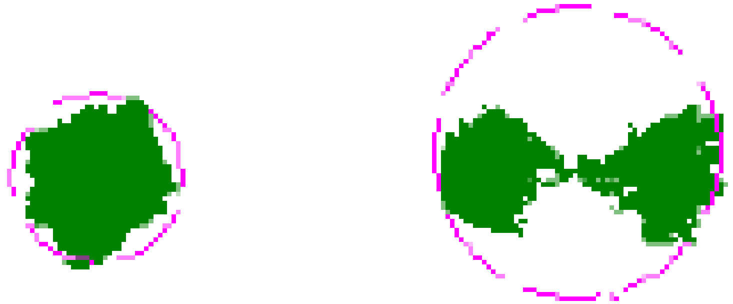
# Large Contour: Identification

**Nodularity** can be used to describe the ratio of the area of each object to its circumscribed circle:



**Isolated Tree** **Tree Clump**

$$Nodularity, N = \frac{Contour\ Area}{Minimum\ Enclosing\ Circle}$$

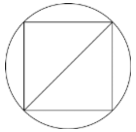
- N is the Nodularity of each tree object in the image and T is the threshold of the Nodularity.

  Condition: If N > T
  
  a. The object is an isolated tree
  b. Else the object is a tree clump

- All isolated trees can be detected and the crown boundary of each isolated tree can be delineated.

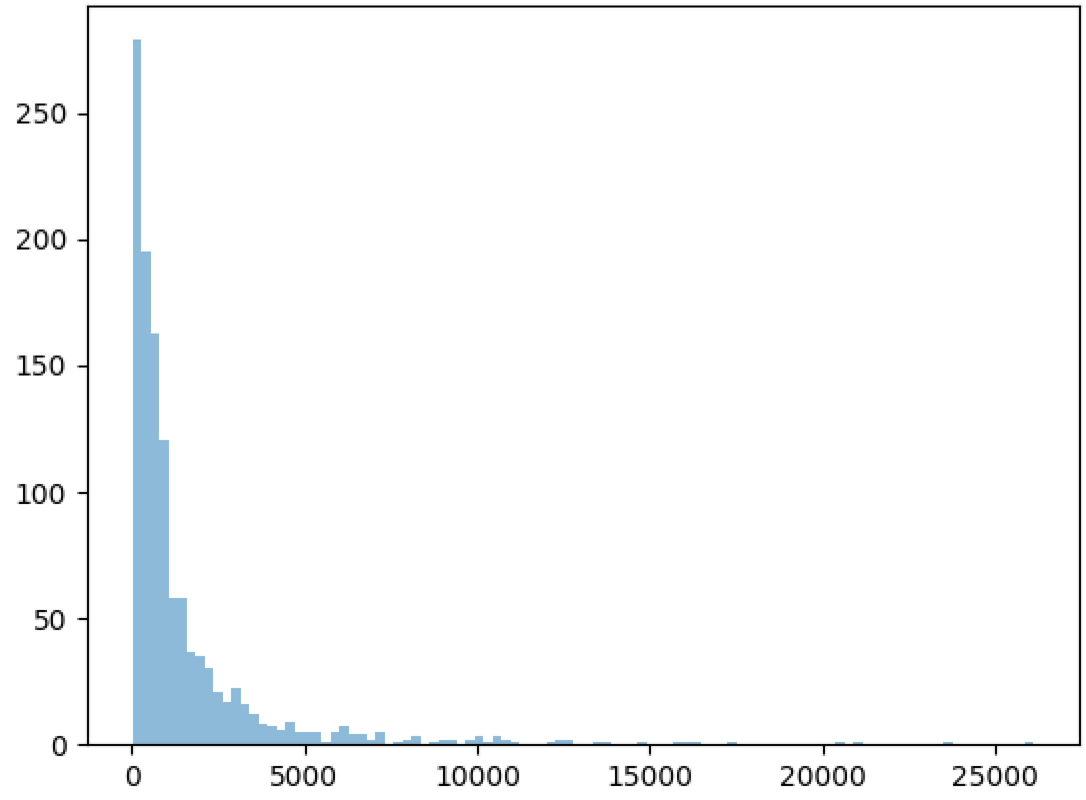
- The average length of circumscribed circles of all the isolated trees can be used to characterize the crown boundary of the isolated tree and construct the size of structure element (SE).

