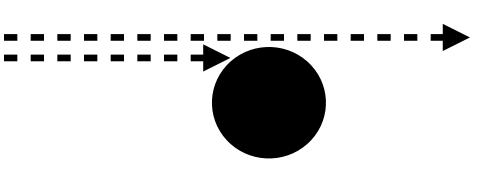
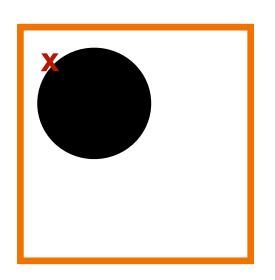
# Notes on updates to centroid code

# **Spot Detection**

# **Previous method**



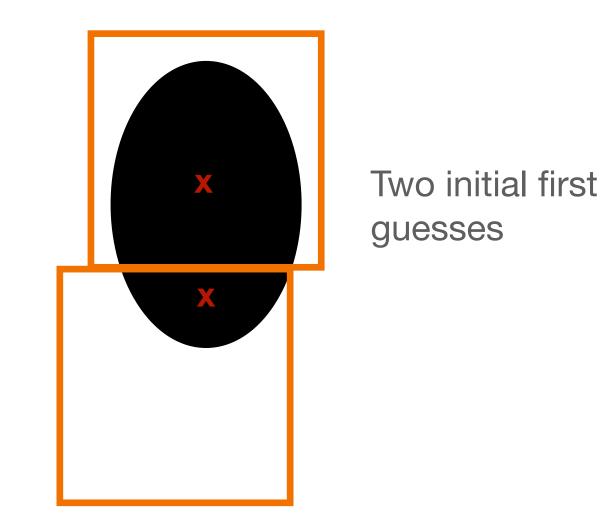
Search image to find a point above the threshold.



- Search in a box, marking all points above the threshold as part of the spot.
- Does not check for contiguity.
- Calculate a running first and second moment
- Moments are input to the windowed centroid routine

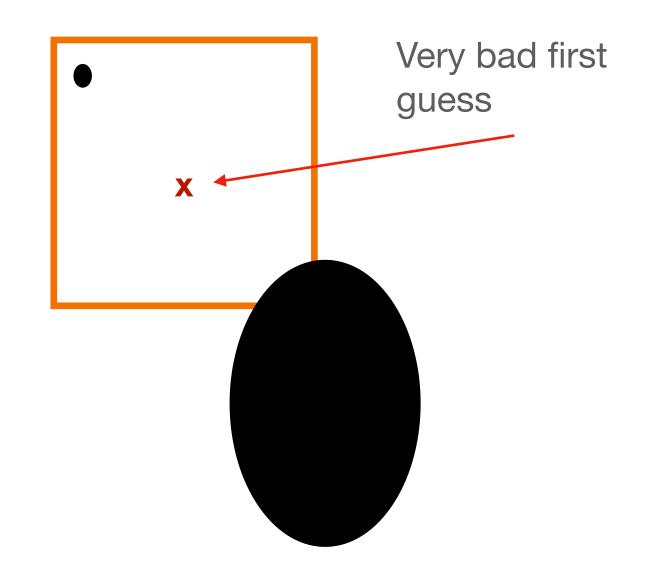
## **Problem:**

- If the spot is larger than the box, two initial spots will be detected.
- Centroids may converge to almost the same position, but they may be several pixels different, depending on the shape of the PSF



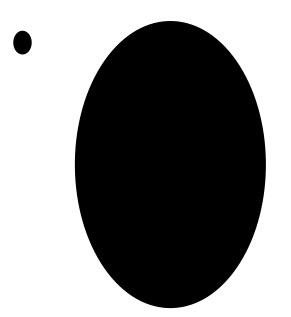
# Make the Box larger?

- A very large box can run into problems with hot pixels which give wrong centroids, based on a very bad choice of initial position.
- This is particularly a problem when setting the threshold fairly low, when you may pick up noise.
- If the box is too large, you may pick up more than one spot, for collided cobras.



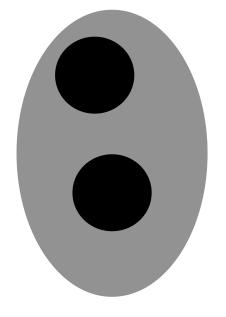
# **Solution:**

- Use routine that finds contiguous spots above the threshold
- Not limited by spot size
- Standard "flood-fill" algorithm



# **Potential failure**

 Too high threshold and double peaked PSFs can find two spots



- Too low a threshold / high background will detect a giant spot (eg, dome lights are on)

- Detection now depends on threshold only (no box size)
- Filter by minimum number of pixels to filter out noise / hot pixels before sending to windowed threshold
- Will not return duplicate spots

# Centroiding and Filtering

## **Windowed Centroid**

- pass kernel size as an external input, based on typical spot size/shape.
- can't calculate on the fly for parallel mode (as sub-sections of the image have slightly different characteristics)
- no actor level change needed for this implementation
- two input parameters: size of box over which centroid calculated, kernel sizes
- box size set to the point where increasing it does not increase accuracy
- kernel size based on typical spot size/shape

