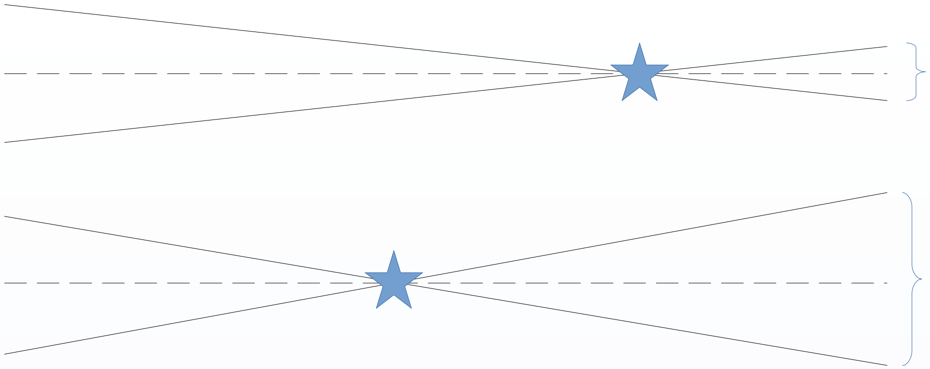
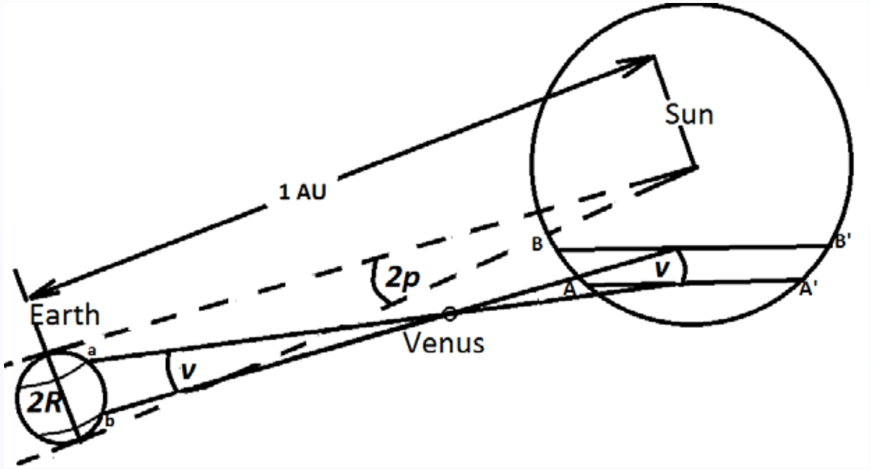
EGM702 – Photogrammetry and Advanced Image Analysis

Week 1, Part 3: Stereophotogrammetry

Recall: Parallax

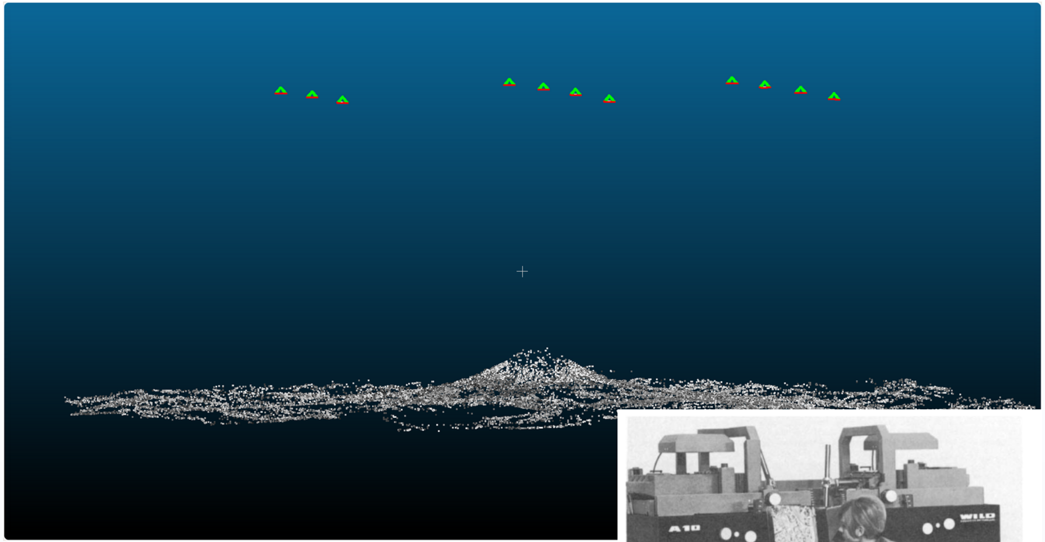
- Depends on distance between observation point and object
- Can be used to measure distances to objects
- Example: Astronomy (Transit of Venus)





