

## Hull Detection

**Definition.** Given a set of points  $X$ , the subset  $S \subset X$  such that the polygon defined by the points in  $S$  contains all points in  $X$ , is called the hull of  $X$ .

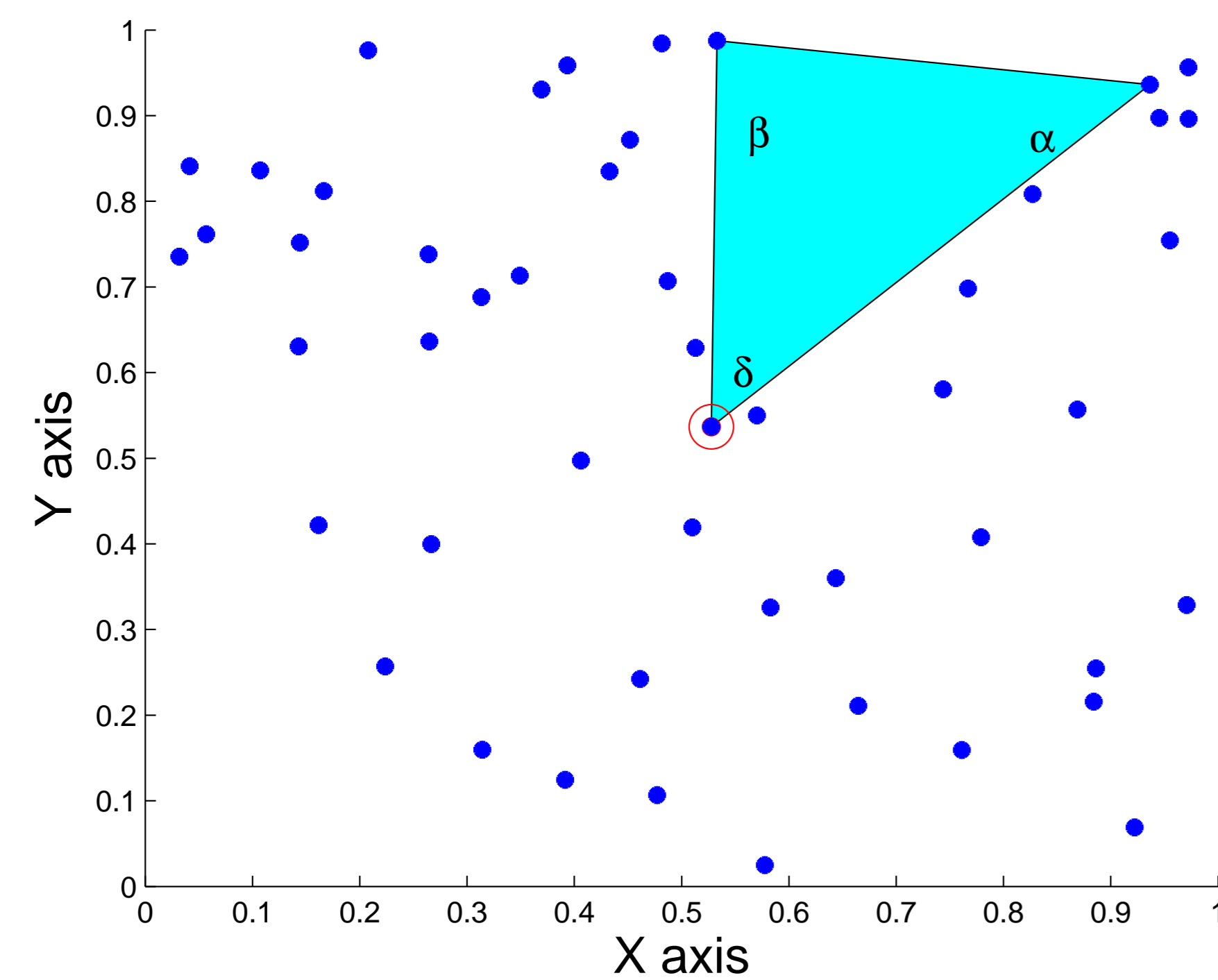
Hull for a set of points can be defined based on

- Convexity
- Minimum footprint/ area
- Shape templates

We define based on Largest Empty Sector Angle (LESA) criterion.

## Largest Empty Sector Angle

The largest angular sector ( $\delta$ ) around a point  $x$  that is empty.



