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An Efficient E-field Parallel Imaging Calibration Algorithm for Next-Generation Radio Telescopes

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ABSTRACT
Abstract here (250 words)

Key words: instrumentation: interferometers – techniques: image processing – techniques: interferometric

1 INTRODUCTION

Motivate problem of calibrating direct imagers. Reference Nithyas paper. (Morales 2011)

2 MATHEMATICAL FRAMEWORK

Introduce notation, describe measurement equation.

$$C^n(a, \hat{\mathbf{s}}_{\rm pix}, f) \equiv \left\langle E_a(f) E'^*(\hat{\mathbf{s}}_{\rm pix}, f)\right\rangle_t \tag{1}$$

$$C^n(a, \hat{\mathbf{s}}_{\rm pix}, f) \rightarrow C_a^{(n)}$$

$$\widetilde{E}_a = g_a E_a^T \tag{2}$$

$$\begin{aligned}\hat{E}(\hat{\mathbf{s}}_{\rm pix}) &= \frac{1}{N_{\rm ant}} \sum_i e^{2\pi i \hat{\mathbf{s}}_{\rm pix}\cdot\mathbf{r}_i} \hat{\widetilde{E}}_i &(3)\\ &= \frac{1}{N_{\rm ant}} \sum_i e^{2\pi i \hat{\mathbf{s}}_{\rm pix}\cdot\mathbf{r}_i} \sum_b \widetilde{W}_b(\mathbf{r}_i - \mathbf{r}_b) \hat{\widetilde{E}}_b &(4)\\ &= \frac{1}{N_{\rm ant}} \sum_i e^{2\pi i \hat{\mathbf{s}}_{\rm pix}\cdot\mathbf{r}_i} \sum_b \widetilde{W}_b(\mathbf{r}_i - \mathbf{r}_b) h_b^{(n)} g_b \widetilde{E}_b^T &(5)\end{aligned}$$

We can then play a trick to transform the beam.

$$\begin{aligned}\hat{E}(\hat{\mathbf{s}}_{\rm pix}) &= \frac{1}{N_{\rm ant}} \sum_b h_b^{(n)} g_b \widetilde{E}_b^T e^{2\pi i \hat{\mathbf{s}}_{\rm pix}\cdot\mathbf{r}_b} \sum_i \widetilde{W}_b(\mathbf{r}_i - \mathbf{r}_b) e^{2\pi i \hat{\mathbf{s}}_{\rm pix}\cdot(\mathbf{r}_i - \mathbf{r}_b)} &(6)\\ &= \frac{1}{N_{\rm ant}} \sum_b h_b^{(n)} g_b \widetilde{E}_b^T e^{2\pi i \hat{\mathbf{s}}_{\rm pix}\cdot\mathbf{r}_b} W_b(\hat{\mathbf{s}}_{\rm pix}) &(7)\end{aligned}$$

Plugging in, we get,

$$\begin{aligned}C_a^{(n)} &= \left\langle \widetilde{E}_a \hat{E}^*(\hat{\mathbf{s}}_{\rm pix})\right\rangle_t &(8)\\ &= \left\langle g_a \widetilde{E}_a^T \frac{1}{N_{\rm ant}} \sum_b h_b^{*(n)} g_b^* \widetilde{E}_b^{*T} e^{-2\pi i \hat{\mathbf{s}}_{\rm pix}\cdot\mathbf{r}_b} W_b^*(\hat{\mathbf{s}}_{\rm pix})\right\rangle_t &(9)\\ & &(10)\end{aligned}$$

Pulling time independent pieces out.

$$\begin{aligned}C_a^{(n)} &= \frac{g_a}{N_{\rm ant}} \sum_b h_b^{*(n)} g_b^* W_b^*(\hat{\mathbf{s}}_{\rm pix}) e^{-2\pi i \hat{\mathbf{s}}_{\rm pix}\cdot\mathbf{r}_b} \left\langle \widetilde{E}_a^T \widetilde{E}_b^{*T}\right\rangle_t &(11)\\ &= \frac{g_a}{N_{\rm ant}} \sum_b h_b^{*(n)} g_b^* W_b^*(\hat{\mathbf{s}}_{\rm pix}) e^{-2\pi i \hat{\mathbf{s}}_{\rm pix}\cdot\mathbf{r}_b} \widetilde{V}_{ab}^T &(12)\end{aligned}$$

Solve for $g_a^{(n+1)}$.

$$g_a^{(n+1)} = C_a^{(n)} N_{\rm ant} \left[\sum_b h_b^{*(n)} g_b^{*(n)} W_b^*(\hat{\mathbf{s}}_{\rm pix}) e^{-2\pi i \hat{\mathbf{s}}_{\rm pix}\cdot\mathbf{r}_b} \widetilde{V}_{ab}^T\right]^{-1} \tag{13}$$

In the case where $h_b = 1/g_b$, this simplifies slightly.

$$g_a^{(n+1)} = C_a^{(n)} N_{\rm ant} \left[\sum_b W_b^*(\hat{\mathbf{s}}_{\rm pix}) e^{-2\pi i \hat{\mathbf{s}}_{\rm pix}\cdot\mathbf{r}_b} \widetilde{V}_{ab}^T\right]^{-1} \tag{14}$$

3 SIMULATION

Describe simulation

4 VERIFICATION

Connect to either cramer-rao or FX solutions in some way

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5 CONCLUSIONS

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REFERENCES

Morales M. F., 2011, PASP, 123, 1265

APPENDIX A: SOME EXTRA MATERIAL

If you want to present additional material which would interrupt the flow of the main paper, it can be placed in an Appendix which appears after the list of references.

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