- SE is adopted to detect the isolated trees from the tree clump

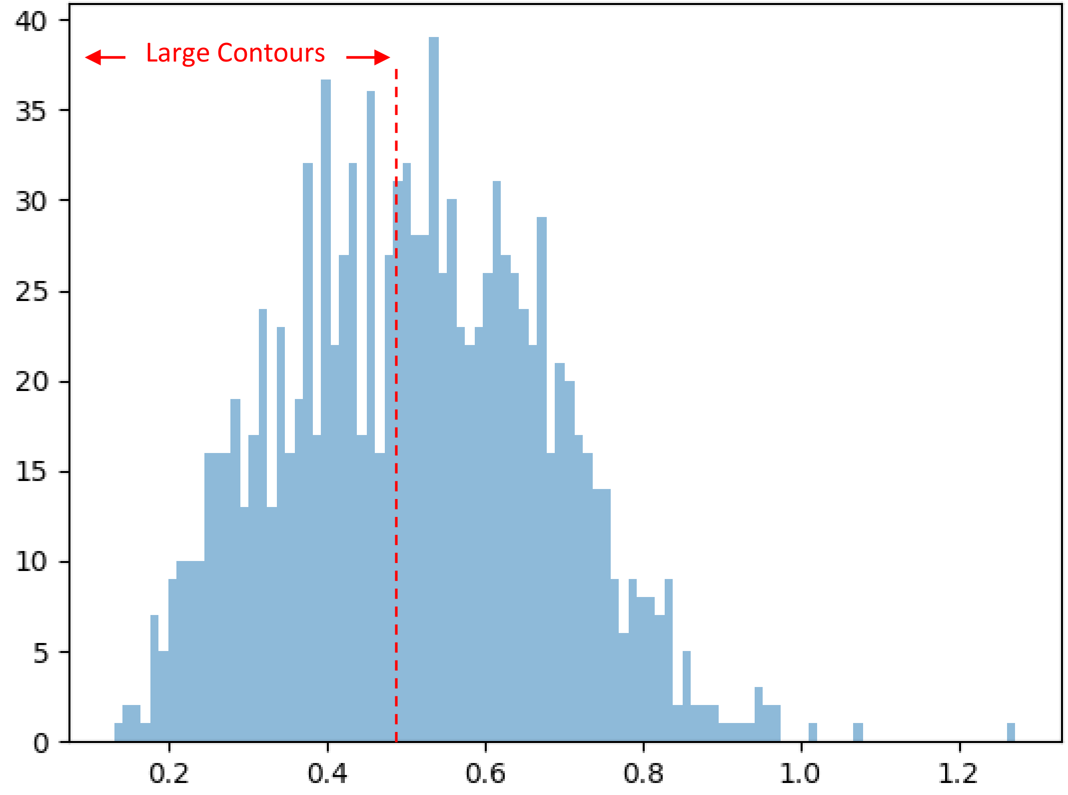
- Used square approximation to circle for the SE 

