Problem definition

Several image editing tasks employ the following distance measure:

\[ d(p, p') = \min_{C(p, p')} \int \sqrt{I(C(t)) \cdot \dot{C}(t)} \, dt = \min_{C(p, p')} \int |\dot{I}(C(t))| \, dt \]

\( d(p, p') \) cannot be approximated faithfully with existing methods (Dijkstra, Fast Marching), applied over the Cartesian grid!

Dijkstra’s algorithm succeeds for

\[ d(p_{1,1}, p_{1,2}) = 1 \]

but fails for

\[ d(p_{1,1}, p_{1,3}) = 1 \]

Image level set tree

- Tree vertices are connected components of the level sets of \( I \)
  - \( k \)-level set of \( I \) is \( \gamma^k = \{ p \in \Omega | I(p) = k \} \)
  - \( \gamma^k \) is the \( k \)th connected component of \( \gamma \)
- Edge weights \( F(y^k, y^m) = |k - m| \)

Distance computation in level set tree

\[ d(p, p') = \min_{C(p, p')} \int |\dot{I}(C(t))| \, dt \]

Decompose \( C(t) \) into a series of segments such that consecutive segments belong to adjacent level sets

\[ d(p, p') = \min_{C(p, p')} \sum_{i=0}^{n} |\dot{I}(C_i(t))| = \min_{C(p, p')} \sum_{i=0}^{n} |k_{i+1} - k_i| \]

Application: user-assisted image segmentation

- User input: foreground and background scribbles (marks)
  - Estimate foreground likelihood function per pixel \( P(p) \)
  - Compute distance to scribbles \( d_f(p), d_b(p) \)
  - Assign labels using \( \text{Object} = \{ p | d_f(p) < d_b(p) \} \)

References


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