Voxel-based 3D Detection and Reconstruction of Multiple Objects from a Single Image

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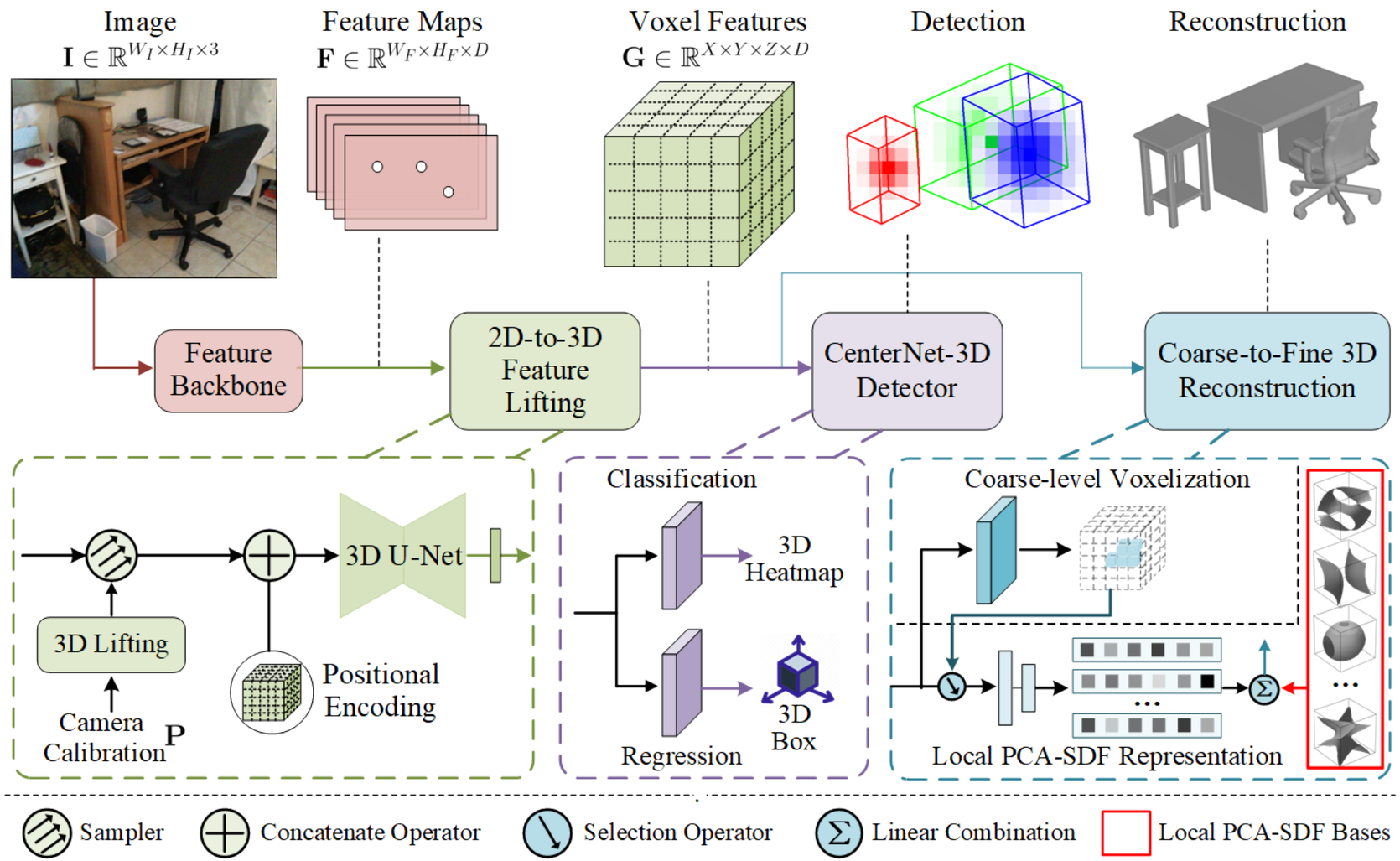
Background

