Marr Revisited: 2D-3D Model Alignment via Surface Normal Prediction

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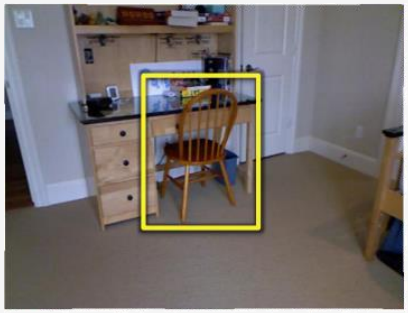
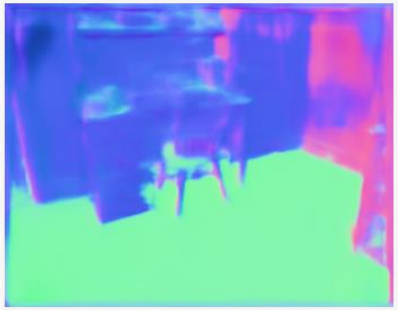
Introduction



Input Image



Predicted Surface Normal

CAD Model Library

Aligned Models

Introduction

Task: 2D ⟶ 2.5D ⟶ 3D

- Surface normal (2.5D) from a single 2D image.
- Pose & style of objects from RGB + 2.5D cues.

Input Image

Predicted Surface Normal

CAD Model Library

3D ShapeNets, Wu et al. [CVPR'15]

Aligned CAD Model

Introduction

- Why Marr's framework?
  - Most data for training 3D representations is **CAD data** (c.f. ShapeNet or ModelNet)
  - Big **gap** between CAD model renders and real 2D images
  - Marr's 2.5D representation helps to **bridge this gap**
  - Marr revisited
- Contributions
  - **Skip-network** architecture for surface normal estimation
  - **CNN** architecture for CAD retrieval combining **image** and predicted surface **normal**

Related work

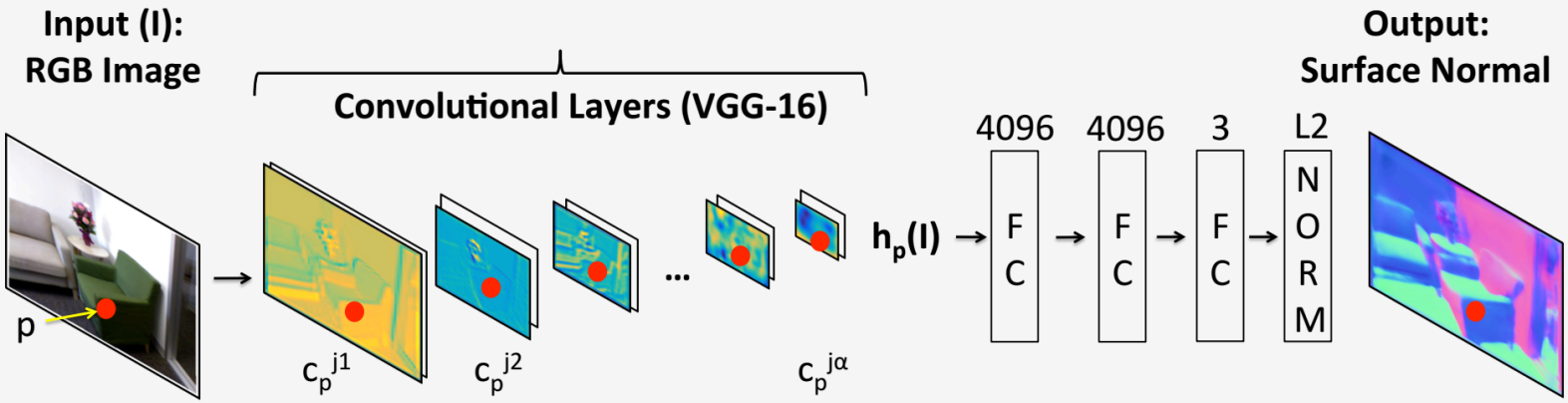
- 3D scene understanding
  - Recovering the 2.5D
    - Discriminative 3D primitives [Fouhey et al 2013]
    - Convex and concave edges [Fouhey et al 2014]
    - Discriminative learning with hand-crafted features [Ladicky et al 2014]
  - Recovering the 3D volumetric objects
    - Train CNNs to predict object class for CAD model alignment [Gupta et al 2015]
    - Train Siamese network modeling style similarity to retrieve product images having similar style as an object in an input photo [Bell et al 2015]

Skip-network architecture

2D ⟶ 2.5D

Surface Normal Estimation

Non-linear optimization of Hypercolumn features for fine details.



