Learning Unsupervised Hierarchical Part Decomposition of 3D Objects from a Single RGB Image

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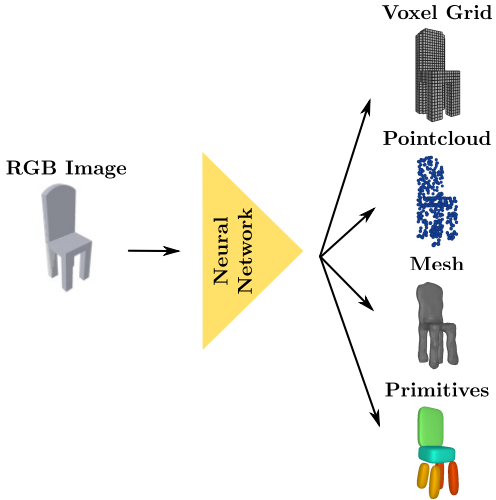
http://superquadrics.com/hierarchical_primitives

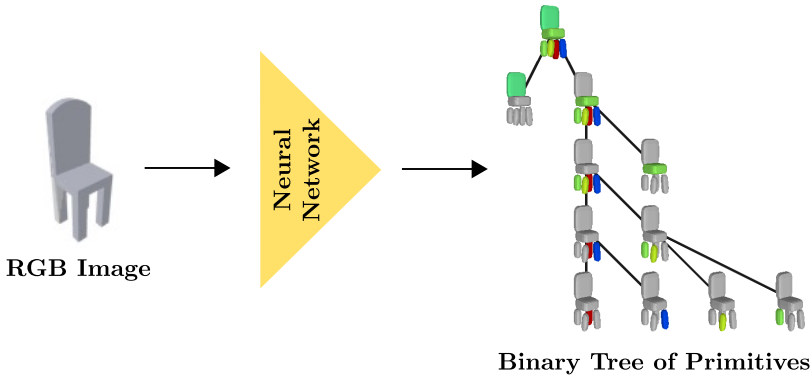
Motivation

Existing shape representations **focus only on reconstructing the geometry** of a 3D object **without considering its part-based decomposition or relations between parts**.



Our Structure-aware Representation

Jointly recovers **the geometry** and **the latent hierarchical layout** of an object as an **unbalanced binary tree of primitives**



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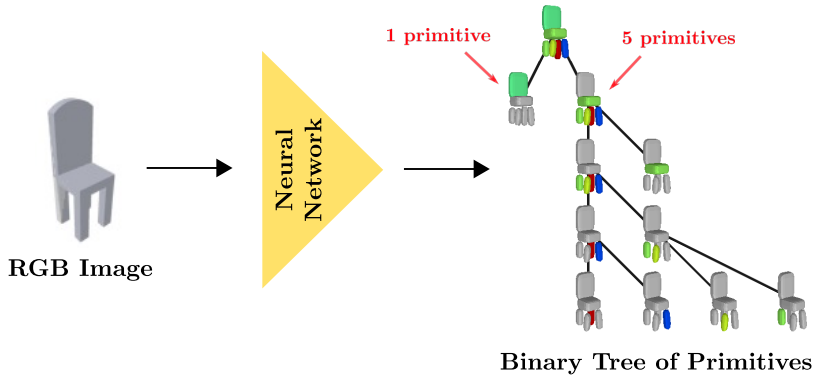

where **simple parts** are represented with fewer primitives and **complex parts** with more components.

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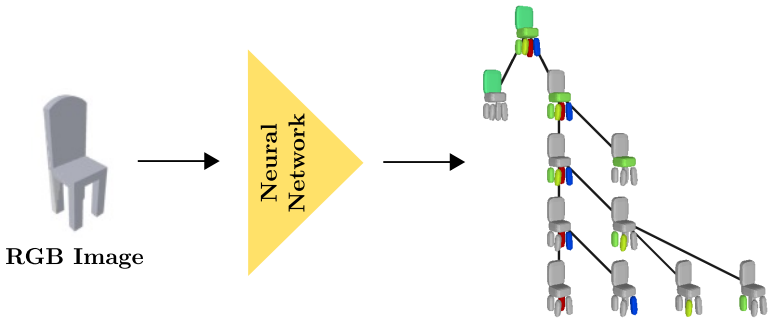
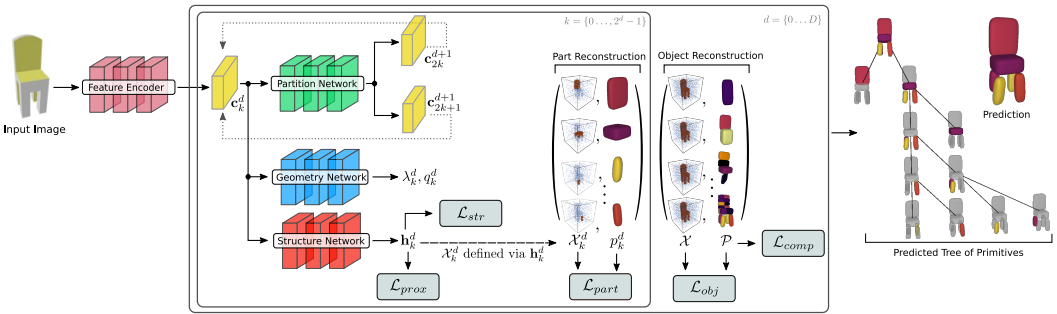