# Will be filtered out before being passed back

# **Filtering Duplicated Spots**

- updates to the detection method means that duplicate spots are no longer returned for a single image
- for parallel mode, duplicate spots in the overlap region are now identical

# **Tests**

- checked for memory leaks
- tested on real system with file input and test database
- actor runs smoothly
- no duplicate points returned
- tested on sets of consecutive images taken with a variety of parameters (Plots on following pages)
  - different exposure times
  - focus sweep data (different PSF sizes)
- note that reprocessing images has to be done with versions of pfs\_instdata and pfs\_utils which match the system when the data were taken; changes in boresight, transformation function and geometry can seriously affect results

# Processing time: ~ 0.3 seconds per frame

# Plots on next pages

- all spots detected with all PSF sizes
- Each plot shows histogram of dx, dy between frames, and a quiver plot of the same
- sequence of plots with different exposure times (0.8, 4.8, 8) dominated by seeing effects
- sequence of plots with different MCS foci, using input kernel size for the centroiding, all
- 4.8s exposures; kernel size doesn't have a strong effect on the results (frame-to-frame variations are larger).

Difference between consecutive images by exposure time - length = 0.005 mm 10768601 (0.8) [12.4] 10768803 (8.0) [3.5] 10768701 (4.8) [2.5] frameld = 10768601 (0.8s)frameld = 10768701 (4.8s)500 200 120 200 dY d dY 300 400 100 300 200 200 100 100 20 0.00 -0.02-0.010.01 0.02 -200-0.020.01 0.02 -0.010.00 0.01 0.02 -0.010.00 -200 -0.02dX or dY dX or dY dX or dY - length = 0.005 mm length = 0.005 mm - length = 0.005 mm frameId = 10768802 (8s) 10768802 (8.0) [3.3] 10768602 (0.8) [15.0] frameId = 10768702 (4.8s)10768702 (4.8) [6.9] frameId = 10768602 (0.8s)200 \_\_\_\_ dY 175 120 150 300 100 125 z <sub>100</sub> 75 50 100 25 -200 -0.02-0.010.00 0.01 0.02 -0.02-0.010.00 0.01 0.02 -200 -0.02-0.010.00 0.01 0.02 dX or dY dX or dY dX or dY - length = 0.005 mm length = 0.005 mm - length = 0.005 mm 10768700 (4.8) [8.3] 10768801 (8.0) [2.9] frameId = 10768600 (0.8s)frameId = 10768700 (4.8s)frameId = 10768801 (8s) 10768600 (0.8) [8.8] 175 200 200 200 dY dY 140 150 120 125 300 100 100 -0.02 -0.01 0.00 0.01 0.02 dX or dY Right: dX and dY. Left: title numbers are focus / exposure time / median of the differences across the field

Difference between consecutive images by focus - length = 0.005 mm frameld = 10759300 (-4.8 (4.8s))10759000 (-10.8) (4.8s) [4.7] 10759300 (-4.8) (4.8s) [7.3] frameld = 10759000 (-10.8 (4.8s))frameld = 10759601 (+1.2 (4.8s))10759601 (+1.2) (4.8s) [4.5] 300 200 dY dY dY 250 175 250 -150 200 200 -125 z 150 Z 150 100 100 50 25 -200 -200 -200 -0.010.00 0.01 0.02 -200-0.02-0.010.00 0.01 0.02 -200-0.02-0.010.00 0.01 0.02 -200-0.02dX or dY dX or dY dX or dY - length = 0.005 mm - length = 0.005 mm - length = 0.005 mm 10759100 (-8.8) (4.8s) [8.1] frameld = 10759100 (-8.8 (4.8s))frameld = 10759700 (+3.2 (4.8s))10759700 (+3.2) (4.8s) [4.7] frameld = 10759400 (-2.8 (4.8s))10759400 (-2.8) (4.8s) [6.0] dX 300 250 dY dY dY 250 200 200 200 -150 150 100 100 100 50 50 -200 -200 -0.02-0.010.00 0.01 0.02 -200 -0.02-0.010.00 0.01 0.02 -200 -100-0.010.00 0.01 0.02 -200 dX or dY dX or dY dX or dY - length = 0.005 mm - length = 0.005 mm - length = 0.005 mm frameld = 10759800 (+5.2 (4.8s))frameld = 10759201 (-6.8 (4.8s))10759201 (-6.8) (4.8s) [4.5] 10759800 (+5.2) (4.8s) [5.1] frameld = 10759500 (-0.8 (4.8s))10759500 (-0.8) (4.8s) [4.4] 300 250 dY 200 dY dY 300 250 250 200 200 -100 -200 -200 -0.02 -0.01 0.00

Right: dX and dY. Left: title numbers are focus / exposure time / median of the differences across the field