Pixelwise View Selection for Unstructured Multi-View Stereo

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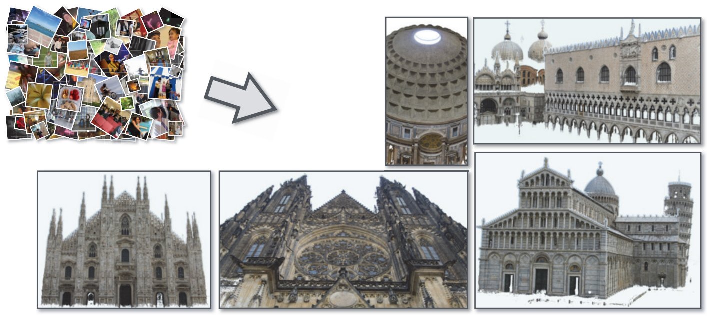
Overview

This work presents an **open source Multi-View Stereo** system for **robust** and **efficient** dense modeling from **unstructured image collections**. Experiments on benchmarks and large-scale Internet photo collections demonstrate **state-of-the-art performance** in terms of accuracy, completeness, and efficiency.



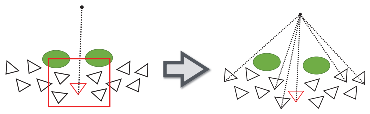
Contributions

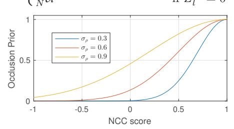
- **Joint depth - normal - occlusion inference** embedded in improved PatchMatch sampling scheme
- **Pixelwise view selection** using photometric and geometric priors
- **Multi-view geometric consistency** for simultaneous refinement and image-based fusion
- **Graph-based filtering and fusion** of depth and normal maps

Pixelwise View Selection

- Occlusion prior

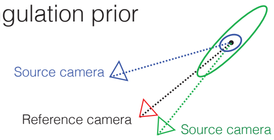
$$P(X_l^m|Z_l^m,\theta_l)=\begin{cases}\frac{1}{NA}\exp\left(-\frac{(1-\rho_l^m(\theta_l))^2}{2\sigma_\rho^2}\right) & \text{if } Z_l^m=1\\ \frac{1}{N}\mathcal{U} & \text{if } Z_l^m=0\end{cases}$$

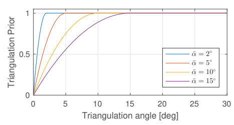




- Triangulation prior

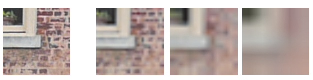
$$P(\alpha_l^m)=1-\frac{(\min(\bar{\alpha},\alpha_l^m)-\bar{\alpha})^2}{\bar{\alpha}^2}$$

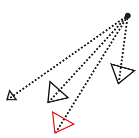


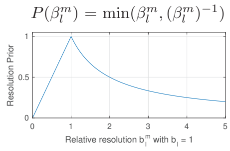


- Resolution prior

$$P(\beta_l^m)=\min(\beta_l^m,(\beta_l^m)^{-1})$$

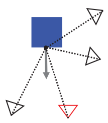


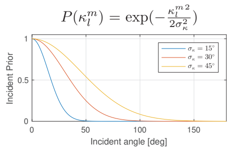




- Incident prior

$$P(\kappa_l^m)=\exp\left(-\frac{{\kappa_l^m}^2}{2\sigma_\kappa^2}\right)$$



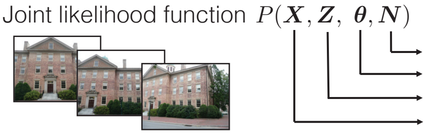


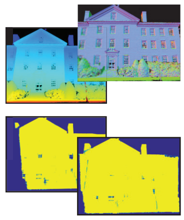
https://colmap.github.io

Source Code | Documentation | Tutorial | Examples

Joint Depth - Normal - Occlusion Inference

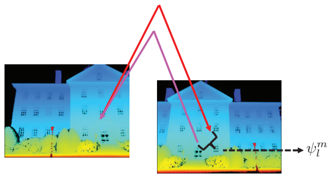
- Joint likelihood function $P(\boldsymbol{X},\boldsymbol{Z},\ \boldsymbol{\theta},\boldsymbol{N})$





- Generalized Expectation Maximization (GEM)
  - *E-Step*: Infer $\boldsymbol{Z}$ using variational inference
  - *M-Step*: Infer $\boldsymbol{\theta},\boldsymbol{N}$ using PatchMatch sampling

Multi-View Geometric Consistency



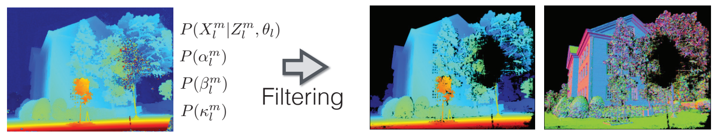
Cost function

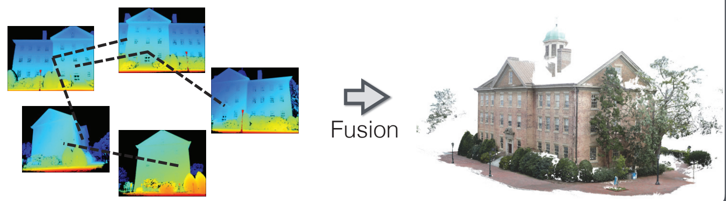
$$\xi_l^m=1-\rho_l^m+\eta\min(\psi_l^m,\psi_{\max})$$

Photometric Geometric

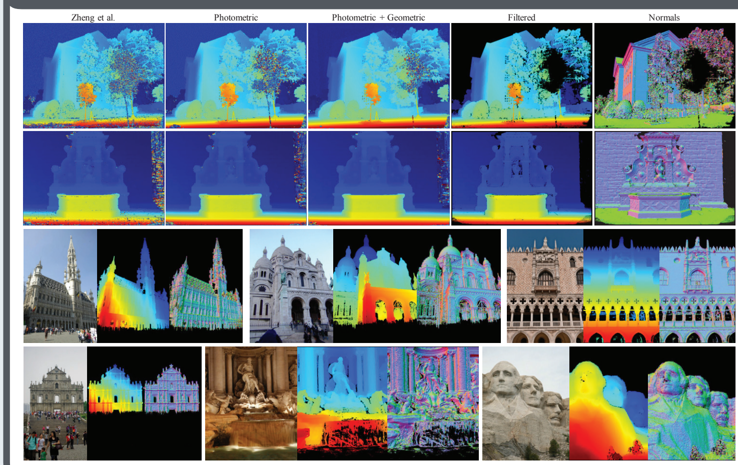
Optimization $\underset{\theta_l^*,\boldsymbol{n}_l^*}{\operatorname{argmin}}\frac{1}{|S|}\sum_{m\in S}\xi_l^m(\theta_l^*,\boldsymbol{n}_l^*)$

Filtering and Fusion





Results



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