The hierarchical part decomposition is learned **without any supervision neither on the object parts nor their structure**.

Our Structure-aware Representation

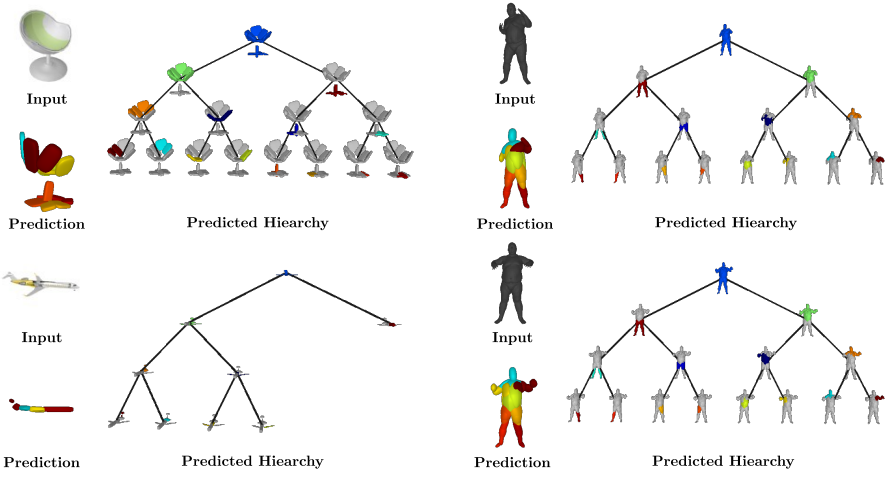
Given an **input** and a **target mesh** represented as a set of occupancy pairs $\mathcal{X} = \{(\mathbf{x}_i, o_i)\}_{i=1}^{N}$, our network predicts **a binary tree of primitives**. For each primitive the network regresses:

- A set of 11 parameters λ_k^d that define the shape, size and position in 3D space of its primitive at each depth level d.
- A reconstruction quality q_k^d.



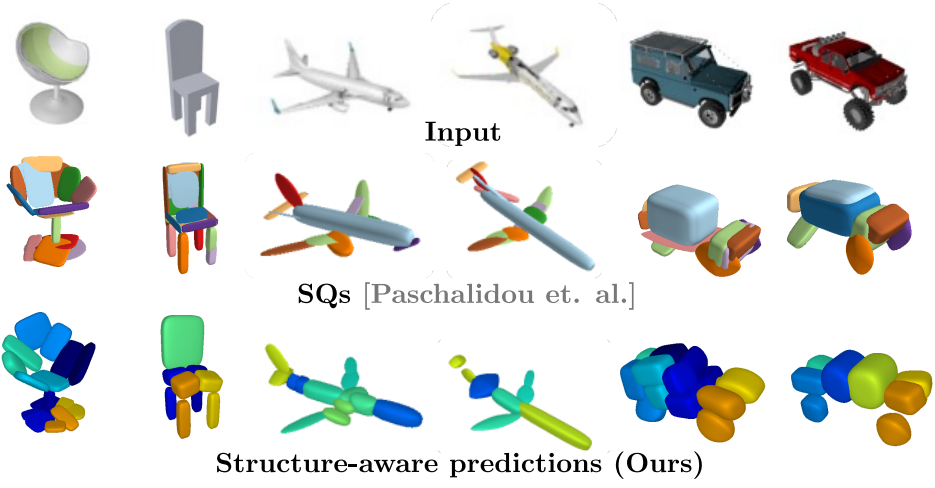
Expressive Shape Abstractions

We evaluate our model on the single view 3D reconstruction task on ShapeNet and D-FAUST.



Expressive Shape Abstractions

We show that considering the part decomposition improves the reconstruction quality.