Hypercolumn (Hariharan et al. [CVPR'15]): $\mathbf{h_p(I) = [c_p^{j1}, c_p^{j2} \dots , c_p^{j\alpha}]}$

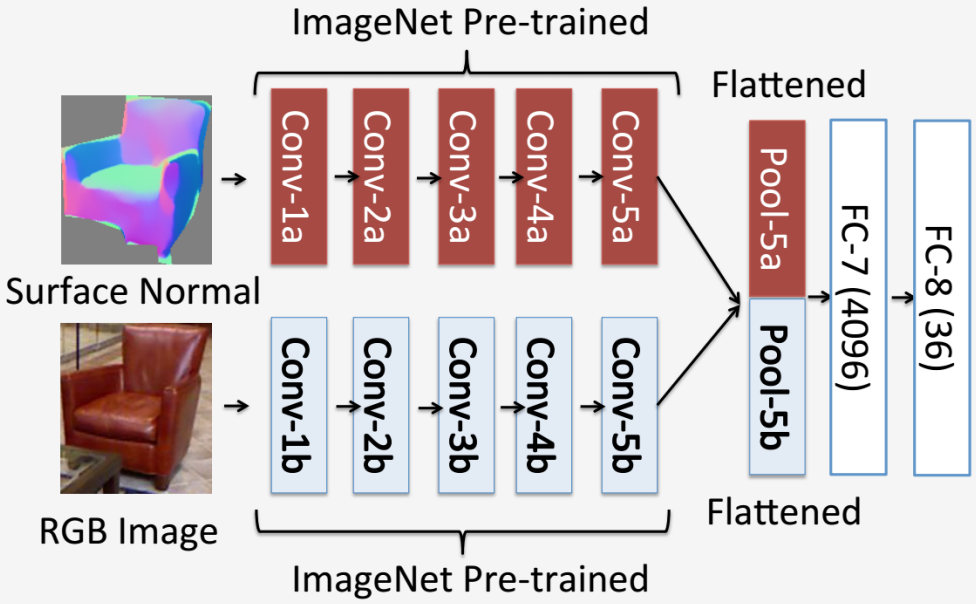
- During training, **N** (= 1500) pixels are sampled per image for optimization.
- At test time, entire image is fed-forward. Output from last layer are the predicted surface normal.