Stereophotogrammetry

- With multiple cameras (or single camera taking multiple photos), can calculate 3D positions
- Historically: using stereoplotter or similar equipment
- Modern: using computer, specialised software
- Can use 2 images, normally we want at least 3



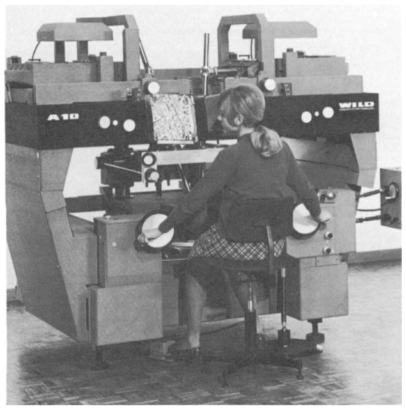
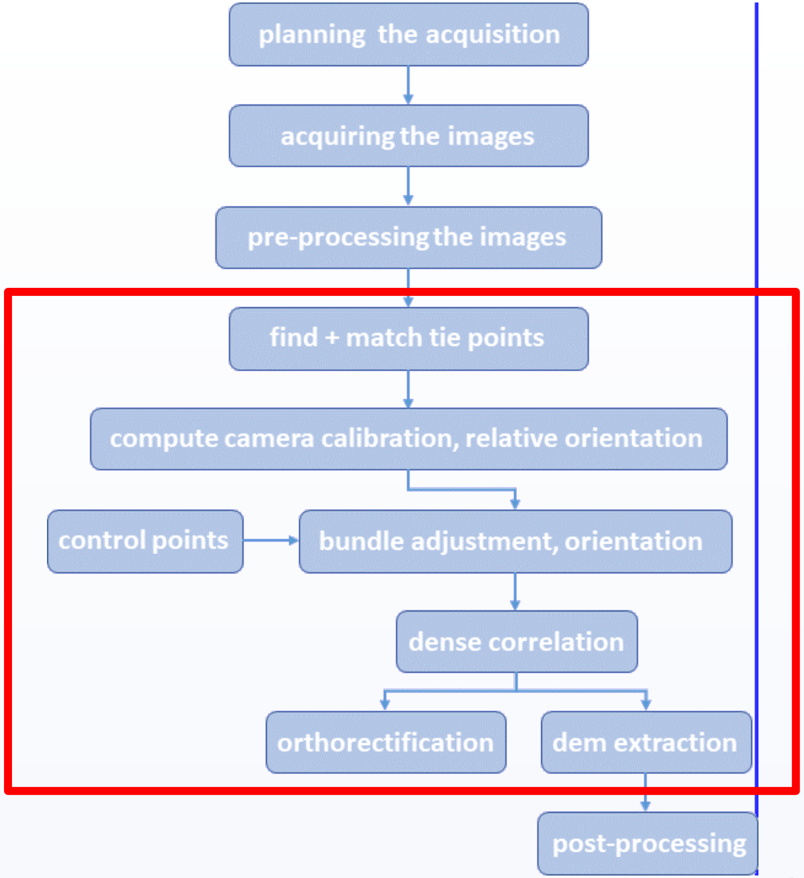


Figure 7.15 Wild A-10 stereoplotter. (*Courtesy:* Wild Heerbrug)