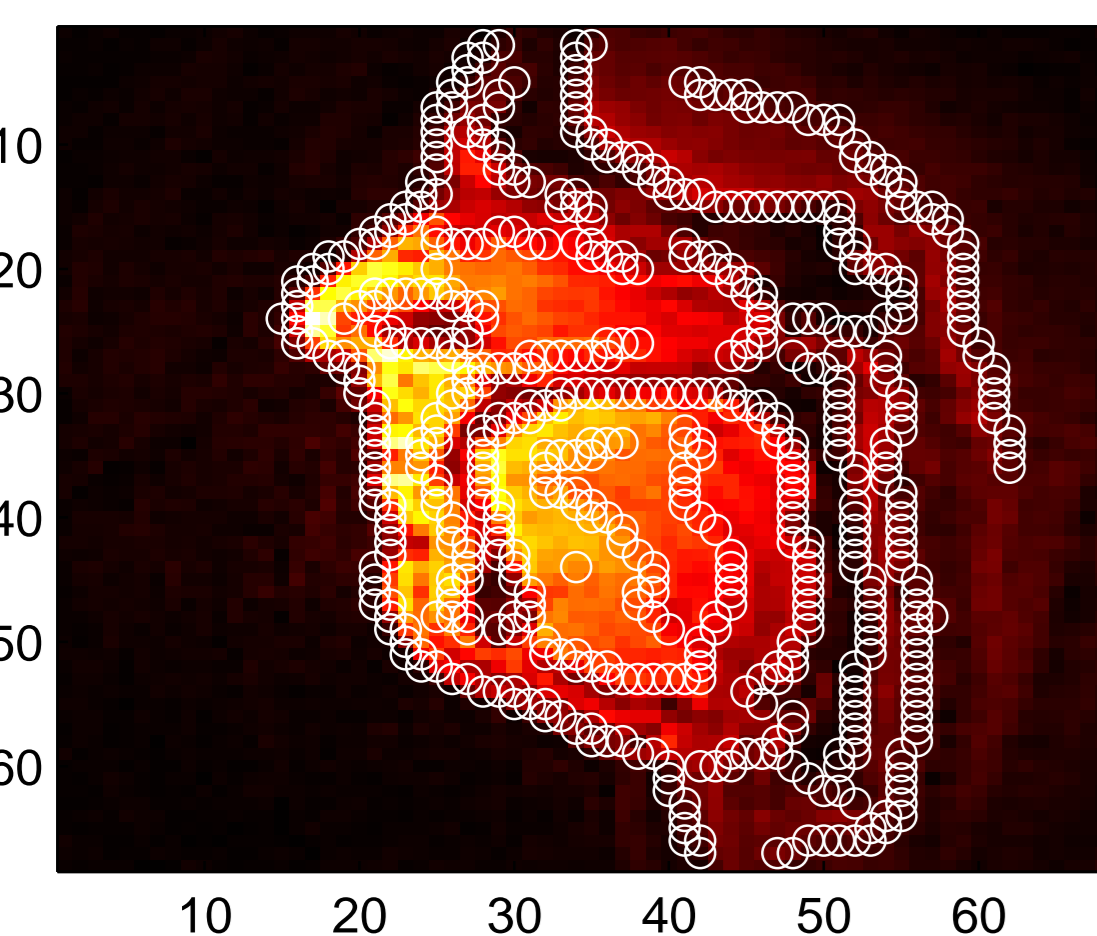
Suppose  $\theta_i, i = 1 \dots n - 1$  are the angles subtended by each point.

