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# Project 3 - Rotobrush

## Segmenting Deformable Objects in a Video

# Segmentation

- Given a point/pixel $x_{i,j}$ in an image, where does it belong?
- Why do we need segmentation?
    - Localization
    - Object Detection
    - Tracking

# Deformable Objects

- Objects that change shape
- Changing shape $\rightarrow$ Can't use static Mask

# SnapCut

1. Segmenting object of interest in first frame
    - Call it foreground, $F$
    - Everything else is the background $B$
2. Create Local Classifiers
    - Local windows along edge of initial mask $W_k^t$
    - Must have *some* overlap between windows (20-30%)
3. For each local window
    1. Initialize Color Model for GMM
    2. Initialize Shape Model
    3. Combine Shape + Color
    4. Update Color + Shape Model

# Digging Deeper

- Use *roipoly()* to select mask
- Select $k$ points around object
  - $k$ ~60×60 windows → Must have overlap
- **Color Model**
  - Per window

$$p_c(x) = \frac{p_c(x|F)}{(p_c(x|F) + p_c(x|B))}$$

  - Fit GMM model → can use MATLAB functions
  - Find probabilities of foreground
- **Color Confidence**
  - Are foreground and background separable?

$$f_c = 1 - \frac{\int_{W_c} |L^t(x) - p_c(x)| \cdot \omega_c(x) dx}{\int_{W_k} \omega_c(x) dx}$$

$$d = \text{euclidean distance between } x \text{ and foreground boundary}$$

$$\omega_c = e^{\frac{-d^2(x)}{\sigma_c^2}}$$

  - $f_c$ is a single value
  - $\omega_c$ → Weight function
  - |L^t(x) - p_c(x) | = Subtract probabilities from mask
- After doing this for every window → Will have border around object
- **Shape Model**

$$f_s(x) = 1 - e^{\frac{-d^2(x)}{\sigma_s^2}}$$

$$\sigma_s \text{is a parameter}$$

  - Shape confidence decreases as color confidence increases
- **Local Window Propagation**
  - Use SIFT features → track $k$ points across frames
  - Update window based on matched point in next frame
    - Use optical flow (MATLAB functions) to update windows
  - Update Color and Shape Models with next frame data

$$p_F^k(x) = f_s(x)L^{t+1}(x) + (1 - f_s(x))p_c(x)$$

$$p_F(x) = \frac{\sum_k p_F^k(x)(|x - c_k| + \epsilon)^{-1}}{\sum_k (|x - c_k| + \epsilon)^{-1}}$$

$$c_k \text{ is the center of the window } \implies \text{ closer points to center weighted more heavily}$$

$$\epsilon \text{ is a small value to regulate points next to or on center}$$

- `Visualization functions given`