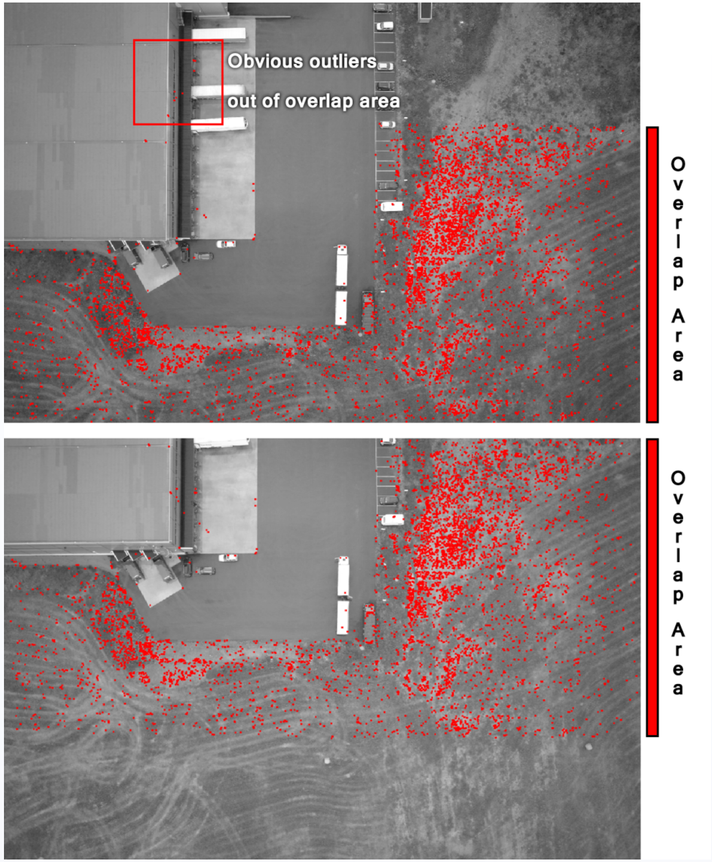
Basic photogrammetry workflow

- Planning/acquisition: Week 1, Part 5
- Control points: Week 1, Part 4
- Practical 1
- Image pre-processing: Week 3



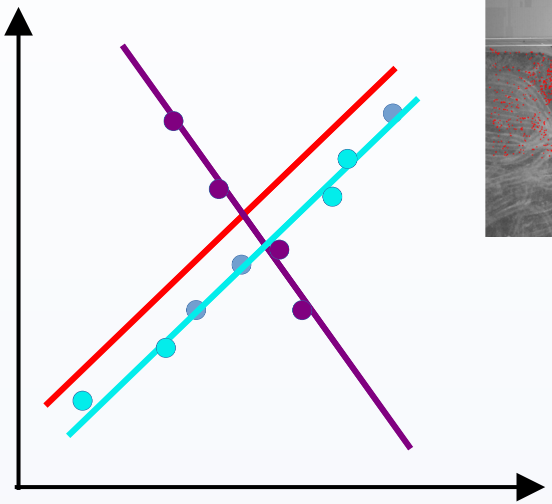
Finding Tie points

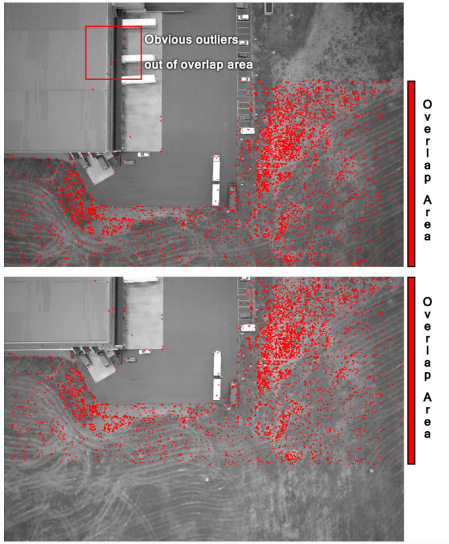
- Points visible in both (at least 2) images
- Can find manually (painful)
  - Historically done with ~6 points
- Automated image-matching algorithms:
  - SIFT (Scale-Invariant Feature Transform)
  - SURF (Speeded Up Robust Features)
  - ORB (Oriented FAST and Rotated BRIEF)
- Help to find relative exterior orientation



Finding Tie points

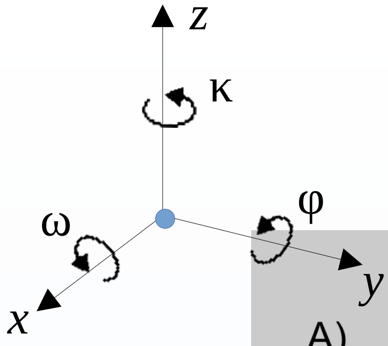
- Potential matches ("features") described as a vector
- "Closest" potential match is returned
- Need some way of identifying, removing outliers
- Example: Random Sample Consensus (RANSAC)