Networks for predicting pose and style

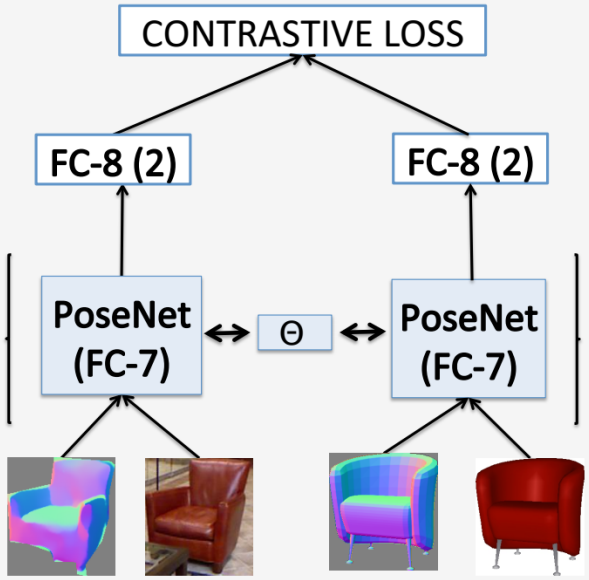
2.5D ⟶ 3D

Pose & Style Estimation

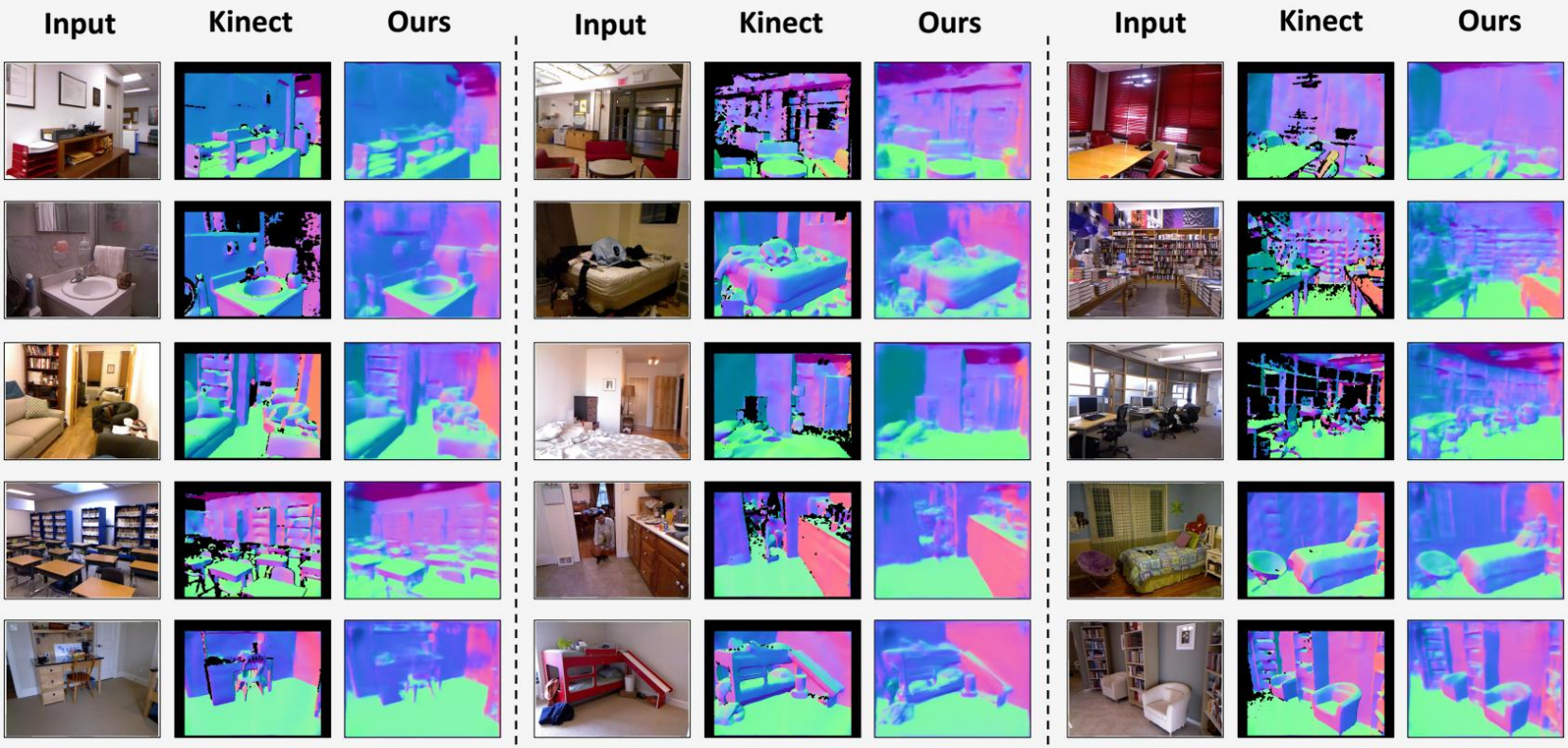
PoseNet: A 36-way pose classification.