# Large Contour: Identification

**Contour Area**

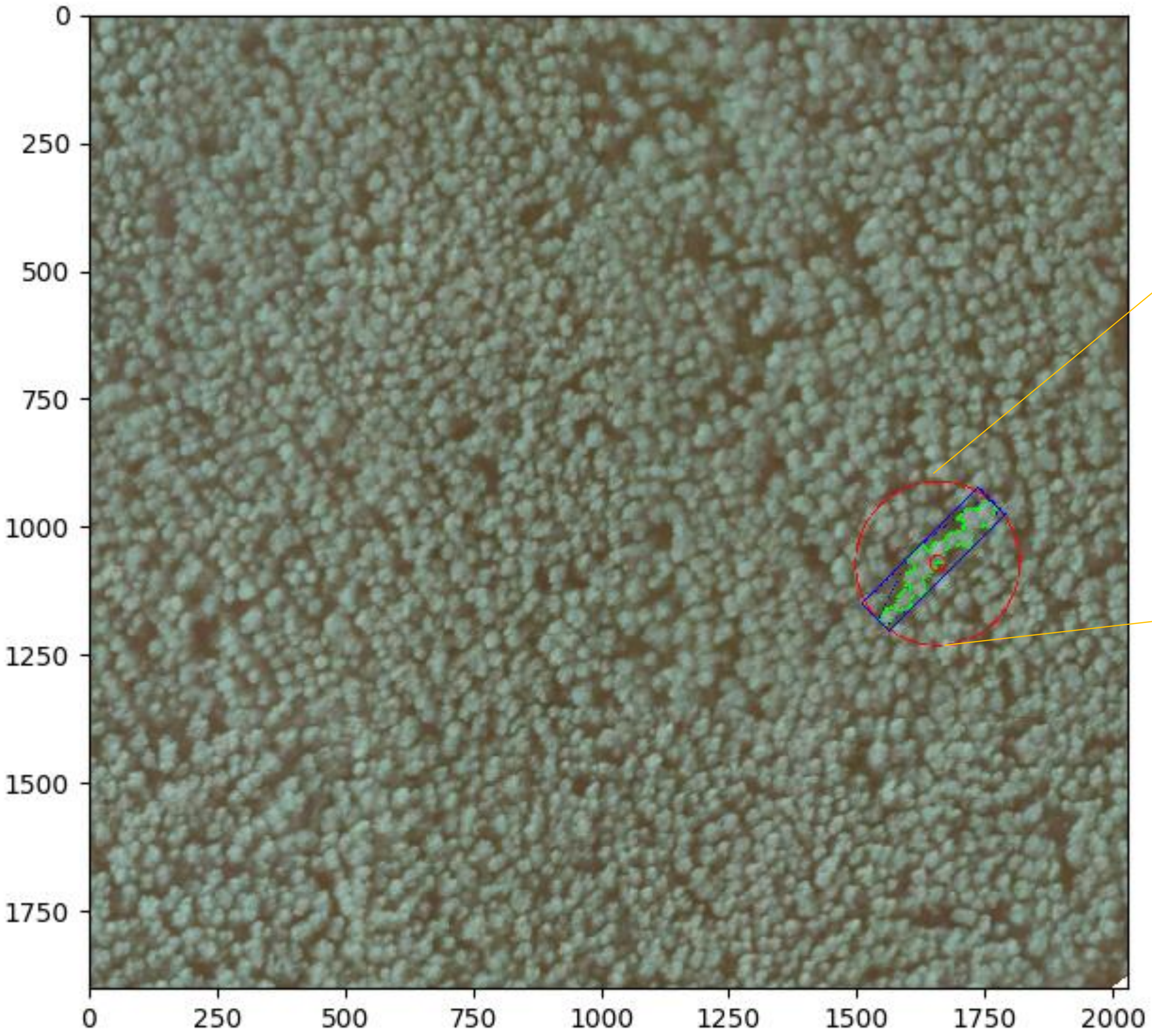


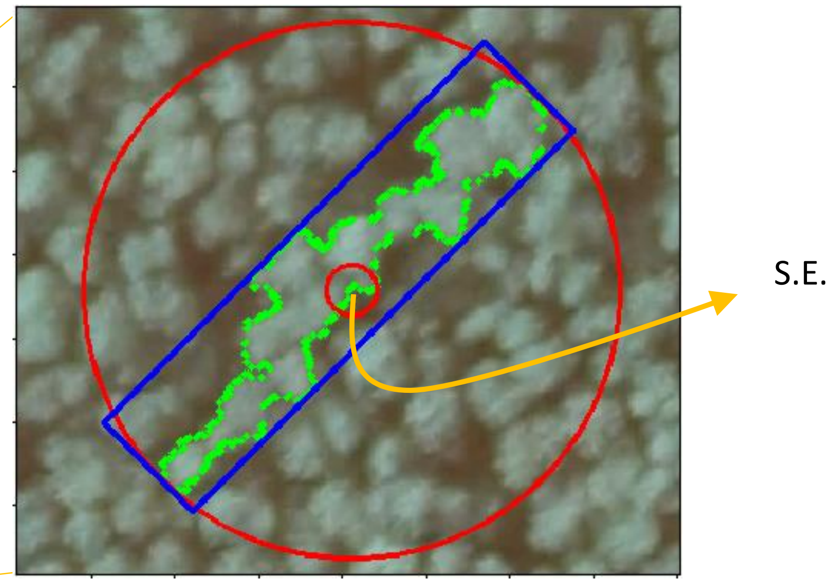

**Contour Nodularity**




$$Nodularity, N = \frac{Contour\ Area}{Minimum\ Enclosing\ Circle}$$

# Example: Large Contour - Identification

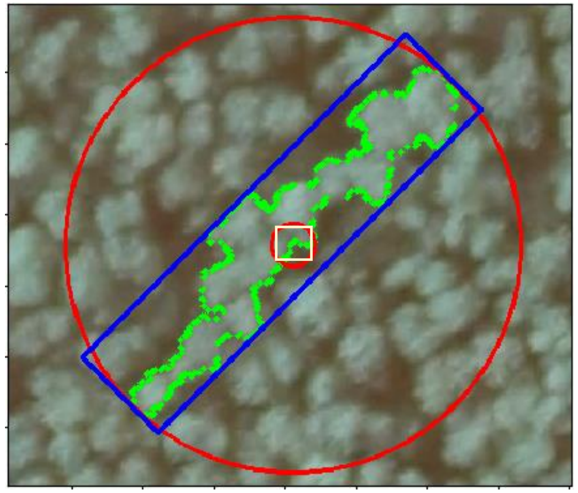



| | |
|---|---|
| • Green line: | Large contour |
| • Big Red Circle: | Contour min enclosing circle |
