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ASC Coordinate Transformation — The Pixlib Library, II

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Abstract. Pixlib, an AXAF Science Center (ASC) coordinate library, has been developed as the continuing effort of (He 1997). Its expansion includes, handling of the High Resolution Mirror Assembly (HRMA) X-ray Detection System (HXDS) stage dither and the five-axis mount (FAM) attachment point movements, correction of misalignments of the mirror mount relative to X-ray calibration facility (XRCF) and to the default FAM axes, as well as solution of sky aspect offsets of flight, etc. In this paper, we will discuss the design and the configuration of the pixlib system, and show, as an example, how to integrate the library into ASC data analysis at XRCF.

1. Introduction

The work of He (1997) established a preliminary framework for the pixlib system, including the parameter-interface data I/O structure, matrix calculation algorithm, and coordinate transformation threading baselines. Since then, the library has undergone thorough re-organization and expansion to meet the AXAF on-going requirements of both ground calibration and flight observation. At the time of writing, the library is about 95% completed with approximate 6000 source lines of codes. It was successfully integrated and built during the XRCF calibration phase.

In this paper, we will highlight the system design and architecture of the library, complementary to the early work, and describe the system configuration in terms of user application. The complexities of coordinate transformation at XRCF and the resolutions will be discussed.

2. Architecture of the ASC Coordinate Library

The building blocks of the Pixlib library are three sub-systems, core, auxiliary, and application interface (API), and the foundation of the library is built with the parameter-interface structure. Figure 1 sketchs the architecture of the library.

As discussed in He (1997), the design of pixlib is modular to allow system expandibility, easy maintenance and simple ways to incorporate new scientific knowledge. The core sub-system, which includes 8 modules (see Figure 2 for

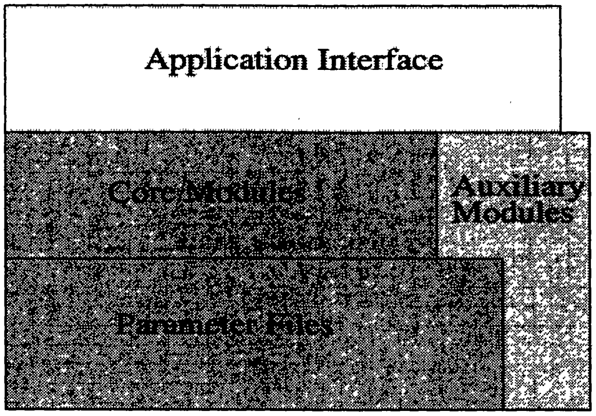

Figure 1. Pixlib library architecture, constructed on three sub-systems which are layered on the parameter-file structure.

details), builds the ASC coordinate frameworks of grating, FAM motion, sky aspect offsets, telemetry (raw) reads, detector-chip tiling, and coordinate transformation among chip pixels and celestial angles. Because of the common needs of generic data sources, handy utilities, module-to-module communication, etc., the library is supported with a 4-module auxiliary sub-system, as shown below.

`pix_errstatus.c` `-- error handling`
`pix_utils.c` `-- utility functions`
`pix_common.c` `-- common data sources to all modules`
`pixlib_hiden.c` `-- internal configuration, bookkeeping`

The upper-level interface of the library is implemented in the module `pixlib.c`, which distributes functions between the lower-level modules. `pixlib.c`, in large part, provides setup functions for system configuration, and other API functions are implemented locally without the need for cross-module function calls. All the API functions are identified by the "`pix_`" prefix.

The data in-stream of the parameter-interface approach simplifies system configuration and data readability. The number and organization of those data files have remained almost same as described in He (1997) with few updates. `pix_pixel_plane.par`, substituting the original `pix_size_cnter.par`, groups 2-D pixel system parameters of focal plane, tiled detector, grating dispersion together; `pix_grating.par` is added to define dispersion period and angle of grating arms.

3. System Configuration

Prior to application program execution, the library needs to be configured properly. The system configuration is optionally either static or dynamic, as illustrated in Figure 2. A set-parameter-value to a parameter file, `pix_coords.par`, handles the static configuration and the user can set values for the following parameters.

