\sigma}^2} = n$.

The key point is that, once the visibility and weights are made to be in proper relation to one another, no adjustments should be made to one without a corresponding adjustment to the other. AIPS does make adjustments to the visibilities and weights in the proper way whenever the logical DOWTCL in SELINI.INC is set. Unfortunately, this is rarely done. That must change if proper weights are to propagate from end to end.

2 Weighting for the VLA

The VLA currently delivers $v_d = \hat{\rho}\Sigma$. Σ is a scaling factor that attempts to convert the correlation coefficient into a visibility in units of deciJy (for historical software-motivated reasons). The number of bits correlated is $n = \Delta t \Delta\nu$. The delivered weight by the VLA is $w_d = 1 = \frac{\Delta t}{[10sec]}$. Users seem to want the currently delivered visibility to remain unchanged so, $v_w = v_d$. We want a weight $w_w = \frac{1}{\sigma^2} = \frac{1}{\hat{\sigma}^2\Sigma^2} = \frac{\Delta t \Delta\nu}{\Sigma^2}$. This means $w_w = \frac{w_d 10 \Delta\nu}{\Sigma^2}$.

2.1 What about the correlator efficiency η_c?

The correlator efficiency factor represents a decrease in sensitivity due to digitization noise. This factor is accounted for in the nominal sensitivity because it is also used to convert from the correlator coefficient to the deciJy scale. It is not necessary to consider this factor again for VLA data.

3 Weighting for the VLBA

The VLBA correlator delivers correlator coefficients along with a scaling factor necessary to properly normalize them. To the extent that the visibility scaling factor simply normalizes the correlation coefficients, it is irrelevant for correct calculation of the weights. Any factors that represent an 'incompleteness' in the number of bits used for correlation are relevant. This certainly should include the doom factors. Also, this includes a tape-playback factor. The weight that FITLD should produce is:

$$w_w = \eta_{playback}\eta_{doom}\Delta t\Delta\nu$$

Currently the delivered weight is $w_d = \eta_{playback}\Delta t$. So,

$$w_w = \eta_{doom}w_d\Delta_\nu$$

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4 Other considerations

These musings do not properly address the strong signal case and proper treatment of the Van Vleck corrections.

5 Acknowledgements

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