$$\max_{\alpha, \beta} \delta = |\alpha - \beta|$$

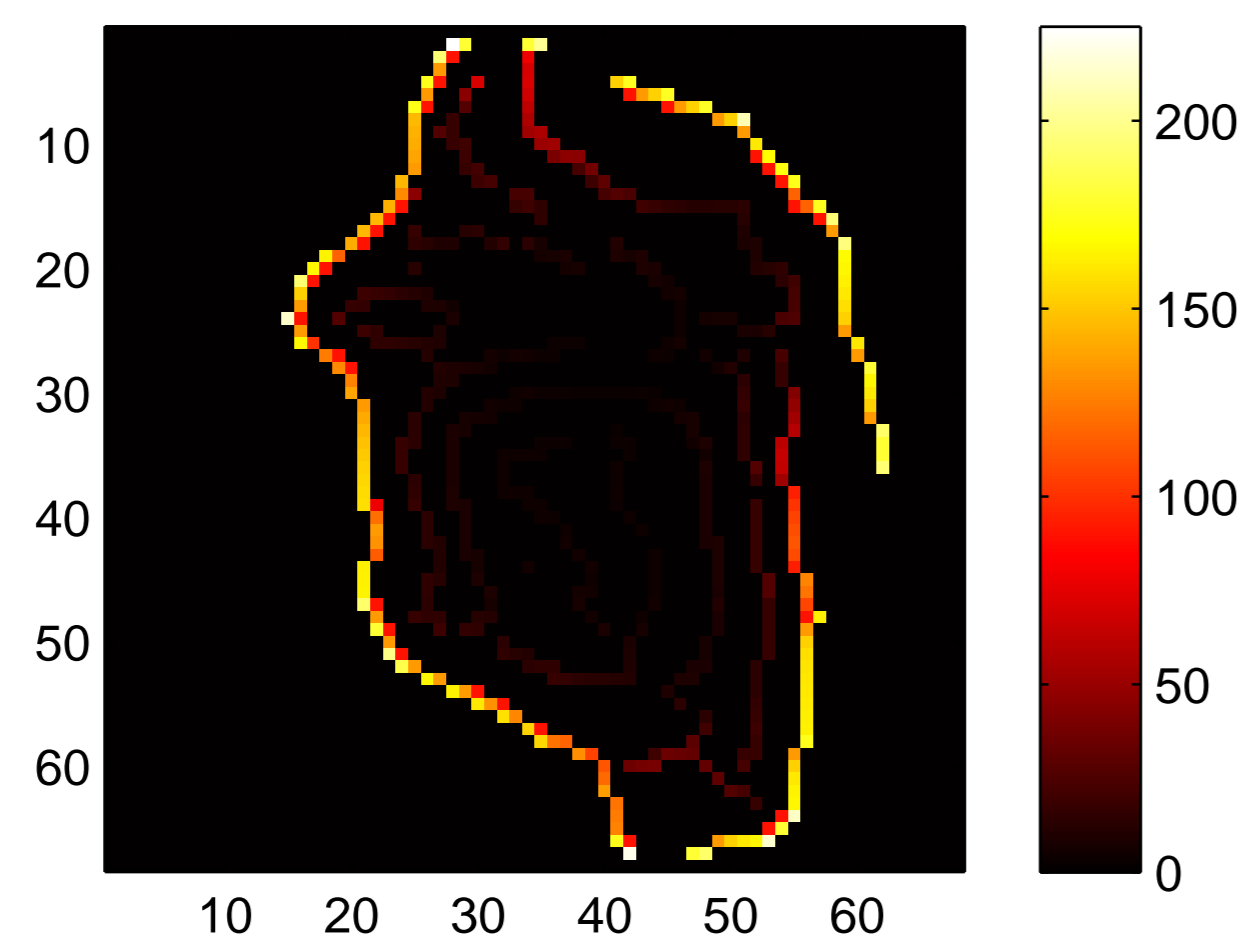
$$\text{s.t. } (\theta_i - \alpha)(\theta_i - \beta) \geq 0, \forall i = 1 \dots n - 1$$