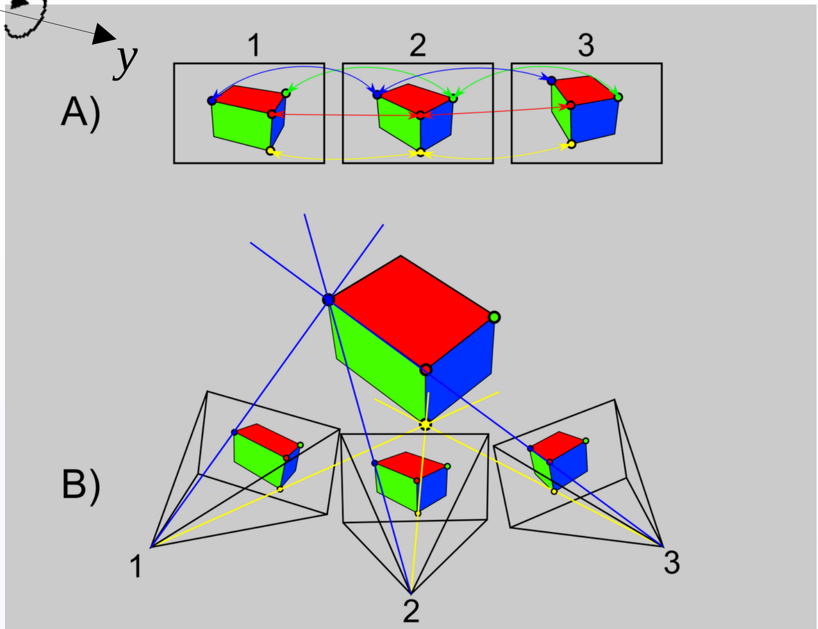




External orientation

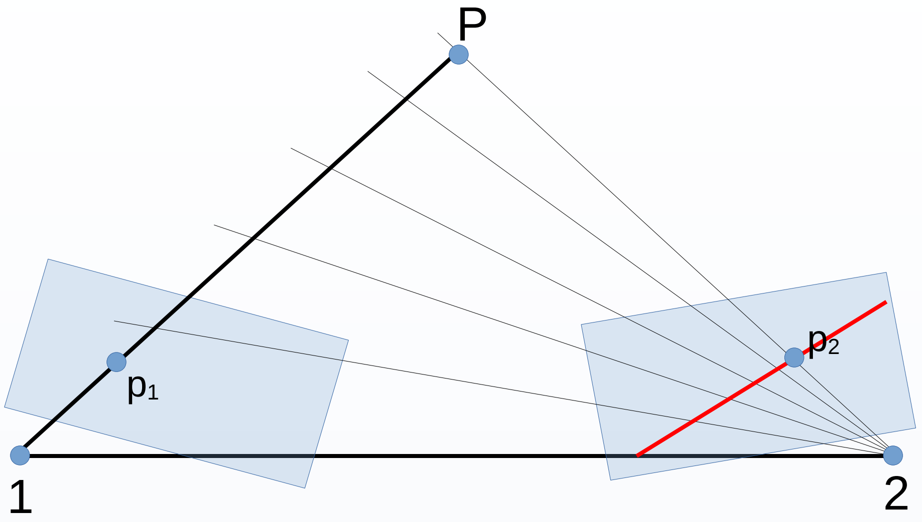
- For each camera:
  - 3 rotation parameters (ω, φ, κ)
  - Center of projection (x, y, z)
- Relative orientation
  - Scaled to camera geometry using tie points only
- Absolute orientation
  - Using real-world control points
  - At least 3 non-colinear points visible in at least 2 images





Epipolar lines

- For each pixel in image 1, we want to find corresponding pixel in image 2 (dense matching)
- Problems:
  - Computationally expensive
  - Pixel might not be visible
  - At pixel scale, features might be hard to distinguish
- One solution: limit search to epipolar lines
- Calculate correlation score for pixels along epipolar line, take the best* match
  - Usually use a certain template size (e.g., 5×5 pixel)



Summary

- With multiple cameras (or multiple images), we can reconstruct 3D positions
- Start by finding matching points between images
- Calculate positions, orientations of cameras
- Use dense matching to find 3D locations of each pixel

Additional resources

- Rupnik et al., 2017 [10.1186/s40965-017-0027-2]
- Toutin, 2002 [10.1109/TGRS.2002.802878]
- Stereo 3D vision [computerphile]