| • Blue Box: | Contour min bounding box |
| • Small Red circle: | Structure Element, S.E. |

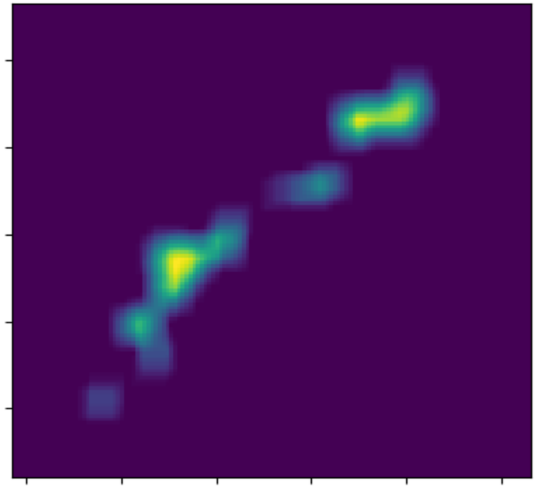
# Example: Large Contour - Processing

Fig 1: Image with S.E.



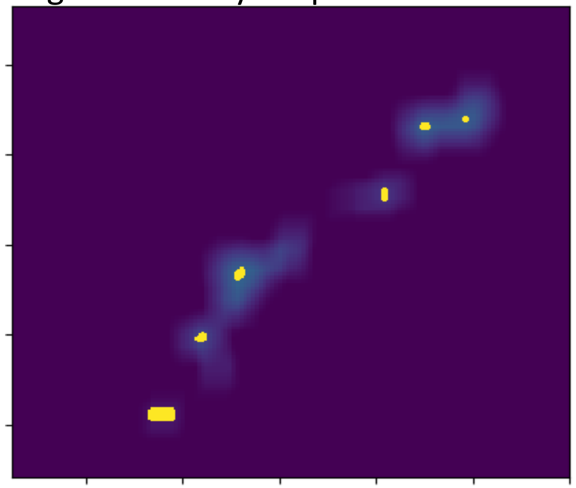
- Image with square approx. S.E.

Fig 2: Similarity Map



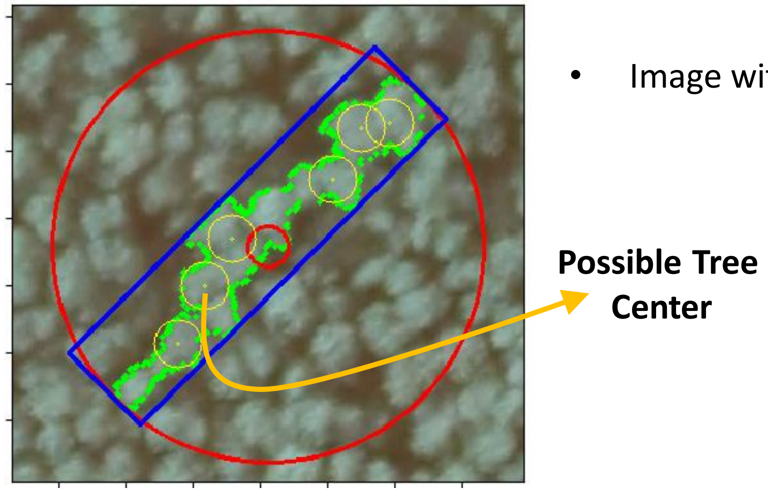
- Create empty mask
- Sliding window through contour
- All pixels increase by 1 in contour

