Structure from Category: A Generic and Prior-less Approach

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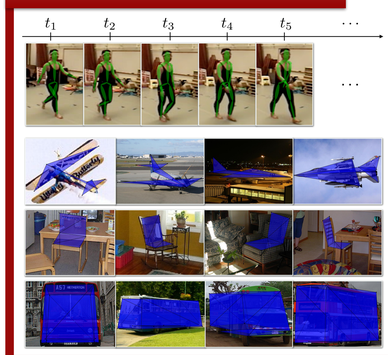
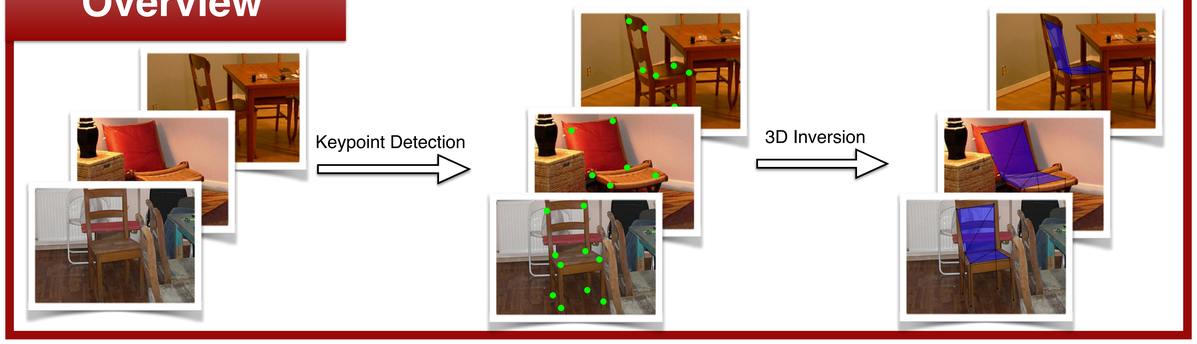
Introduction



Non-rigid Structure from Motion:
Inferring the camera motion and shape of non-rigid objects + **additional constraints** (e.g. temporal order.)

Structure from Category:
Inferring the camera motion and shape of objects in the same object category (aeroplanes, chairs, buses and etc.)

Overview



3D Inversion

Assume the 3D shape of instance f, $\mathbf{S}_f$ can be well-approximated as a linear combination of a set of rotated 3D bases $\{\mathbf{B}_l\}_{l=1}^{L}$:

$$\mathbf{S}_f = \sum_{l=1}^{L} c_{fl}\mathbf{R}_{fl}\mathbf{B}_l \Longrightarrow \begin{bmatrix}\mathbf{W}_1\\ \vdots \\ \mathbf{W}_F\end{bmatrix} = \begin{bmatrix}\mathbf{KS}_1\\ \vdots \\ \mathbf{KS}_F\end{bmatrix} + \begin{bmatrix}\mathbf{T}_1\\ \vdots \\ \mathbf{T}_F\end{bmatrix} = \begin{bmatrix} c_{11}\mathbf{KR}_{11} & \cdots & c_{1L}\mathbf{KR}_{1L} \\ \vdots & \vdots & \vdots \\ c_{F1}\mathbf{KR}_{F1} & \cdots & c_{FL}\mathbf{KR}_{FL}\end{bmatrix}\begin{bmatrix}\mathbf{B}_1\\ \vdots \\ \mathbf{B}_L\end{bmatrix} + \begin{bmatrix}\mathbf{T}_1\\ \vdots \\ \mathbf{T}_F\end{bmatrix}$$

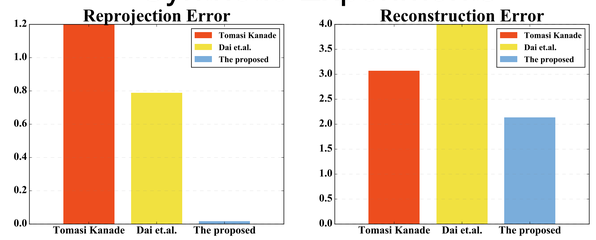
To estimate the 3D shape, we minimize the re-projection error:

$$\begin{aligned} \min_{\mathbf{M},\mathbf{B},\mathbf{T}} \quad & \frac{1}{2}\left\|\mathbf{\Gamma}\odot(\mathbf{MB}+\mathbf{T})-\mathbf{W}\right\|_F^2 + \lambda\|\mathbf{C}\|_1 \\ \text{s.t.} \quad & \mathbf{M}_{fl}\mathbf{M}_{fl}^T = c_{fl}^2\mathbf{I}_2,\ f=1,...,F,\ l=1,...,L, \\ & \|\mathbf{B}_l\|_F = 1,\ f=1,...,F, \end{aligned} \xrightarrow{\text{relax}} \begin{aligned} \min_{\mathbf{M},\mathbf{B},\mathbf{T}} \quad & \frac{1}{2}\left\|\mathbf{\Gamma}\odot(\mathbf{MB}+\mathbf{T})-\mathbf{W}\right\|_F^2 + \lambda\sum_{l,f}\|\mathbf{M}_{fl}\|_2 \\ \text{s.t.} \quad & \|\mathbf{B}_l\|_F = 1,\ l=1,...,L, \end{aligned}$$

