MeshStereo: A Global Stereo Model with Mesh Alignment Regularization for View Interpolation

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Motivation
- Output high-quality meshes for view interpolation
- Unify depth map estimation and mesh generation

Variables
- \( \alpha \): A splitting probability for each 2D vertex
- \( D \): A depth value for each barycenter
- \( N \): A normal for each triangle

Formulation

\[
E_{\text{All}}(N, D, \alpha) = E_{\text{MatchingCost}} + E_{\text{NormalSmooth}} + E_{\text{Alignment}} + E_{\text{SplitPenalty}} + E_{\text{SplitSmooth}}
\]

Upper Layer MRF:
- \( E_{\text{SplitPenalty}}(\alpha) = \sum_{s,t \in N} \alpha_s \cdot \tau_s \)
  \( \tau_s = \exp(-|\nabla f(x_s, y_s)|/\gamma_1) \)
- \( E_{\text{SplitSmooth}}(\alpha) \sum_{s,t \in N} w_{st}(\alpha_s - \alpha_t)^2 \)
  \( w_{st} = \exp(-|k(x_s) - k(x_t)|/\gamma_2) \)
  \( k(x) = \max_j \{|f(x) - f(x_j)| < 10, \forall j \} \)

Lower Layer MRF:
- \( E_{\text{MatchingCost}}(N, D) = \sum_i \rho(n_i, d_i, p) \)
- \( E_{\text{NormalSmooth}}(N) = \sum_{i,j \in N} w_{ij}(n_i - n_j) \cdot (n_i - n_j) \)

Gluer:
- \( E_{\text{Alignment}}(N, D, \alpha) = \sum_s (1 - \alpha_s) \cdot \sum_{i,j \in G_s} w_{ij}(D_i(x_s) - D_j(x_s))^2 \)

Optimization

\[
\begin{align*}
E_{\text{UPPER}} &= E_{\text{Alignment}} + E_{\text{SplitPenalty}} + E_{\text{SplitSmooth}} \\
E_{\text{LOWER}} &= E_{\text{Alignment}} + E_{\text{MatchingCost}} + E_{\text{NormalSmooth}}
\end{align*}
\]

Minimize \( E_{\text{UPPER}} \) and \( E_{\text{LOWER}} \)
- Quadratic in \( \alpha \), has closed-form solution
- Non-convex, difficult, Relax it and optimize in another loop

- Increase \( \theta \) from 0 to \( \infty \), optimize alternatively between blue and green
- Optimize blue part by PatchMatch
- Optimize green part in closed-form

Stereo Results
- Preserve fine structures
- First place on Middlebury 3.0 at submission time

Generated Meshes
- Color
- ELAS
- SGM
- Ours