Fig 3: Similarity Map Peak Centers



- Find peaks from similarity map
- Min peak dist is 10 pixels i.e. iri/bri
- Find contours of the points
- Find center of the contour

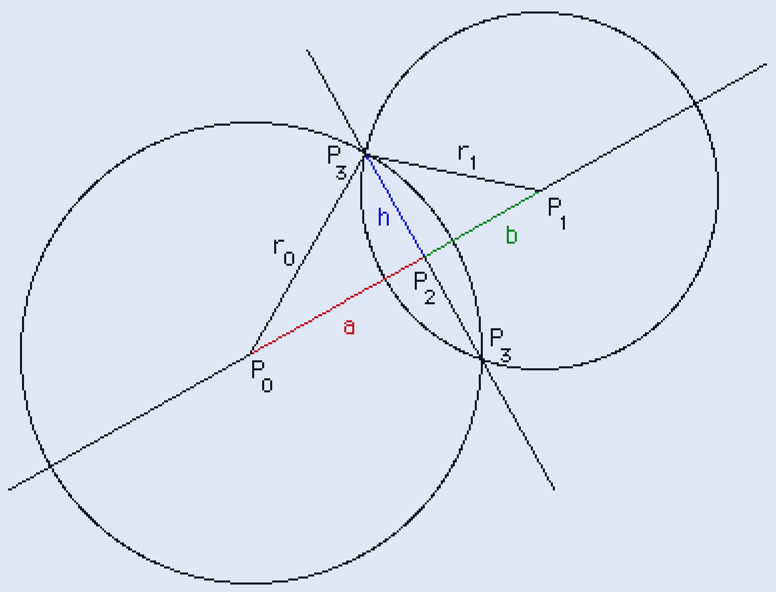
Fig 4: Peak Centers on image




- Image with tree centers and S.E.

# Example: Large Contour - Delineation

***Finding the Perpendicular Bisector***




**<u>Overlapping circles</u>** identified as:

- Euclidean dist. between centers < SE diameter

Fig 1: Image with bisector

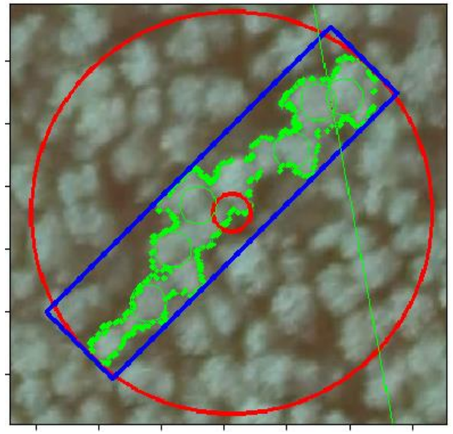


Fig 2: Cntr and bisector mask

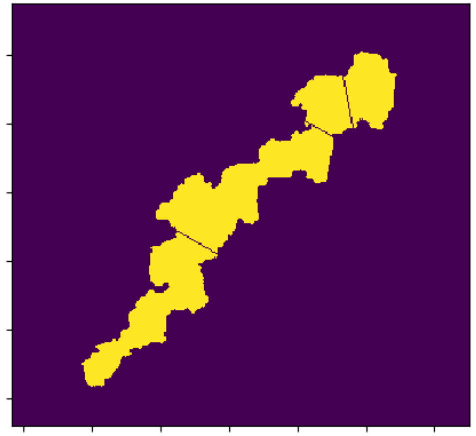
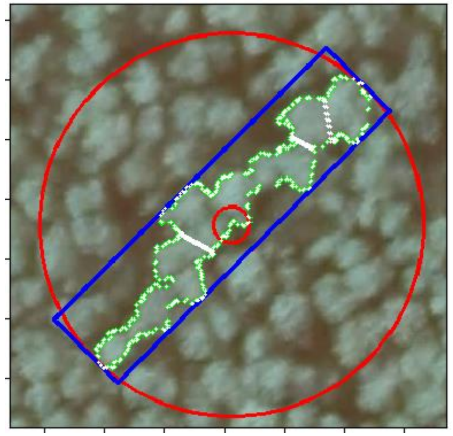


Fig 3: Cntr delineation



- Only overlapping (d <= SE diameter) and near overlapping (d > SE diameter & d < 1.75*SE diameter) points are handled
- Far overlapping points to be handled based on prevalence