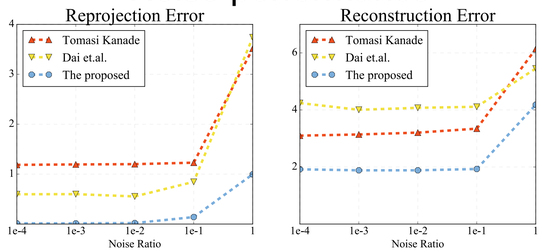
which can be solved by ADMMs.

Experiments

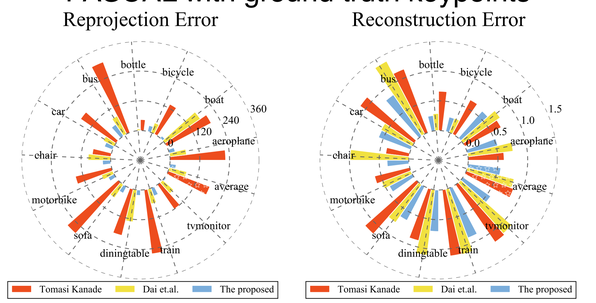
Synthetic Experiments



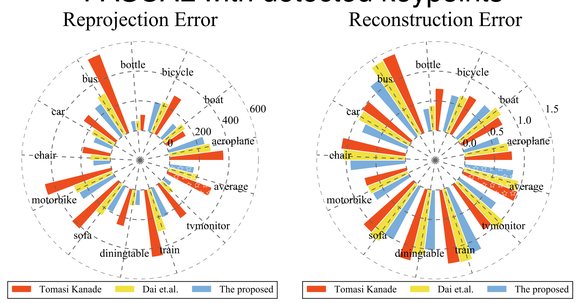
Noise performance



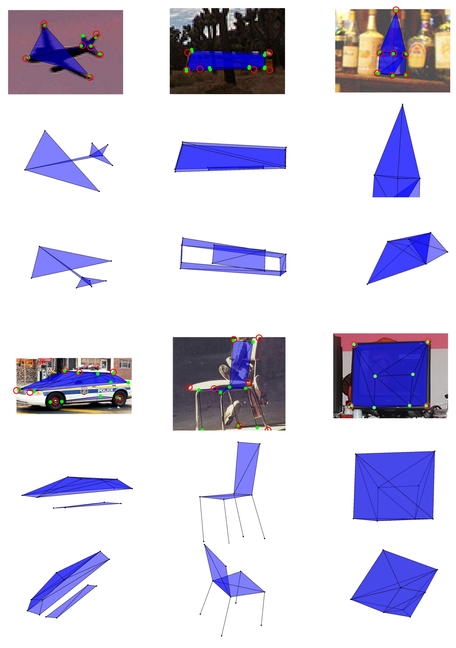
PASCAL with ground truth keypoints



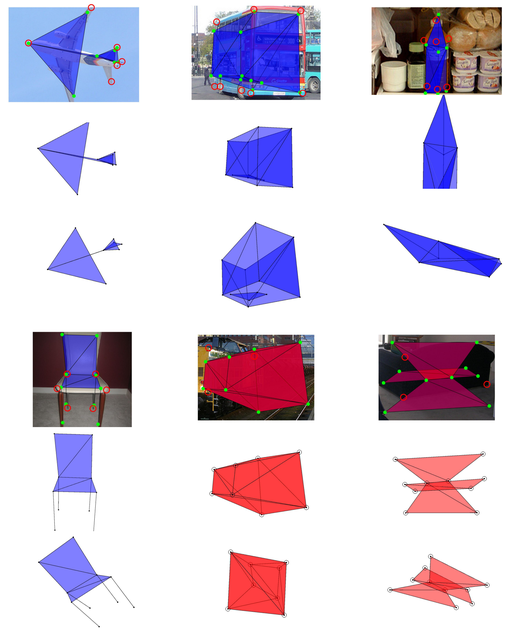
PASCAL with detected keypoints



PASCAL with ground truth keypoints



PASCAL with detected keypoints



This material is based upon work supported by the National Science Foundation Graduate Research Fellowship under Grant No. 1526033. Any opinion, findings, and conclusions or recommendations expressed in this material are those of the authors(s) and do not necessarily reflect the views of the National Science Foundation.