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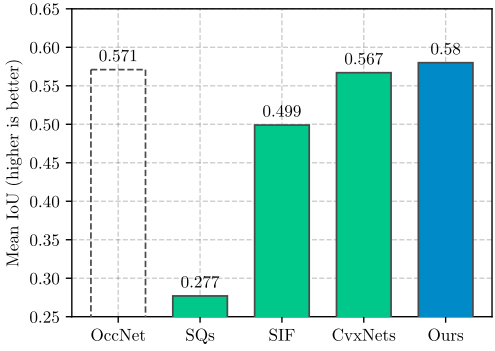
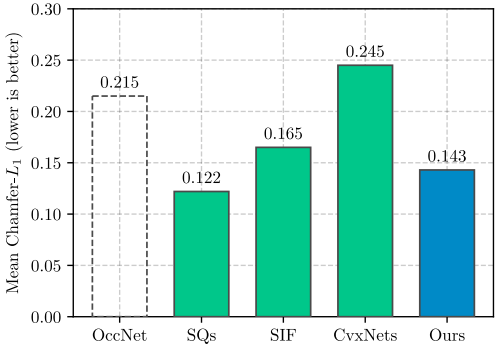
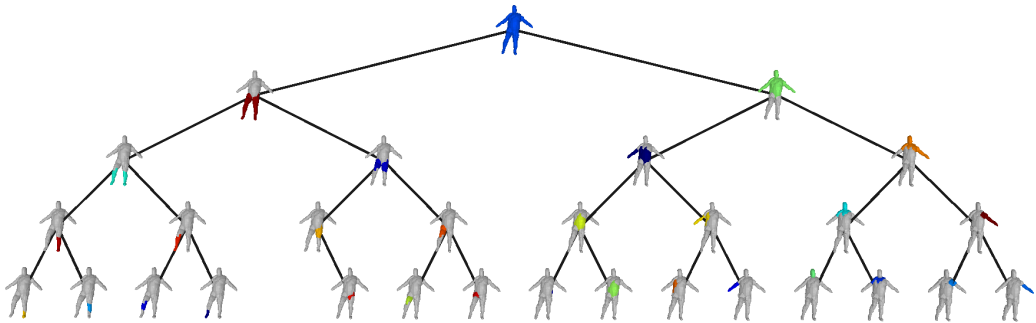




Implicit Shape Representantations Primitive-based Representations Ours

Semantic Interpretation of Learned Hierarchies

We show that our model recovers **semantic hierarchies** as the same node is consistently used for representing the same object part.



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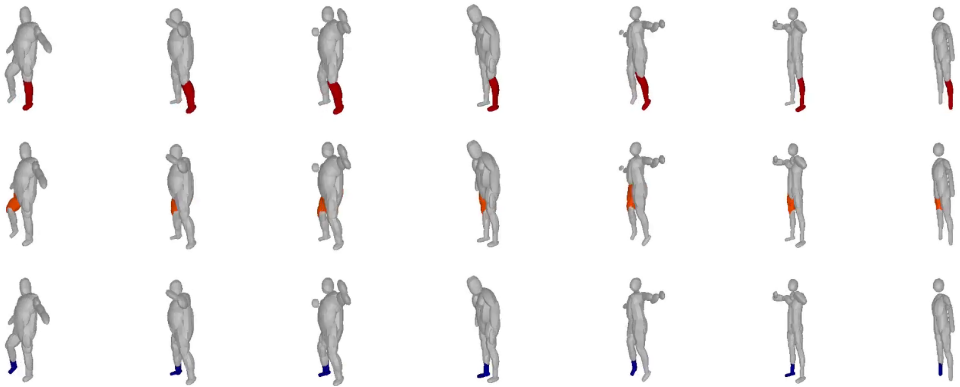

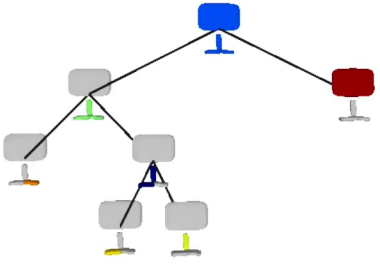

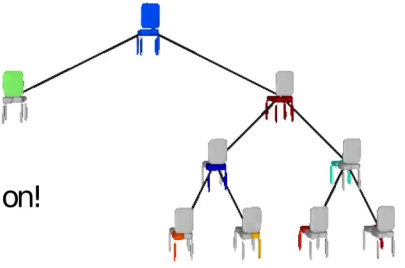

Thank you for your attention!

Project Page: http://superquadrics.com/hierarchical_primitives