# Example: Large Contour – Issue #1

Consider a circle with radius $d$ and center $(x_1, y_1)$. This is the equation:

$$(x - x_1)^2 + (y - y_1)^2 = d^2$$

Let $m$ be the slope of the line from $(x_1, y_1)$ to $(x_2, y_2)$. ($m = \frac{y_2 - y_1}{x_2 - x_1}$). Our line must satisfy the equation:

$$y - y_1 = m(x - x_1)$$

$$y = m(x - x_1) + y_1$$

We want to find when these two will intersect, so substituting:

$$(x - x_1)^2 + (m(x - x_1) + y_1 - y_1)^2 = d^2$$

$$(x - x_1)^2 + m^2(x - x_1)^2 = d^2$$

$$(1 + m^2)(x - x_1)^2 = d^2$$

$$(x - x_1)^2 = \frac{d^2}{1 + m^2}$$

$$x - x_1 = \pm\sqrt{\frac{d^2}{1 + m^2}}$$

$$x = x_1 \pm \sqrt{\frac{d^2}{1 + m^2}}$$

Fig 1: Image with S.E.

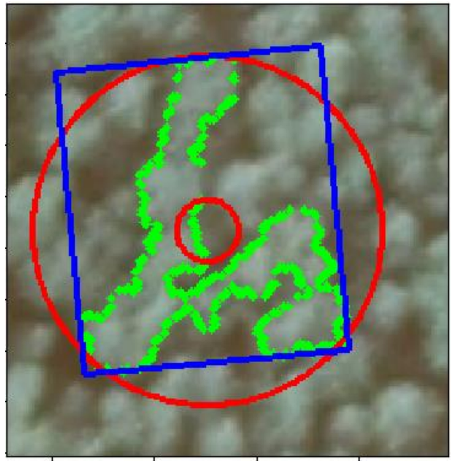
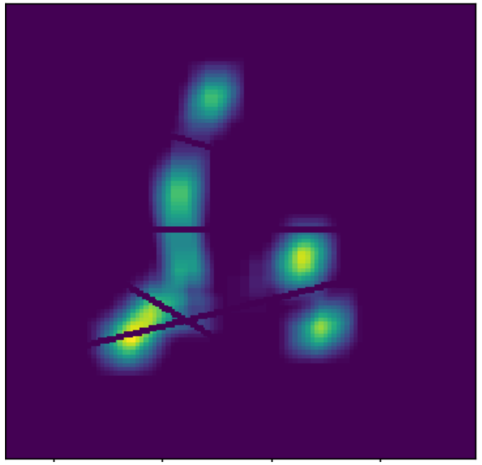


Fig 2: Similarity map with bisectors



- **Problem:** Perpendicular bisectors cuts across other contours – line is extended on whole image
- Better solution to draw a line the length of the SE diameter
- Use equation of line length where $d^2 = (x_2 - x_1)^2 + (y_2 - y_1)^2$

$$and,\ m = \frac{(y_2 - y_1)}{(x_2 - x_1)} \rightarrow m(x_2 - x_1) = (y_2 - y_1)$$

# Example: Large Contour – Issue #1 Resolved

Consider a circle with radius $d$ and center $(x_1, y_1)$. This is the equation:

$$(x - x_1)^2 + (y - y_1)^2 = d^2$$

Let $m$ be the slope of the line from $(x_1, y_1)$ to $(x_2, y_2)$. ($m = \dfrac{y_2 - y_1}{x_2 - x_1}$). Our line must satisfy the equation:

$$y - y_1 = m(x - x_1)$$

$$y = m(x - x_1) + y_1$$

We want to find when these two will intersect, so substituting:

$$(x - x_1)^2 + (m(x - x_1) + y_1 - y_1)^2 = d^2$$

$$(x - x_1)^2 + m^2(x - x_1)^2 = d^2$$

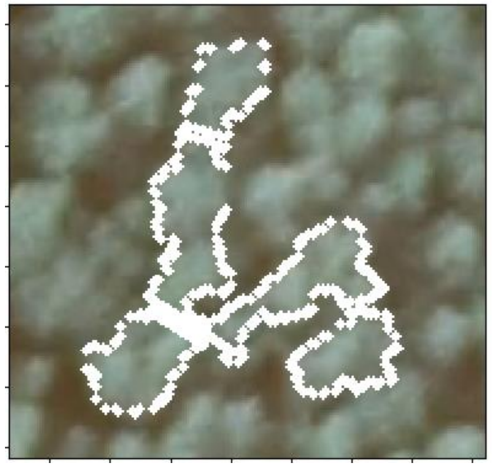
$$(1 + m^2)(x - x_1)^2 = d^2$$

$$(x - x_1)^2 = \frac{d^2}{1 + m^2}$$

$$x - x_1 = \pm\sqrt{\frac{d^2}{1 + m^2}}$$

$$x = x_1 \pm \sqrt{\frac{d^2}{1 + m^2}}$$

Fig 1: Correct Cntr Delineation



- Perpendicular bisectors cuts contour without going across it

# Example: Large Contour – Issue #2

- **Problem**: Distance between SE with thresholds used to determine delineation
    - Overlapping (d <= SE diameter)
    - Near overlapping (d > SE diameter & d < 1.75*SE diameter)
- Leads to more than two neighbors for each point
- Revise strategy where each SE has 2 neighbors except for end points

Fig 1: Cntr

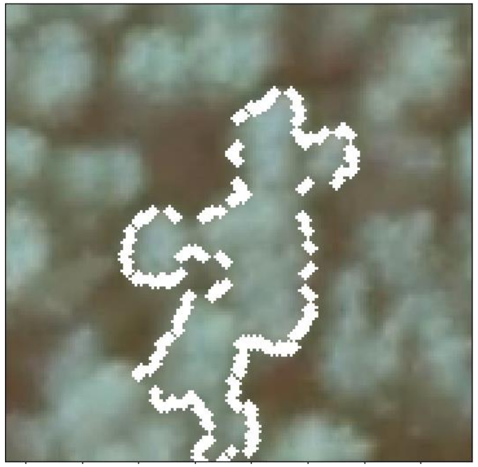


Fig 2: Cntr with SE

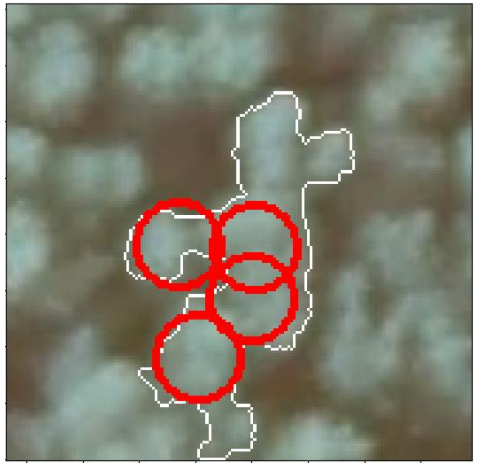


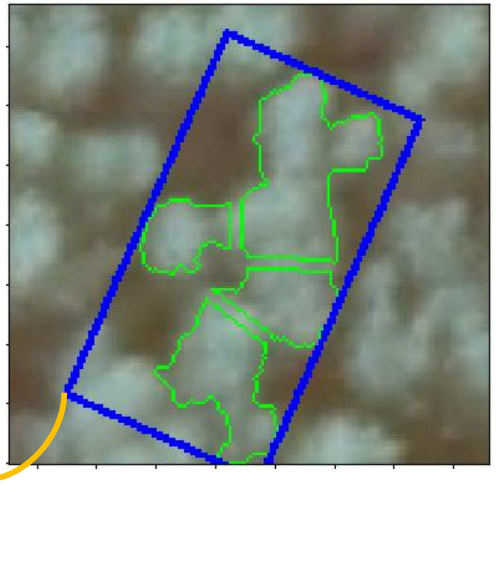
Fig 3: Incorrect Cntr Delineation

# Example: Large Contour – Issue #2 Resolved

- Found order of each SE:
  - Pt 1: Reference point is closest to leftmost point in box
  - Pt 2: The minimum distance to Pt 1 excluding Pt 1
  - Pt 3: The minimum distance to Pt 2 excluding Pt 1 and Pt 2
  - …

Fig 1: Cntr with SE


Fig 2: Correct Cntr Delineation



**Reference Point**

# Example: Large Contour – Results

Fig 1: Sample Area #1


- Contour delineation works well on average but some issues persist
- Issue #1 line cuts into contours in the following: 5 6
- Issue #2 circle order 1
  - Some circles may have > 2 legitimate neighbors (spot marked X)
- Expect that most of the contours will be like in 3