Deep Extreme Level Set Evolution

Interactive Instance Segmentation

DELSE combines powerful CNN image feature extraction with Level Set Evolution. It is end-to-end differentiable, and produces "well behaved" object contours.

Level Set Representation

- Implicit curve with level set function \( \phi \):
  \[ C = \{ (x, y) | \phi(x, y) = 0 \} \]
- Foreground: \( \{ (x, y) | \phi(x, y) > 0 \} \)
- Background: \( \{ (x, y) | \phi(x, y) < 0 \} \)
- Curve evolution with level sets
  \[ \partial_t \phi(x, y) = \alpha \nabla \phi \]

Level Set Energy Design

- **Motion Term**: determines the motion of level set evolution. DELSE predicts a vector field \( \mathbf{v}(x, y) \) with motion and evolve with:
  \[ \partial_t \phi(x, y) = \nabla \cdot \mathbf{v}(x, y) \]
- **Curvature Term**: To make the curve's shape generally well-behaved, DELSE regularize the predicted curve by moving it in the direction of its curvature. This term is selective with a learned modulation function \( \mathbf{m}(%) \):
  \[ \partial_t \phi(x, y) = \nabla \cdot \mathbf{v}(x, y) - \alpha \Delta \phi \]
- **Regularization Term**: To maintain a desirable shape of LSF, DELSE regularize \( |\nabla \phi| \) to be either close to 0 or 1 with:
  \[ \alpha = \frac{1}{1 + e^{-|\nabla \phi|}} \]

Architecture of DELSE:

Extreme points are encoded as a heat map and concatenated with the image, which are then passed to the encoder CNN. A multi-branch architecture is used to predict the initial curve and parameters used in level set evolution.

Model Architecture

Object Instance Annotation with Deep Extreme Level Set Evolution

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Qualitative Results

Qualitative results on Cityscapes. Note that our model takes ground-truth boxes as input, following the setting of Polygon-RNN.

Qualitative results for occluded objects on Cityscapes. Top row: ground-truth. Bottom row: DELSE.

Visualization of CNN branches outputs.

Visualization of Level Set Evolution through time.

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