Lost In Space Algorithm Research

Bryant.

Why do we need to solve for the Lost in Space problem?

- To determine our camera orientation by star identification.

- A common strategy is to use a triangulation method, which has been done way better than my solution. Why?

Dalabie, Durt, and Vander steen's Algorithm (2011).

Tjorven Delabie, Thomas Durt, and Jeroen Vandersteen. "Highly Robust Lost-in-Space Algorithm Based on the Shortest Distance Transform", Journal of Guidance, Control, and Dynamics, Vol. 36, No. 2 (2013), pp. 476-484.

- Not triangle, but it has been the only algorithm that any of us have looked at. (Shortest Distance Transform Technique.)
- Images comparable to the camera image are generated from the Hipparcos database.
- Two brightest stars method and centroid method to match images.
- Handles false, missing, and distorted stars.
- But how distribute points on sphere

Liebe’s Algorithm (1993).

C. C. Liebe, “Star trackers for attitude determination,” IEEE Aerospace and Electronic Systems Magazine, vol. 10, no. 6, pp. 10–16, 1995.

- Guide triangles formed by guide stars.
- 1000 stars were selected from Smithsonian Astrophysical Observatory.
- 185,000 star triangles.
- 94.6% Recognition rate.
- Identification time: ~10 s.

Mortari's Algorithm (2004).

D. Mortari, M. A. Samaan, C. Bruccoleri, and J. L. Junkins, "The pyramid star identification technique," Navigation, vol. 51, no. 3, pp. 171–184, 2004.

- Pyramidal algorithm: match four stars by ordering angular distance between stars.
- Really good at false star identification.
- Highly efficient and fast.
- No analysis of errors for measurements.

Cole and Crassidis' Algorithm (2006).

C. L. Cole and J. L. Crassidis, "Fast star-pattern recognition using planar triangles," Journal of Guidance, Control, and Dynamics, vol. 29, no. 1, pp. 64–71, 2006.

- Triangulation of stars (+area and polar moment.)
- Number of similar solutions are rapidly reduced.
- Large memory required to hold triangle data.
- Affected by star positional noise in the image.

Yang's Algorithm (2007).

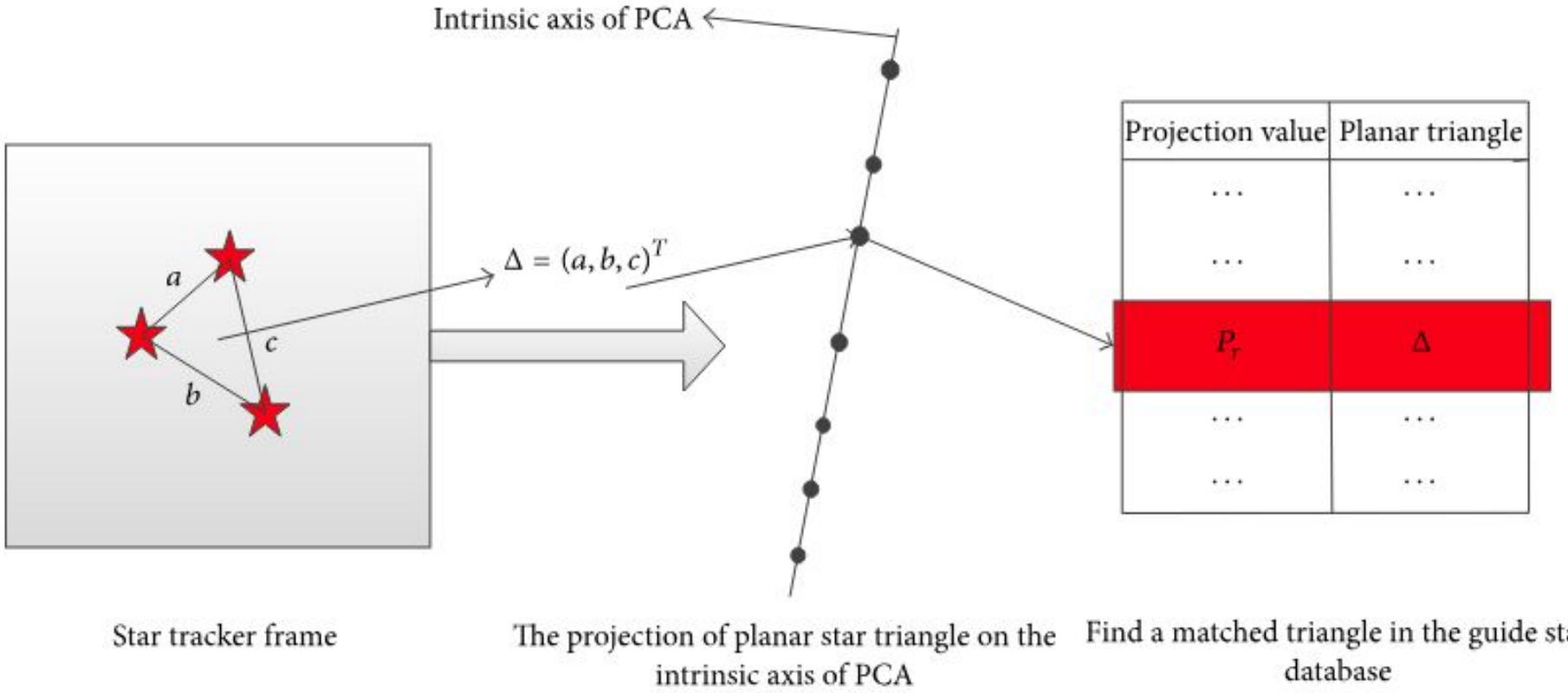
J. Yang, G.-J. Zhang, and J. Jiang, "Fast star identification algorithm using P vector," Acta Aeronautica et Astronautica Sinica, vol. 28, no. 4, pp. 897–900, 2007.

- Storing parameters for each triangle.
- Star identification very vulnerable to magnitude noise b/c of brightest stars.
- Will not work if FOV cannot form a triangle from the catalog.

Zhou and Ye's Algorithm (2015).

Fuqiang Zhou and Tao Ye, "Lost-in-Space Star Identification Using Planar Triangle Principal Component Analysis Algorithm," Mathematical Problems in Engineering, vol. 2015, Article ID 982420, 11 pages, 2015.

- A star pattern is computed using the 3 sides of the triangle projected on a projection line.
- K-Vector range speeds up catalog indexing.
- More robust than planar triangle and P-vector algorithms.
- No real sky images were tested.


Intrinsic axis of PCA
a
b
c
$\Delta = (a, b, c)^T$
Projection value
Planar triangle
P_T
Δ
Star tracker frame
The projection of planar star triangle on the intrinsic axis of PCA
Find a matched triangle in the guide star database

Brown and Stubis's Algorithm (2017).

J. Brown and Stubis, K., "TETRA: Star Identification with Hash Tables", 2017..

- Solves Lost in Space with hash table. (as suggested by Prof. Pister.)
- Combines Mortari's Pyramidal algorithm with Samaan's ND Star ID algorithm with modifications.
- Hash tables used to efficiently perform cross-referencing step and lookup.