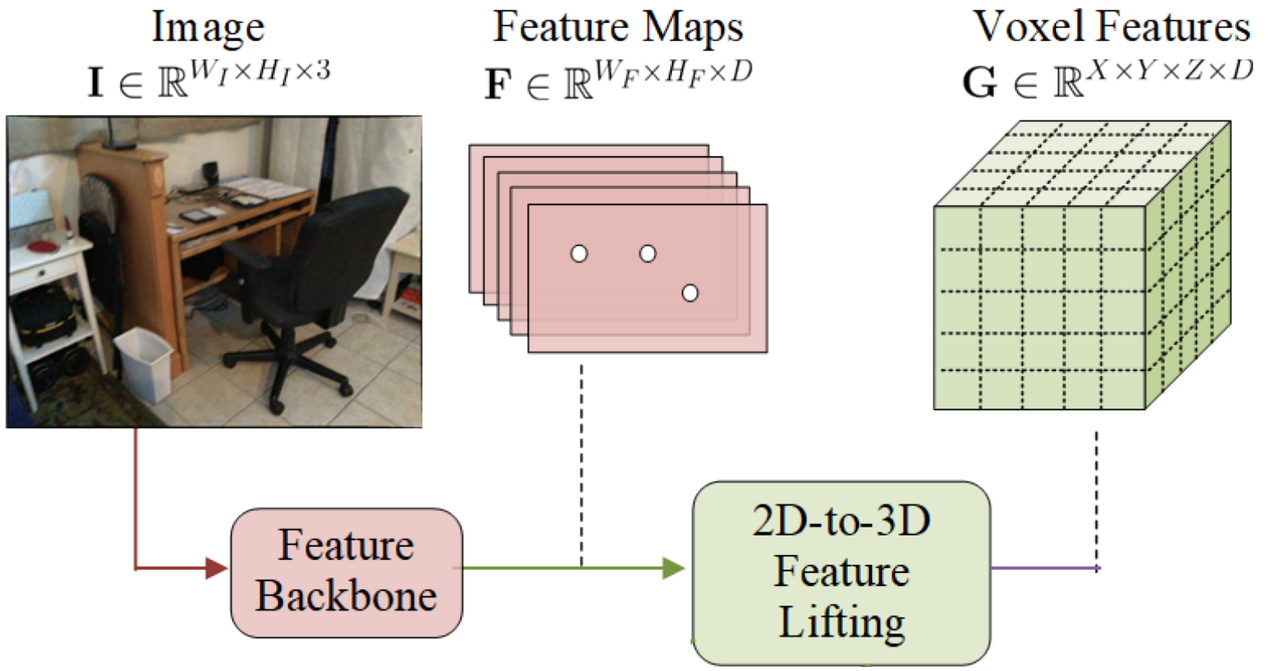
- Single Image 3D detection and reconstruction.
- Multiple Objects - 3D information recover.
- Deep Learning Methods.
- Voxel-SDF-based 3D geometry representation.
- Produce 3D Bounding-Box, 3D heatmap, and 3D shape.