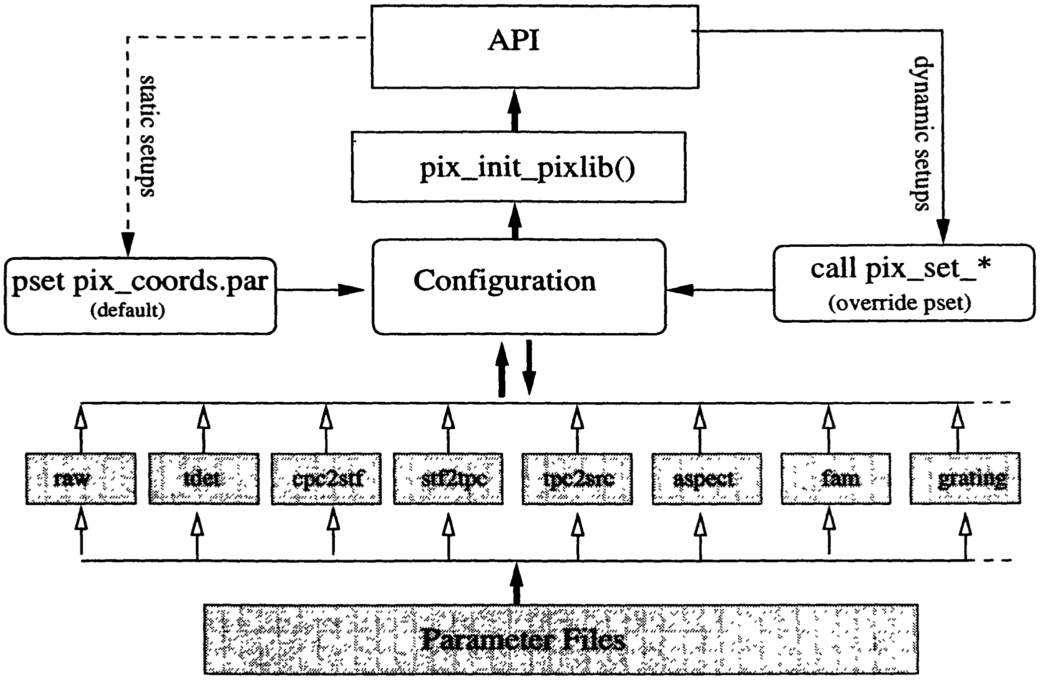

Figure 2. Pixlib data flow and system configuration. Each smaller box above represents a module. For example, the "raw" and "cpc2stf" boxes denote the modules of pix_raw.c and pix_cp2stf.c, respectively.

```
 flength = Telescope focal length in mm
aimpnt   = Name of aim point  of detector
   fpsys = Focal Plane pixel system
 tdetsys = Tile Detector pixel system
  gdpsys = Grating Dispersion pixel system
 grating = Grating arm
   align = FAM    misalignment angle in degrees(pitch, yaw, roll)
  mirror = mirror misalignment angle in degrees(pitch, yaw, roll)
```

In the course of the system initiation, executed through `pix_init_`pixlib(), internal functions lookup the parameter table to parse the information down to relevant modules, which are then configured accordingly.

An alternative way to configure the system is to make function, "`pix_set_*`", calls in application program following the initiation. `pix_set_flength(int)`, for instance, is equivalent to the pset "flength" for `pix_coords.par`, and `pix_set_fpsys(int)` to the pset "fpsys", to name a few. The consequence of those calls is to override the static configuration which is the system defaults.

4. Coordinate Transformation at XRCF

Coordinate transformations at XRCF need to be carefully handled when the FAM feet move and the HXDS stage dithers. In the default, boresight configuration the FAM axes are parallel to the XRCF (and Local Science Instrument, LSI) axes, but they may undergo some movements in addition to the HXDS stage dithering and possible mirror mount movement. Therefore, those effects, as listed below, must be accounted for before coordinate transformations between focal plane and LSI system are made:

- misalignments of the default FAM axes from the mirror due to FAM attachment point motion,
- motion of the HXDS stage from the default FAM reference point,
- possible misalignments of the mirror mount relative to the XRCF prescribed by pitch-yaw angles,
- misalignments of the FAM axes from the default due to FAM feet motion.

The following two functions, in addition to other generic configurations, effectively supply the system configuration for coordinate transformation at XRCF. The routine

```
pix_set_mirror (double hpy[2],        /* in degrees */
                double stage[3],      /* in mm      */
                double stage_ang[3])  /* in degrees */
```

corrects misalignment from the mirror axis by measuring its displacement from the boresight configuration of the default FAM frame (`stage_ang`) for a given mirror position (`hpy`) in mirror nodal coordinate system. The `hpy` is measured in HRMA pitch and yaw axes, and the HXDS stage position (`stage`) monitored relative to the default FAM reference point. The routine

```
pix_set_align(
    double mir_align[3], /* (yaw, pitch, roll), in degrees */
    double stg_align[3]) /* (yaw, pitch, roll), in degrees */
```

serves to assess

- misalignments of mirror mount (`mir_align`) relative to XRCF axes are measured in the given yaw-pitch-roll Euler angles in the mirror nodal coordinate, and
- misalignments of the default FAM (`stg_align`) relative to XRCF axes are corrected in terms of yaw-pitch-roll Euler angles in the default FAM frame.

The system configuration above was successfully applied to and integrated into ASC data analysis during the X-ray calibration.

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References

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