IMAGE REGISTRATION USING POINT SOURCE CORRELATION

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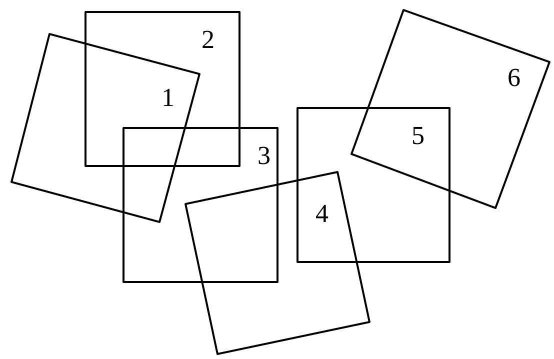
AIM: To perform image registration and generate delta-files using an automated point source correlation method. An algorithm is suggested below.

1. Suppose we want to compute the rotational, translational offsets between the frames randomly arranged as shown:



2. From the point-source extractor, each frame will have an associated list of point sources detected there in with coordinates (*x, y*).

3. Using the CRVAL, CRPIX, CROTA and TNX distortion keywords for each image, every detected point source is transformed to RA, DEC. In other words, to an "absolute" coordinate system for all the frames in question. The RA, DEC positions are then transformed back to the *x,y* image plane using a pure TAN projection for use in the registration step below.

4. In (RA, DEC) space, point-source matching between all possible "pairs" of frames is performed. Both position and flux matching will be performed using bright sources within a user-specified tolerance search radius. So in the above example, suppose we have point sources common between the frame pairs: (1,2), (2,3), (3,1), (3,4), (4,5) and (5,6). The minimum requirement is to have at least two point sources common between pairs with a separation >10 pixels. The closest match will be used in ambiguous cases where a source is fit with more than one component.

5. Using the TAN projected *x,y* positions (step 1), the frames in each correlated pair are registered to each other. In other words, 1 with 2, 2 with 3, 3 with 1 etc, resulting in a list of "pairwise" rotational and translational shifts: (theta_12, X_12, Y_12), (theta_23, X_23, Y_23), (theta_31, X_31, Y_31) etc.. The usual registration equations are used to compute these shifts and their uncertainties (see DELTAFPOINT module). A robust minimization algorithm that utilizes all the matched sources will be used. At least two point sources are needed to uniquely determine theta and hence shifts in X and Y.

6. Now we need to choose the reference image from which to define the relative shifts for each "individual" frame. The user will have two options: first, any pre-specified image from the input list, or second, a mean “fiducial” image which is defined as the average of all image positions in the ensemble. Let us assume image number 3 in the above figure as the reference.

7. Having defined the reference image and using the pairwise shifts computed in step 5 above, a shift (theta, X, Y) is determined for each individual image relative to the reference. This is accomplished using a "chain-ladder" algorithm where the successive pairwise shifts are summed until the frame in question is tied to the reference image. But that’s not all. We will have to make use of all the information given by all neighboring images correlated with the image in question. In other words, there may be many paths leading from image-to-reference within a web of multiple correlations. For example, frame 1 above can be tired to the reference (frame3) via two paths: $1\rightarrow2, 2\rightarrow3$ or directly $1\rightarrow3$.

8. In the end, a “delta-file” of effective rotational, translational shifts connecting each image to the reference will be computed. This is accomplished by taking a (inverse-variance) weighted mean of all the possible correlated-image paths. The uncertainty in these shifts will be significantly reduced with an increase in the number of correlated paths tying each image to the reference.

9. Note that the frames need NOT overlap with the reference image, they should only be tied to the reference image via a series of parwise shifts between adjacent frames. Frames which fail to have point sources common with adjacent frames (and hence disjoint from the reference image), will require registration using pointing header keywords. In fact, this new module will read in the delta-file generated from pointing (from module DELTAFPOINT) and update its entries to the refined values computed using the above method.