Overlap and geometric calibration

good overlap not achieved without optical distortion compensation

↳ describing here the calibration work!

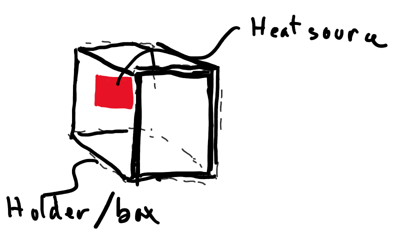
Camera calibration.

We want to calibrate:

- intrinsics
  - FoV
  - distortion model
  - Image center.
- extrinsics
  - sensor relative orientation.
  - parasitic rotations BTW servos

Most of calibration methods not possible due to low res BUT we have a rotation stage!

⇒ do a thermal point source and scan it!



Sensor is 32 px for 55°

→ 1.7°/px

→ $\frac{1.7}{180} \times 3.14$ rad/px $\sim \frac{1.8}{180} \times 3.$

$\sim$ 0,03 rad/px

⇒ a punctual source is << 3 cm @ 1 meter distance

⇒ we do a 1 cm hole @ 3 meters → $\sim \frac{1}{10}$ px

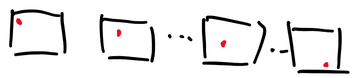
⇒ scanning a span of ~ 70° H / 50° V

every 1° → 3500 imgs

2° → 875 imgs

4° → ~220 imgs

5° → 140 images

We will obtain 

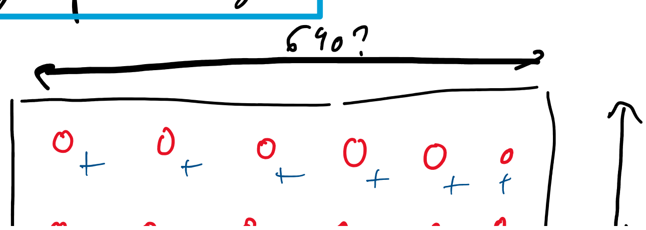
Extracting spot coords

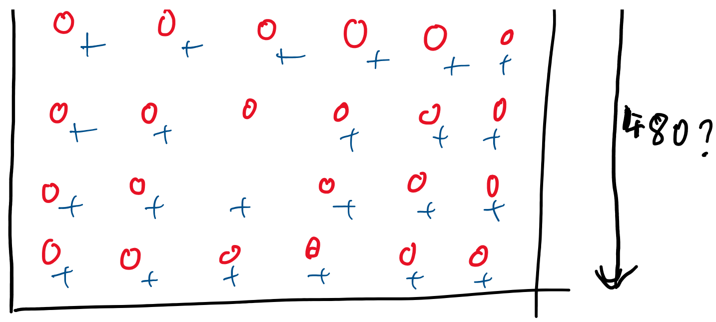
1. find the pixel with max T°
2. Set to 0 every pixel > 5 px away
3. compute $X_0 = \frac{\sum_y \sum_x x \cdot T'(x,y)}{\sum_y \sum_x T'(x,y)}$

$T'(x,y)$: temperature @ xy after step 2

0. Check if there is a datapoint, or add image to exclude list.

Display for debug





O: Max T° of all images.

+: Expected Max position given camera params

⇒ will allow iterating for intial guess
+equation test.

Now for the fun part
The theory / Model !

From source to pixel

- rotation in space
  - ↳ we define the center of the world @ the camera ⇒ Relative position ≈ 3 angles + 1 distance.
  - The distance does not matter as the source is a point
- Rotation about Z (KNOWN)
- Unknown small rotation
- Rotation about X: (KNOWN)
- Unknown other rotation
  mostly "y_i" (sensor axes)

- Point perspective
- Sensor distortion radial and "elliptical"

⇒ free parameters

3 rotations
1 known rotation
3 rotations (small)
1 known rotation
3 rotations (2 small)
~~2 sensor center~~ → No impact
(2) sensor FOV (~~maybe 1?~~ → non square pixels)
XX 1 sensor/lens distortion ↳ only r^2 term really improves

⚠ :-(probably linked!

⇒ 13 + XX parameters
↳ 10 + XX useful.

Running it!

- Centering camera by hand
- Computing angles with 33% Random rejection

⇒ test 1 ⟷ 43° ↕ 28° ΔA = 3° Reject 25%.
↳ 107 images ⇒ ≈ 5-10 minutes

⇒ test 2 ΔA = 1.5° reject 66 %.
↳ 340 images ⇒ 1380 s ≈ 25 minutes

Fitting it !

⇒ We go from a 0.8px distance (after rotation of ~7°)
to a 0.2px distance by adding

KEY FACTORS | Non square pixels
FOV correction
Spherical distortion

Mechanical target was 5 units $= \frac{5}{4096} \times 360° = 0{,}43° = 0{,}26\,px$

⇒ This is probably part of the limiting factor

(sensor will start acquisition when position better than 5 units
but servo will continue moving towards target so effective
is better than that)