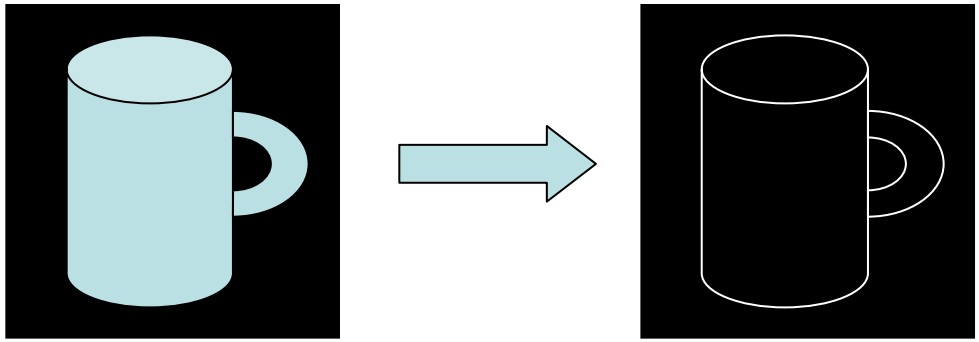
Recall: How Do We Extract Contours?

1. Detect edge points, i.e., pixels at which the intensity (or colour, range, etc.) undergoes a sharp discontinuity.
2. Link the edge points together to form connected chains, or contours.
3. Partition and/or group the contours to form appropriate features for object recognition.

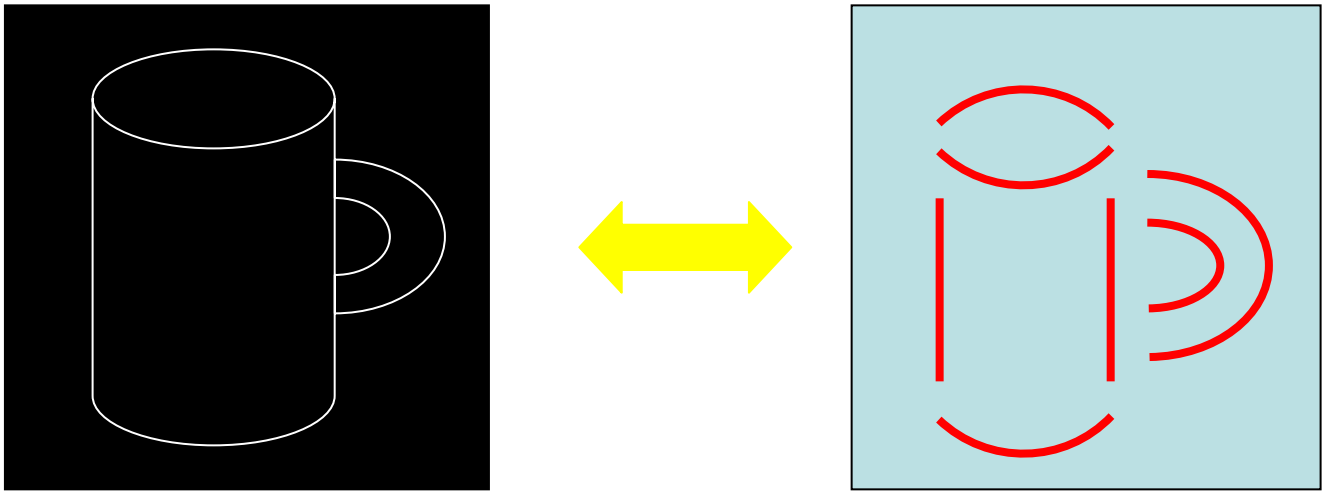
Aiming at the Model

- Recall the features of our shape model:

- If contour extraction were ideal:



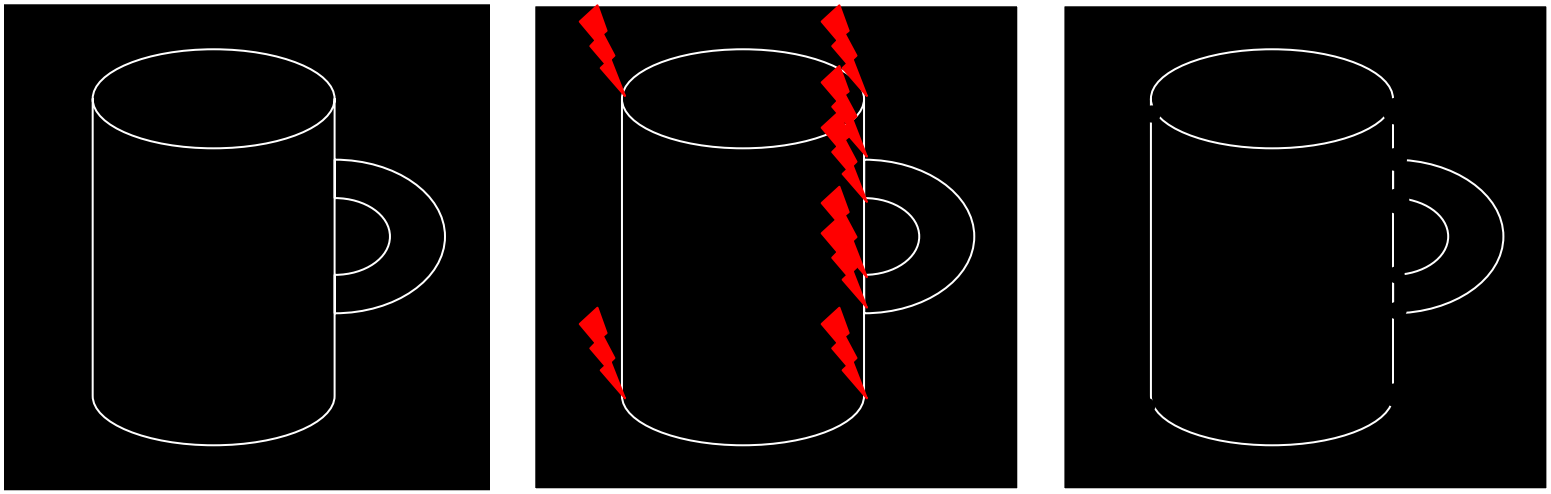
Speaking the Same Language



- What do we need to do to the image contours to allow us to match them to our model contours?

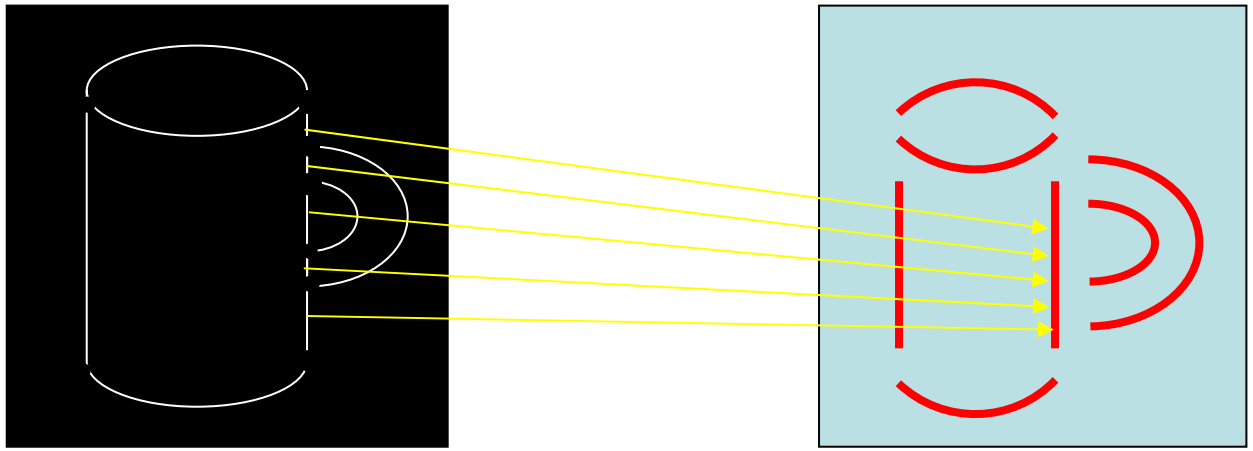
Curve Segmentation

- How do we segment our contours so that the resulting features can be compared to our model?
- Could cut contours at curvature extrema and junctions:



Overpartitioning

- This works, but may lead to overpartitioning at junctions:



- Let's do this, and we'll worry about grouping overpartitioned contours (as well as other groupable contours) later.

Parsing a Curve

- Two Methods:
  - Modeling the boundary between two curves – how they meet regardless of the shapes of the curves.
  - Modeling the two curve features – the shapes of the curves, regardless of how they meet.
  - Each method must somehow take into account the scale of a curve.

Method 1: Modeling the Corners

- Given a discrete curve given by a set of points, parameterized by arc length u:

$$\Gamma(u) = (x(u), y(u))$$

- Evolved versions Γ_σ are computed by smoothing the curve with varying σ:

$$\Gamma_\sigma = (X(u,\sigma), Y(u,\sigma))$$
$$X(u,\sigma) = x(u) \otimes g(u,\sigma)$$
$$Y(u,\sigma) = y(u) \otimes g(u,\sigma)$$

Computing Curvature

- Curvature κ is defined as (Mokhtarian and Mackworth, 1992):

$$\kappa(u,\sigma) = \frac{X_u(u,\sigma)Y_{uu}(u,\sigma) - X_{uu}(u,\sigma)Y_u(u,\sigma)}{(X_u(u,\sigma)^2 + Y_u(u,\sigma)^2)^{3/2}}$$

$$X_u = x(u) \otimes g_u(u,\sigma)$$

$$Y_u = y(u) \otimes g_u(u,\sigma)$$

$$X_{uu} = x(u) \otimes g_{uu}(u,\sigma)$$

$$Y_{uu} = y(u) \otimes g_{uu}(u,\sigma)$$

Curvature Scale-Space (CSS) Corner Detection

1. At coarsest scale in curvature scale space (CSS), identify local maxima subject to the following criteria:
   - absolute curvature above threshold, t.
   - absolute curvature at least twice one of the neighbouring local minima.
2. Track detected corners to finest scale to improve localization
3. demonstration

Method 2: Modeling the Curves

- Ramer's algorithm (1976) - a simple linear approximation:
  - Compute perpendicular distance between each contour point to line joining contour endpoints.
  - If max perpendicular distance exceeds tolerance, split the contour at max point, and recursively repeat with each subcontour.
- More difficult for higher-order polynomials, e.g., grow models from seed points subject to fitting error – choose best set of models minimizing description length.

Example