ACS/WFC Geometric Distortion: Time Dependency Study

ABSTRACT
We re-visit the issue of the time-dependency variation of the linear terms in the ACS/WFC geometric distortion. We performed a detailed photometric/astrometric study using F606W FLT and FLC images from the calibration field near globular cluster 47 Tucanae. We analyzed the time dependency of the linear terms by comparing individual observations with a standard catalog. A previous calibration of these drifts proved to be able to restore positions to the milli-arcsecond level for pre-SM4 data. We confirm this previously existing solution and we provide new and simple corrections for both FLT and FLC images that will allow observers to perform global astrometric studies with 0.02 WFC pixel precision using both pre- and post-SM4 images.

INTRODUCTION

The Hubble Space Telescope (HST) Advanced Camera for Surveys (ACS) Wide Field Camera (WFC) consists of two 4096 X 2048 pixel charge-coupled devices (CCDs). In 2004, during the reduction of the Hubble Ultra Deep Field, it was noticed that there was a problem with the alignment of images obtained at different orientations. We revised the pre-SM4 solution and derived an empirical correction of time-dependency in the linear terms for post-SM4 distortion. The empirical corrections are presented in ISR ACS 2013-03.

THE LINEAR TERMS

We used a general linear transformation to map the positions from a distortion-corrected frame \((x_{\text{corr}}, y_{\text{corr}})\) into a distortion-free field \((x, y)\):

\[
\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} A & B \\ C & D \end{pmatrix} \times \begin{pmatrix} x_{\text{corr}} - x_c \\ y_{\text{corr}} - y_c \end{pmatrix} + \begin{pmatrix} x_c \\ y_c \end{pmatrix}
\]

The rotation, scale and skew terms follow from the relations:

\[
\begin{align*}
\text{orientation} & : \tan(\theta) = (B - C)/(A + D) \\
\text{scale} & : s = \sqrt{AD - BC} \\
\text{skew terms} & : C_1 = (A - D)/2s \\
& \quad C_2 = (B + C)/2s
\end{align*}
\]

We express the matrix of coefficients as the product of a pure rotation matrix and a pure skew matrix:

\[
\begin{pmatrix} A & B \\ C & D \end{pmatrix} = s \times \begin{pmatrix} \cos \theta & \sin \theta \\ -\sin \theta & \cos \theta \end{pmatrix} \times \begin{pmatrix} 1 + \nu u & \nu \\ u & 1 - \nu \end{pmatrix}
\]

rotation \quad pure skew

\[
u = C_1 \sin \theta + C_2 \cos \theta
\]

\[
\nu = C_1 \cos \theta - C_2 \sin \theta
\]

We studied the time dependency of the skew functions \(\nu\) and \(\nu\).

OBSERVATIONS

We used a selection of FLT and FLC images from the 47 Tucanae ACS/WFC F606W database.

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Table 1: F606W observations used in this study.

PHOTOMETRY AND ASTROMETRY

Positions and fluxes were measured using the FORTRAN software img2xym_WFC.09x10. Figure 1 shows the quality of fit as a function of instrumental magnitude. False detections and contamination from stars belonging to the Small Magellanic Cloud were discarded by selecting sources with position residual less than 0.07 WFC pixel (~3.5 mas).

RESULTS

We calculated the skew functions \(\nu\) and \(\nu\). Their radian values have been scaled by 2048 to convert into WFC pixels at the extreme edge of the detector. We observe linear trends with time for pre- and post-SM4 data.

We fit linear functions to the results to estimate a time-dependent correction. Figure 2 shows the variation with time of the skew before and after the time-dependent correction was applied.

REFERENCES

Anderson, J. 2002, HST Calibration Workshop, 13

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