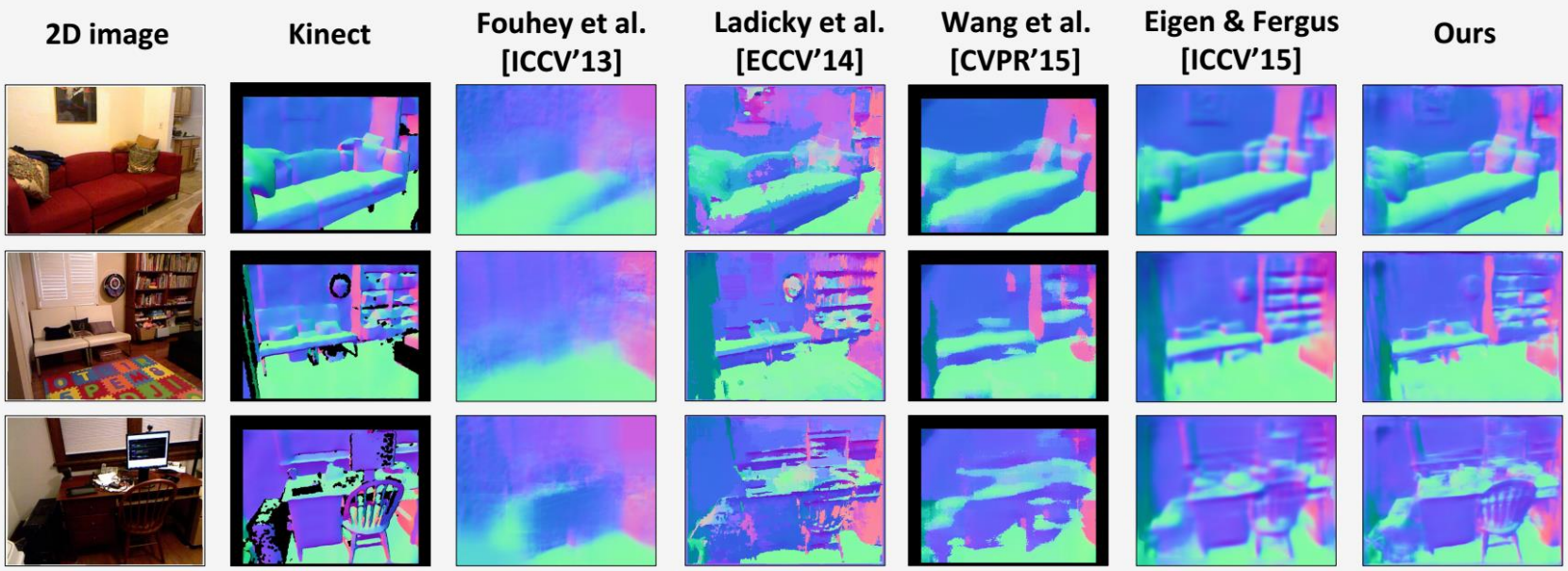
StyleNet: Are they similar?



