Star Tracker Attitude Solution from Spinning Platform with Rapid Streak Detection

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Star trackers are well established sensors for attitude determination. In our previous work, we presented a new star tracker methodology to find fast attitude solutions from low end cameras based on a stable attitude, having stars appear as point sources. In the current work, we are extending the methodology to incorporated attitude solutions for star trackers that are used in a rotating space craft. In this case, stars appear as streaks. The problem is that the streaks might disintegrate, especially when traced over many pixels, and start and end point of the streaks are extremely difficult to determine.

In a brute force detection algorithm approach, the single parts of the streak are then interpreted as single independent detections. See Fig. 1. As the attitude shall not be assumed to be a priori not known, assumptions about the streak length and orientation cannot be made without severely restricting the problem.

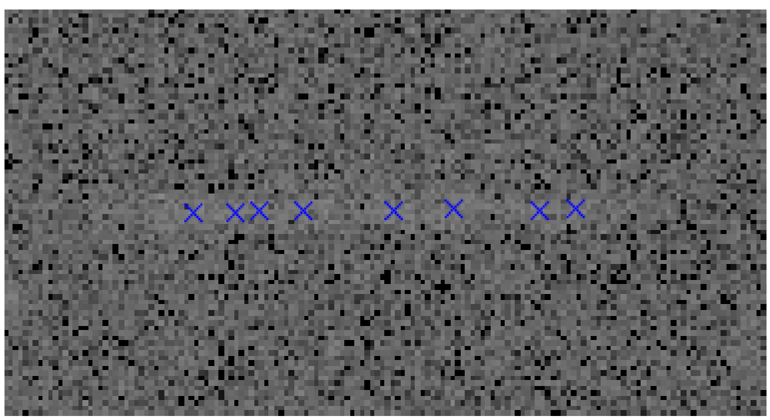

Fig. 1 Faint disintegrated streaks with single detections in blue.

In this paper we introduce a different method for the rapid detection of brighter and faint streaks and compare it to the cost function approach that is introduced in Dawson et. al. [1]. The proposed method is a two step approach. Taking a rectangle function folded over a Gaussian surface, a three dimensional surface is define

$$m = \frac{\ell_0}{2}\left[\mathrm{Erf}\left(\frac{\mathrm{L}-2\mathrm{H}_x}{2\sqrt{2\sigma_\Pi^2}}\right)+\mathrm{Erf}\left(\frac{\mathrm{L}+2\mathrm{H}_x}{2\sqrt{2\sigma_\Pi^2}}\right)\right]\exp\left(-\frac{1}{2}\frac{H_y^2}{\sigma_\Pi^2+\sigma_y^2}\right)\frac{\sqrt{2\pi\sigma_y^2}}{\sqrt{2\pi(\sigma_\Pi^2+\sigma_y^2)}}$$

σ_y: width of rectangle function of convolution, H denotes the Hessian Matrix, and $\omega \equiv [x_0, y_0, \phi_0, \ell_0, L, \sigma_\Pi^2]$

with x_0, y_0: are the center of the streak, ϕ_0 is the angle with respect to the x-axis, l_0 is the surface brightness, L is the length of the streak, and σ_Π is standard deviation of Point Spread Function (PSF). All the streak parameters are a prior undetermined.

In a two-step approach, only a very coarse first guess is generated. Subsequently, a Broyden–Fletcher–Goldfarb–Shanno (BFGS) approach is used to find a refined estimated.

The same methodology is used for ground-based tracking of space objects without a priori information.

References:

[1] Dawson, W., Schneider, M., and Kamath, C., “Blind Detection of Ultra-faint Streaks with a Maximum Likelihood Method,” *AMOS Technology Conference*, 2016