Fine Guidance Sensor Instrument Report

DATA SMOOTHING AND DOUBLE STAR DATA REDUCTION
IN THE TRANSFER FUNCTION MODE DATA REDUCTION PACKAGE

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I. DATA SMOOTHING

The data smoothing task of the STScI Transfer Function Mode Reduction Package (TFMRP) includes program SCURVE which creates pointwise and polynomial data files from raw TRANSfer data files. The user must supply the .scur file (as output by the astrometry data unpacking software; see Bucciarelli and Lattanzi 1991) and identify the axis (x or y) (s)he wishes to fit.

The calling structure of SCURVE is as follows.

SCURVE

  PREPARE_SCURVE
  MAKE_SCURVE
  SORT
  CUT_SCURVE
  SCURVE_INTERP
    NORMAL
    ATB
    LUDCMP
    LUBKSB
    APROD
  FINISH_SCURVE
  INTERP

SCURVE is the controlling program.

PREPARE_SCURVE reads the .scur file (as output by the astrometry data unpacking software; see Bucciarelli and Lattanzi 1991) specified by the user and converts the star selector encoder angles to x and y axis coordinates and creates the output file s_raw.dat
which includes the x and y coordinates and their corresponding photon counts in channels A and B.

**MAKE_SCURVE** reads s.raw.dat and writes the S-curve for the specified axis (x or y) to the output file for084.dat. The S-curve is roughly centered at \( x = 0 \) (or \( y = 0 \) for y axis curves). The pmt mismatch is accounted for by averaging the first and last 128 mismatch values. The counts are sorted according to their x (or y) coordinate and if one coordinate value appears more than once its counts are averaged and the duplicity removed.

**CUT_SCURVE** reads for084.dat files and cuts the ends of the S-curve writing only the innermost 0.8 arcsec of the curve to file for084c.dat.

**SCURVE_INTERP** reads for084c.dat and fits a continuous piecewise polynomial to the data. The program first attempts to fit a cubic polynomial with continuous first and second derivatives to the data; if there are not enough data points to do this, the program defaults to a lower order polynomial. The polynomial is written to file corrinp.dat; the smoothed pointwise S-curve, i.e., the polynomial evaluated at the x (or y) coordinates of for084c.dat is written to file comp_scurve.dat.

**NORMAL, ATB, LUDCMP, LUBKSB and APROD** are matrix manipulation subroutines.

**FINISH_SCURVE** centers the S-curve at \( x = 0 \) (or \( y = 0 \)) and calculates the left and right end averages of the comp_scurve.dat S-curve and uses these averages to extend the scurve to \( 0 +/- 0.6 \) arcsec. The parity of the S-curve is reversed in the output file finish.dat.

**INTERP** is a quadratic interpolation subroutine.

A copy of the fortran code for program SCURVE is included in Appendix 1.
II. DOUBLE STAR DATA REDUCTION

The double star data reduction portion of the Transfer Function Mode Reduction Package (TFMRP) consists of program BINARY which determines the separation of the binary components and the difference in their magnitudes for each of the two FGS axes and the position angle of the binary.

Program BINARY compares an observed (binary) Transfer Function to a reference (single) Transfer Function and finds the best fit binary configuration i.e., offset, separation, and magnitude difference (Dmag) for the observed S-curve. This is accomplished in two steps: First, a matrix of synthetic binary S-curves is generated from the polynomial representation of the reference S-curve. This matrix is searched for the offset which yields the highest correlation with the observed S-curve. This offset is then used to find the separation and Dmag of the binary S-curve which minimize the square of the integral of the residuals. These best fit separation and Dmag are then used as input to the second step in which the best fit offset, separation and Dmag are determined by minimizing the sum of the squares of the residuals from the reference curve. It is an explicit assumption in both of the above steps that the binary S-curve can be represented by a linear combination of single star S-curves.

The user does not currently have the option of running the correlation and least squares sections of the program separately but the best fit parameters are output for both steps.

The user must supply (at least) the following two files: The polynomial representations of the reference (single star) S-curve and the observed (binary) S-curve. The polynomial files must be in the format of corrinp.dat as output from subroutine SCURVE_INTERP of program SCURVE. The user also has the option of having the software determine the position angle of the binary. If the position angle is to be computed, the user must supply additional data files (as described above) for both the x and y axes as well as a FITS HEADER file.

Some of the current limitations of this program include: The observed system may not have more than two components (i.e., no triples); the x and y axes are treated separately.
The calling structure of the program is as follows: BINARY

INTRO
SETDEFS
PLOTS
POLYFIT
  GEN_DTEMPL
  SHIFT_DT
  ORDINA
  SHIFT_DT
  CORR_TRANSF
  SHIFT_DT1
POINTFIT
POS_ANGLE

Subroutine BINARY is the controlling program.

Subroutine INTRO introduces the user to the program. The user is told what the program does and how it does it and what data (s)he needs to supply.

Subroutine SETDEFS sets the ranges of values searched and the corresponding step sizes for offset, separation and Dmag. The user is given the option of plotting the reference and observed S-curves and default values for the ranges and step sizes are offered.

Subroutine PLOTS uses PGPLOT to plot the reference and observed S-curves to the output device of the user’s choice.

Subroutine POLYFIT uses the polynomial representations of the reference and observed S-curves to determine the best fit offset, separation, and Dmag of the observed binary.

Subroutine GEN_DTEMPL generates a synthetic binary S-curve polynomial with a given separation and Dmag from the reference polynomial.
Subroutine \texttt{SHIFT\_DT} determines a new polynomial \( y'(x+dx) \) such that \( y'(x+dx) = y(x) \).

Subroutine \texttt{ORDINA} is a sorting subroutine.

Subroutine \texttt{CORR\_TRANSF} returns the offset that results in the highest correlation between the observed binary and the synthetic binary constructed in \texttt{GEN\_DTEMPL}. The best separation and Dmag are chosen to minimize the square of the integral of the residuals.

Subroutine \texttt{SHIFT\_DT1} determines a new polynomial \( y'(x+dx) \) such that \( y'(x+dx) = y(x) \).

Subroutine \texttt{POINTFIT} uses the output of \texttt{POLYFIT} as starting guesses in determining the best fit offset, separation, and Dmag by minimizing the sum of the squares of the residuals. Better accuracy in some cases may be obtained with \texttt{POINTFIT} than with \texttt{POLYFIT}.

Subroutine \texttt{POS\_ANGLE} uses the computed values of separation and Dmag for the x and y axes and the predicted roll angle of the spacecraft to determine the position angle of the binary.

The fortran code for program \texttt{BINARY} is included in Appendix 2.
Appendix 1

SCURVE Source Code
Appendix 2

BINARY Source Code