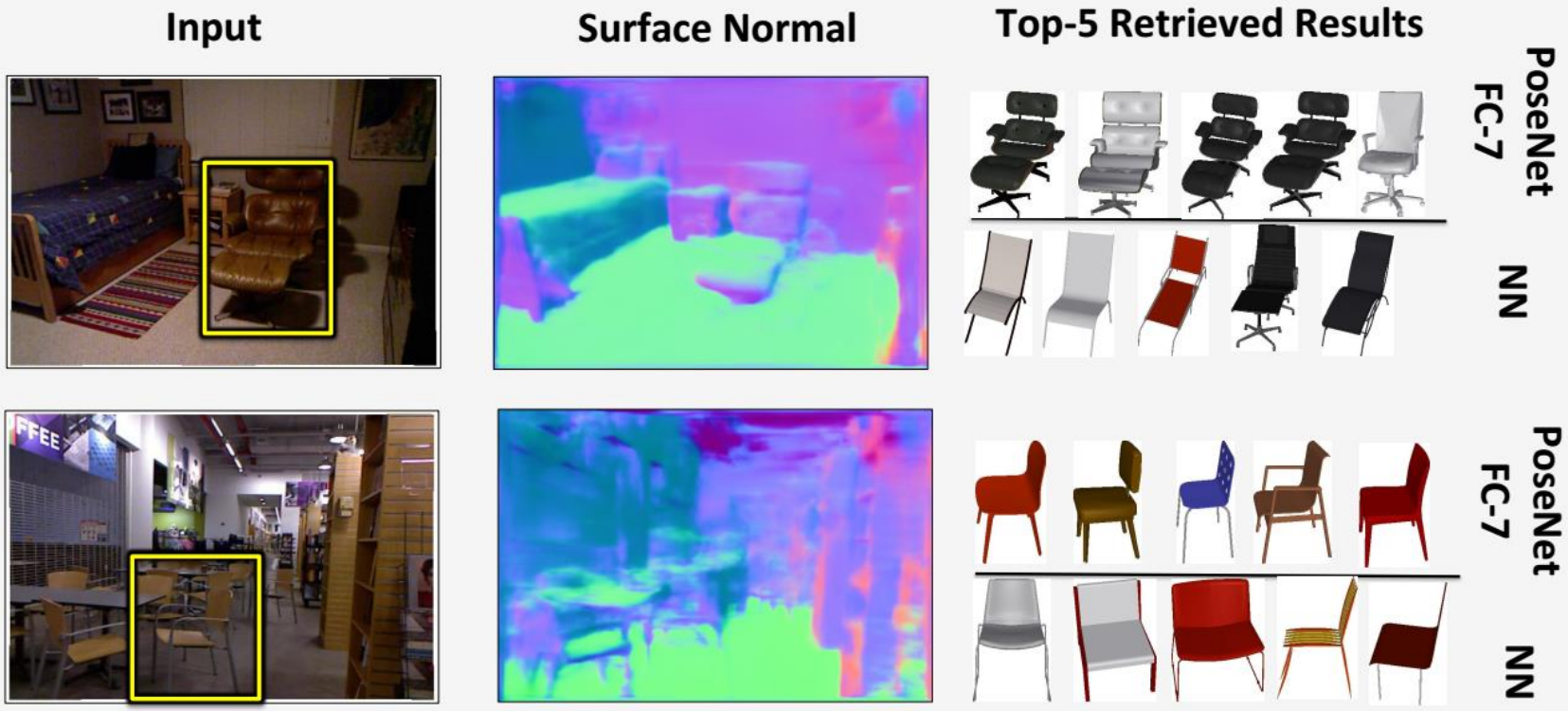
Surface Normal Estimation



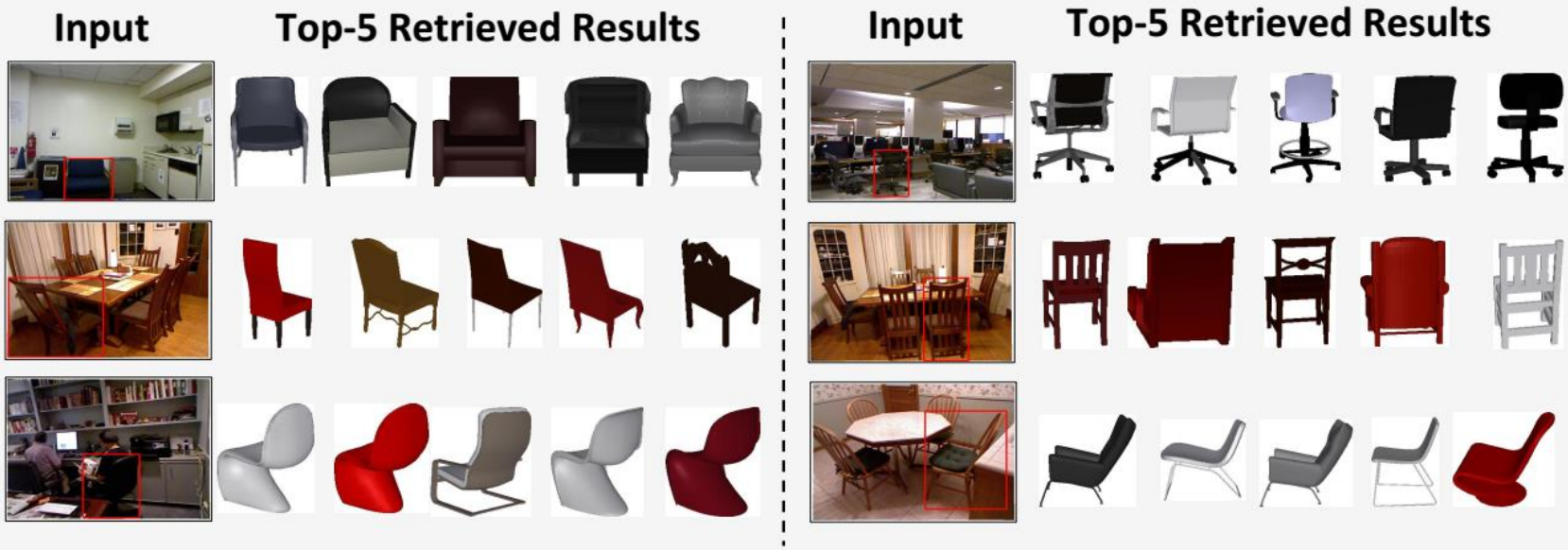
Qualitative Comparison



Pose Estimation



Pose Estimation



Style Estimation