## Example

Image with detected edge points

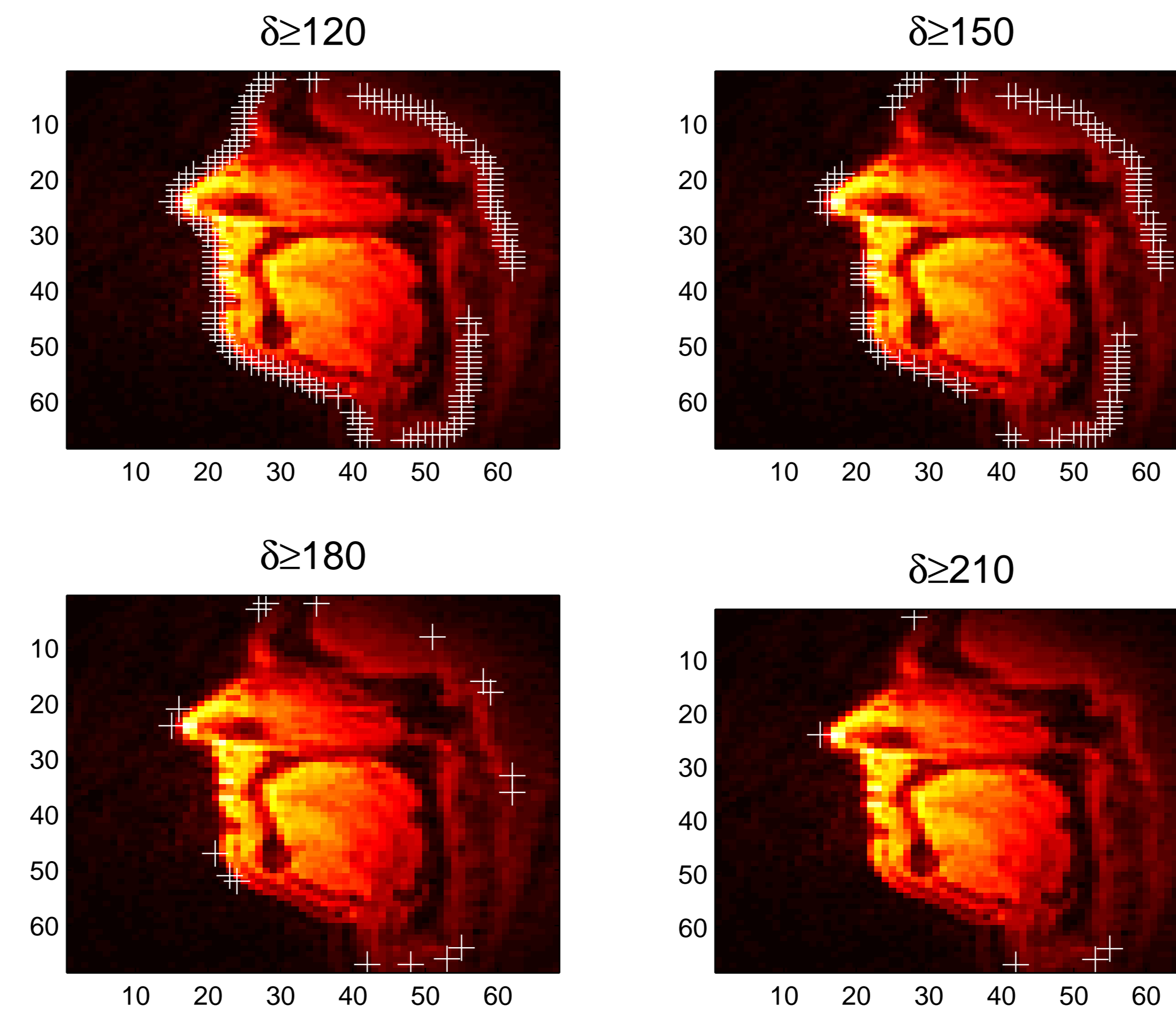


LESA scores for each point



## Geometry of the Hull

$$H(\theta) = \{x \mid x \in X, \delta(x) \geq \theta\}$$



- It can be shown that  $H(180^\circ)$  is a convex hull.
- $H(\theta), \theta < 180^\circ$  is a hull of increasing convexity
- $H(\theta), \theta > 180^\circ$  is not a hull but highlight sharp points