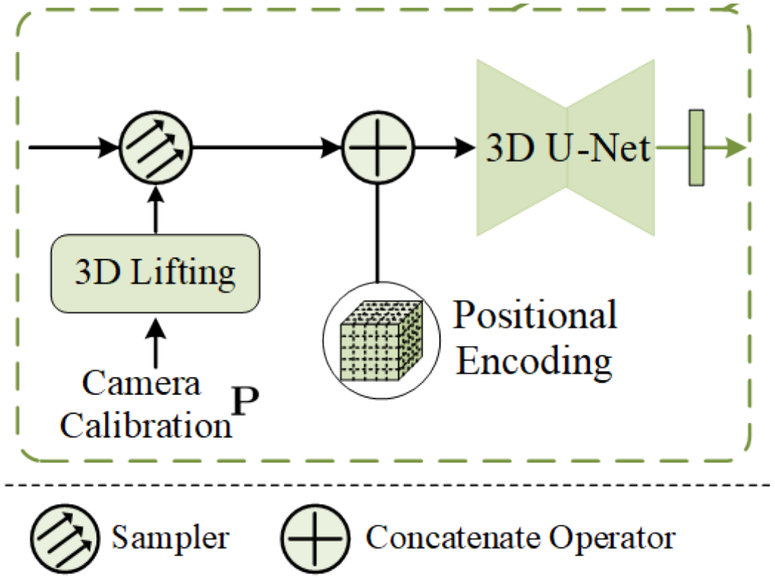
3 Stage Pipeline



Feature Extraction

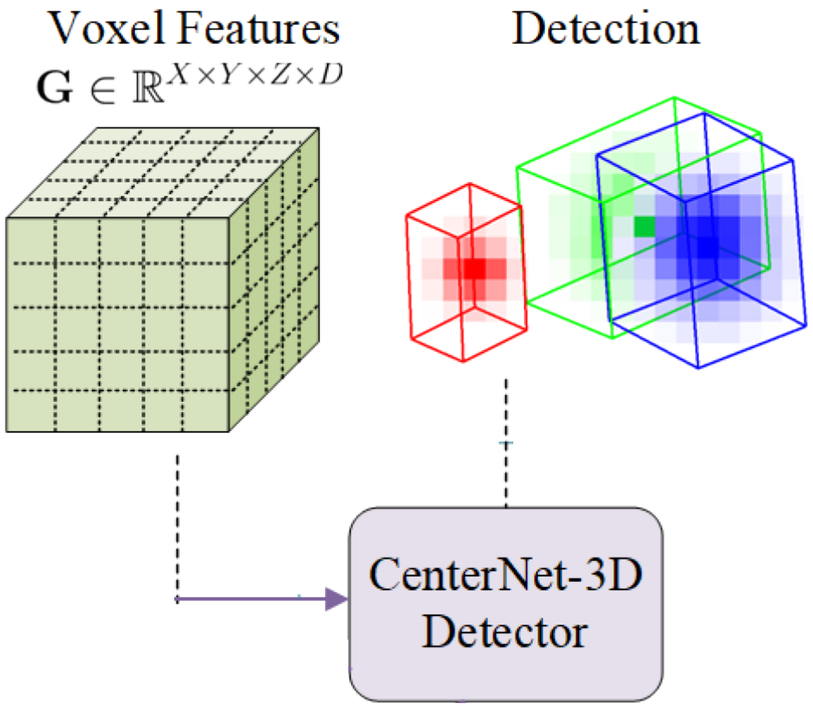
Stage I

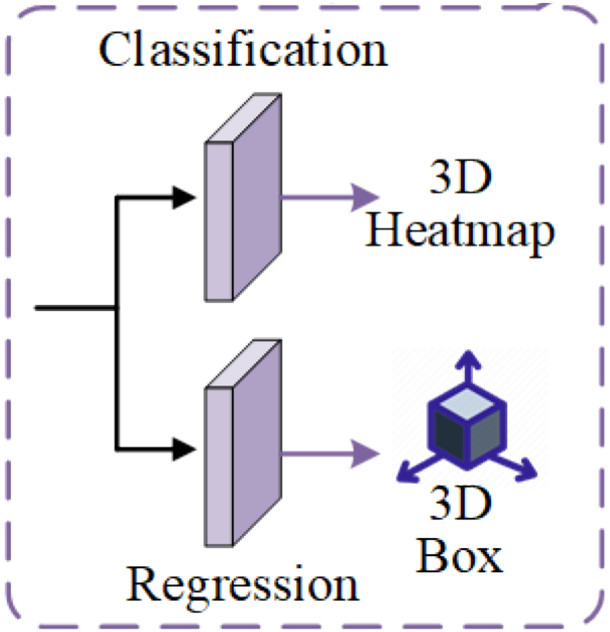




CenterNet-3D Detector

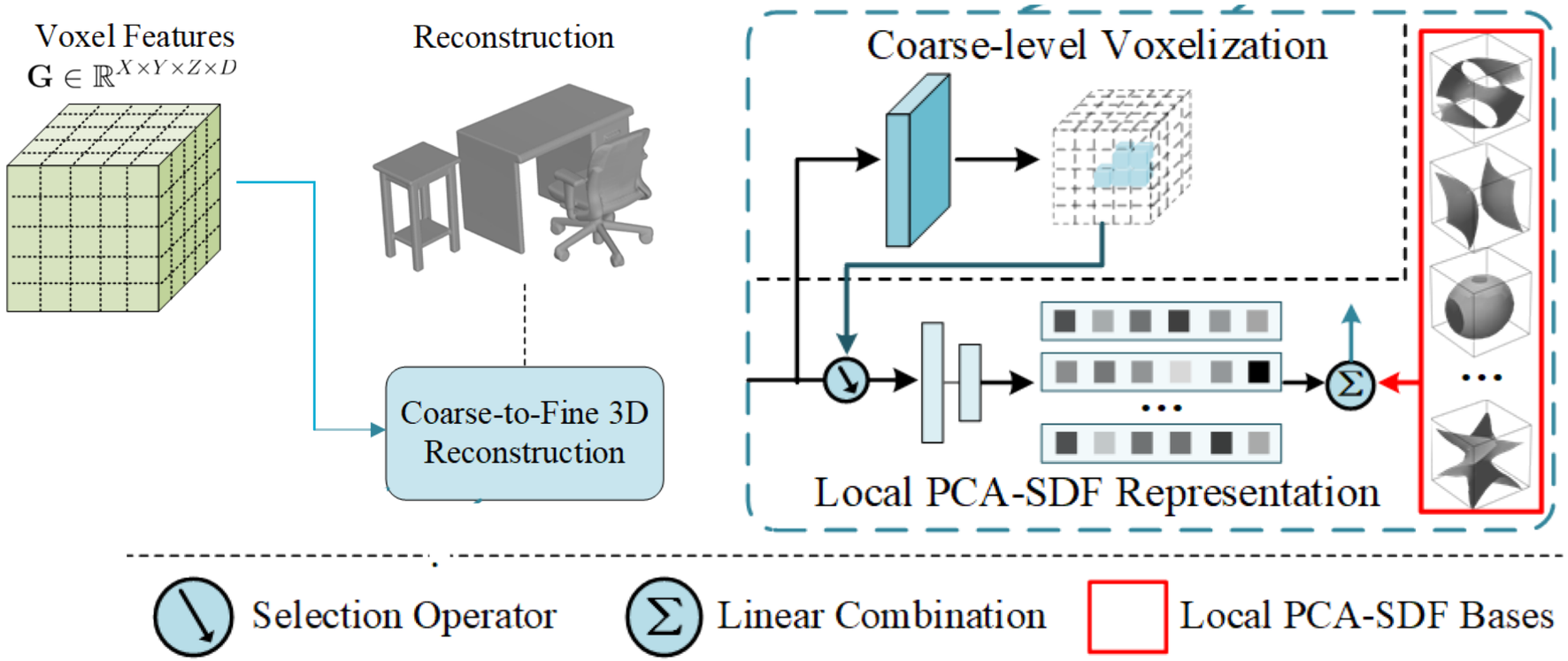
Stage II





Coarse-to-Fine 3D Reconstruction

Stage III



Datasets

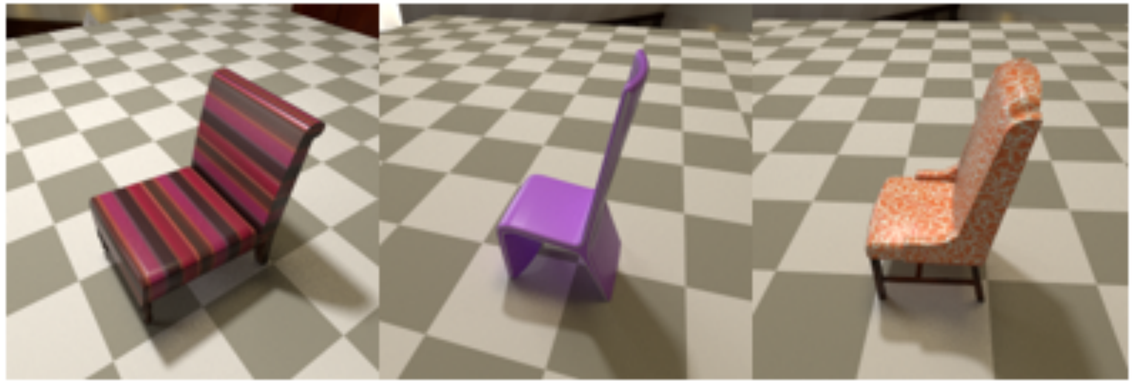
ShapeNet.v2 & CoReNet, with pre-processing

GT

Projected

Results

Pic



GT

Ours

Academic Contribution

- A hybrid 3D object detection and reconstruction pipeline with a single 2D image as input.
- A novel detector called CenterNet-3D, which predicts 3D locations of object center, and produces 3D heatmap and bounding-box of objects presented in the image.
- A coarse-to-fine method based on a novel local PCA-SDF geometry representation. Such representation brings 10x speed-up during inference and provides greater details of local 3D shape.

Concepts Learnt in CS 282

- Types of Machine Learning: supervised & unsupervised learning.
- Components of learning: Target function, hypothesis set, algorithm, …
- Expected Risk Minimization: Training Process.
- Noise and Error: Loss function design, no preference.
- MSE vs. MAE: Loss function, L2, L1.
- Stochastic Gradient Descent: Adam optimizer.
- Perceptron: Multi-Layer Perceptron

Concepts Learnt in CS 282

- Theory of Generalization: VC inequality, Data size and hypothesis set.
- Overfitting and Regularization: Structural Risk Minimization, Regular terms.

Contribution as CS 282 Project

- Re-implement the pipeline, and reproduce the results.
  - Note that the authors open-sourced only a portion of their codes and data, which is not sufficient to run the pipeline.
- Introduce, analyze, and discuss the methods proposed in this paper.
- Discuss our insights, related with the topics introduced in CS 282.

Team

- Teng Xu: Report, Slides, and Presentation. Project Management.
- Kaixin Yao: Overall Pipeline Programming. Responsible for coding.
- Peiheng Cai: Sec. 2.1, Feature Extraction Implementation.
- Jie Fu: Sec. 2.2, CenterNet-3D Detector Implementation.
- Heyang Li: Sec. 2.3, Coarse-to-Fine 3D Reconstruction Implememtation.

Thanks for watching!