Star Matching Algorithm Based on Relative Triplet Distances

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Objective

Given two images containing stars:

- One image with a large number of stars (hundreds).
- One image with a smaller number of stars (10–20).

The goal is to match stars between the two images by comparing relative distances between triplets of stars.

Formal Algorithm Description

Input

- S_1 – list of stars from the larger image.
- S_2 – list of stars from the smaller image.

Each star is represented by Cartesian coordinates (x, y).

Output

A set of matches between stars from S_2 to stars from S_1.

Algorithm Steps

1. **Generate triplet signatures:**
   - For each possible triplet (a, b, c) in S_2:
     - Compute the three internal distances:
     $$d_1 = d(a, b), \quad d_2 = d(a, c), \quad d_3 = d(b, c)$$
     - Sort the distances in ascending order to create a **triplet signature**.
2. **Generate triplet signatures for S_1:**
   - For each triplet (p, q, r) in S_1:
     - Compute the three internal distances.
     - Sort them in ascending order.
3. **Compare signatures:**
   - For each triplet signature from S_2:
     - Find matching triplet signatures from S_1 where distances are similar (within a defined tolerance ϵ).
     - A match is confirmed if:
     $$|d_1^{S_2} - d_1^{S_1}| < \epsilon, \quad |d_2^{S_2} - d_2^{S_1}| < \epsilon, \quad |d_3^{S_2} - d_3^{S_1}| < \epsilon$$
     - ϵ – distance threshold for matching .

4. **Establish star matches:**
    - When a matching triplet is found, deduce the mapping between corresponding stars.
    - Use the established matches to infer further matches if possible.
5. **Output:**
    - Return the list of star matches between S_2 and S_1.

Advantages

- Allows stable matching even when there are small rotations, translations, or scale changes between the images.
- Relies on internal geometric relations rather than absolute positions.

Disadvantages

- Computationally intensive if there are many stars (because the number of triplets grows quickly).
- Requires careful tuning of the tolerance parameter ϵ to avoid false matches.

Summary

This algorithm provides a simple yet effective method for matching stars between different images by analyzing relative distances between triplets of stars. It is especially robust for small rotations and scale changes between images.