## Application to vocal tract realtime MR images

### Data:

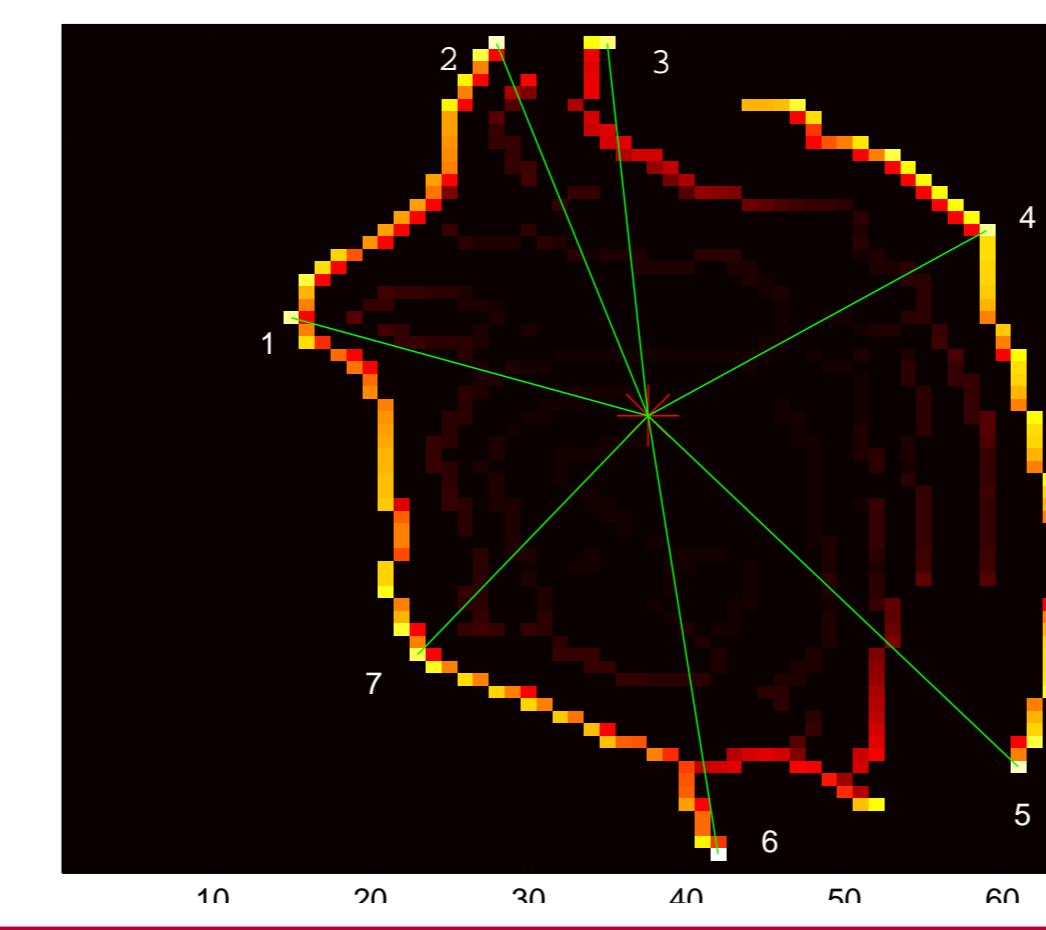
- The *USC-TIMIT* corpus comprising moving vocal tract images
- Common problem is the subject's **head motion**

### Approach:

- Detect **nosetip** and **chin** as sharp points in rtMRI contour
- Estimate rotation and translation to correct for head motion

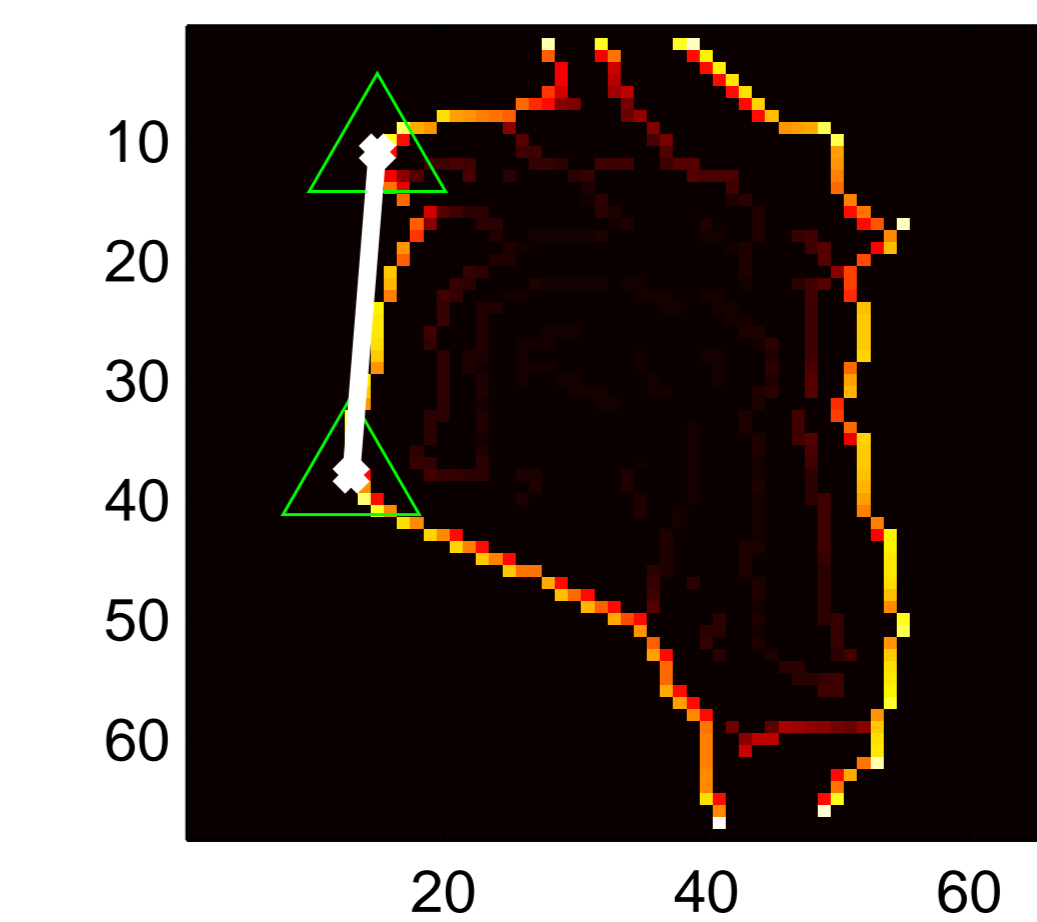
### Algorithm:

- $\delta(x) \geq 195^\circ \rightarrow H_1, H_2 \dots$
- Center of points in  $H \rightarrow H_0$
- Sort by angle at  $H_0$
- Choose nosetip and chin by sorting index

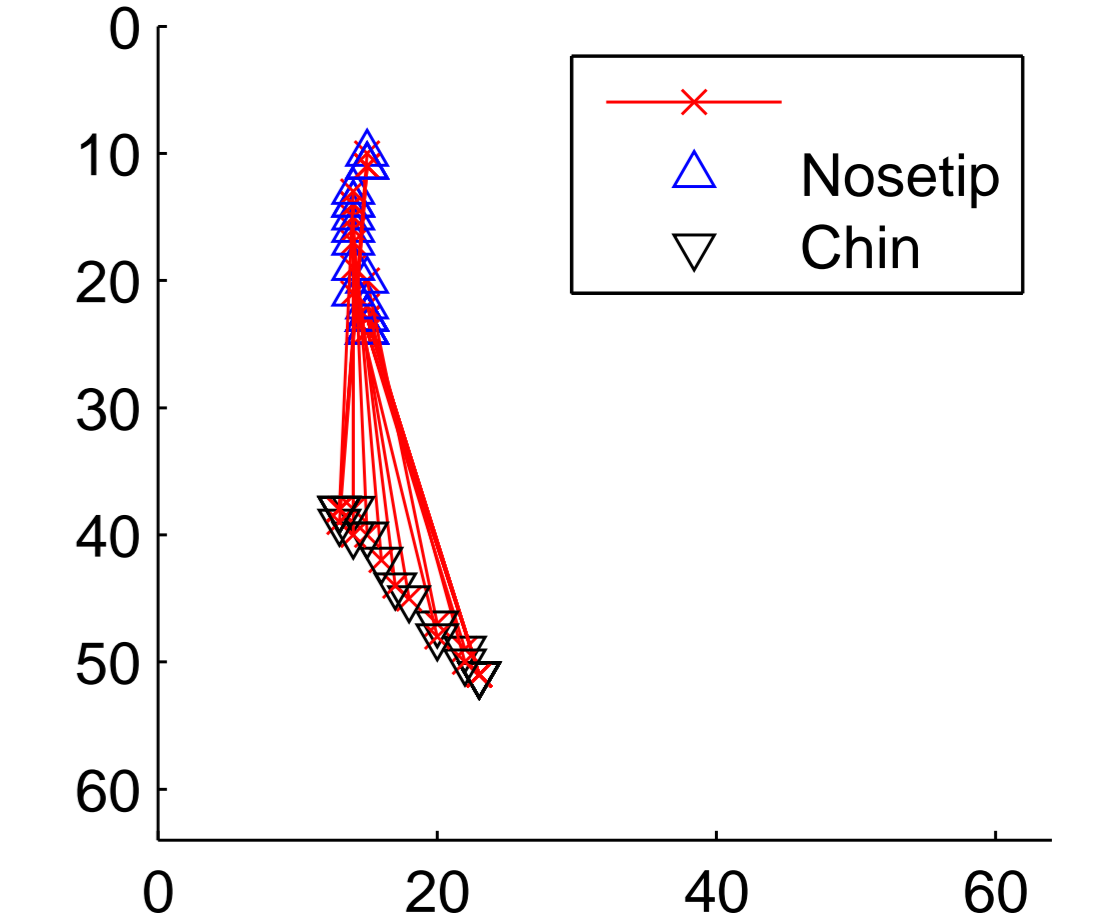


## Tracking Results

Nosetip and Chin Detection



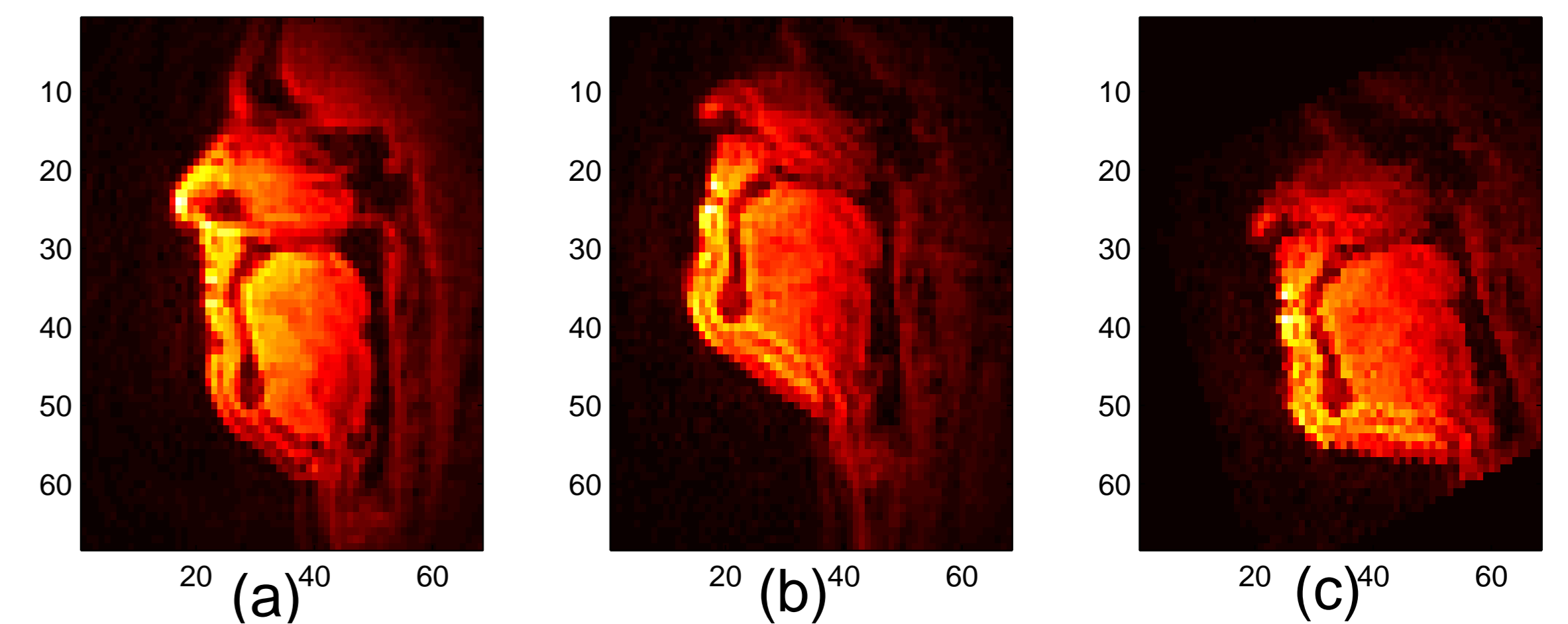
Tracking



Check a demo of the algorithm at work.



## Head motion correction



a) First frame b) Frame with head movement c) Frame corrected for head movement

### Head movement correction algorithm

- Match nosetip points
- Estimate angle of rotation about matched nosetip points

## Discussion and Future Work

- Chin point is on a non-rigid structure
- Vocal tract shape changes during head motion
- Use nosetip and chin to find other landmark points e.g. lips
- Direct adaptive tracking of the vocal tract

