POINT CLOUD SEGMENTATION USING HIERARCHICAL TREE FOR ARCHITECTURAL MODELS

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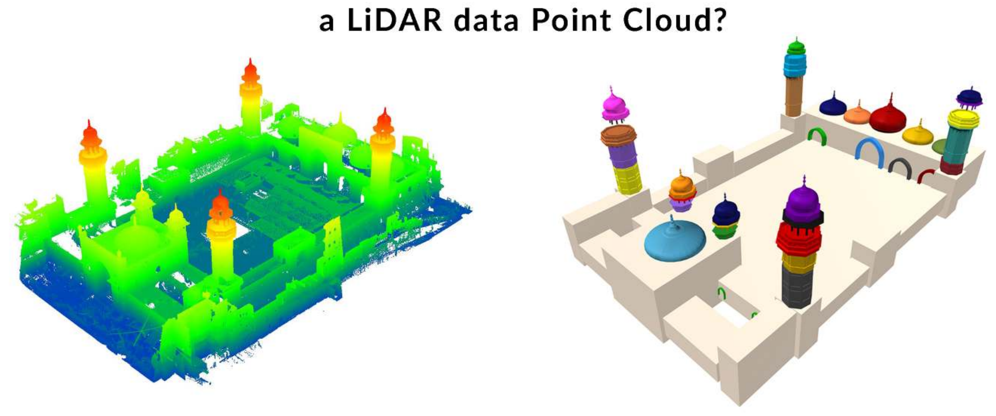
1 Introduction

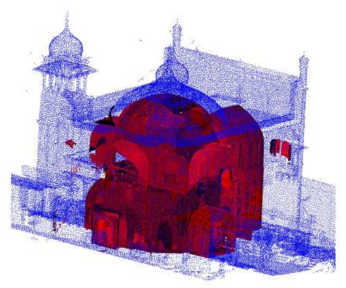
Problem

Can we make a 3D model from a LiDAR data Point Cloud?



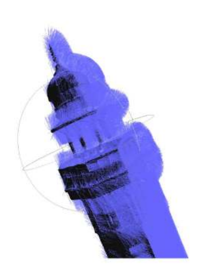
Challenges

(a) Registration



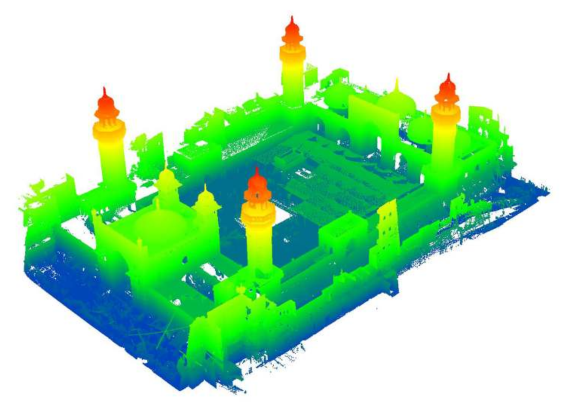
(b) Hollow Regions

(c) Varying density and Occlusion



(d) Normals

2 Pipeline



(a) Point Cloud Processing

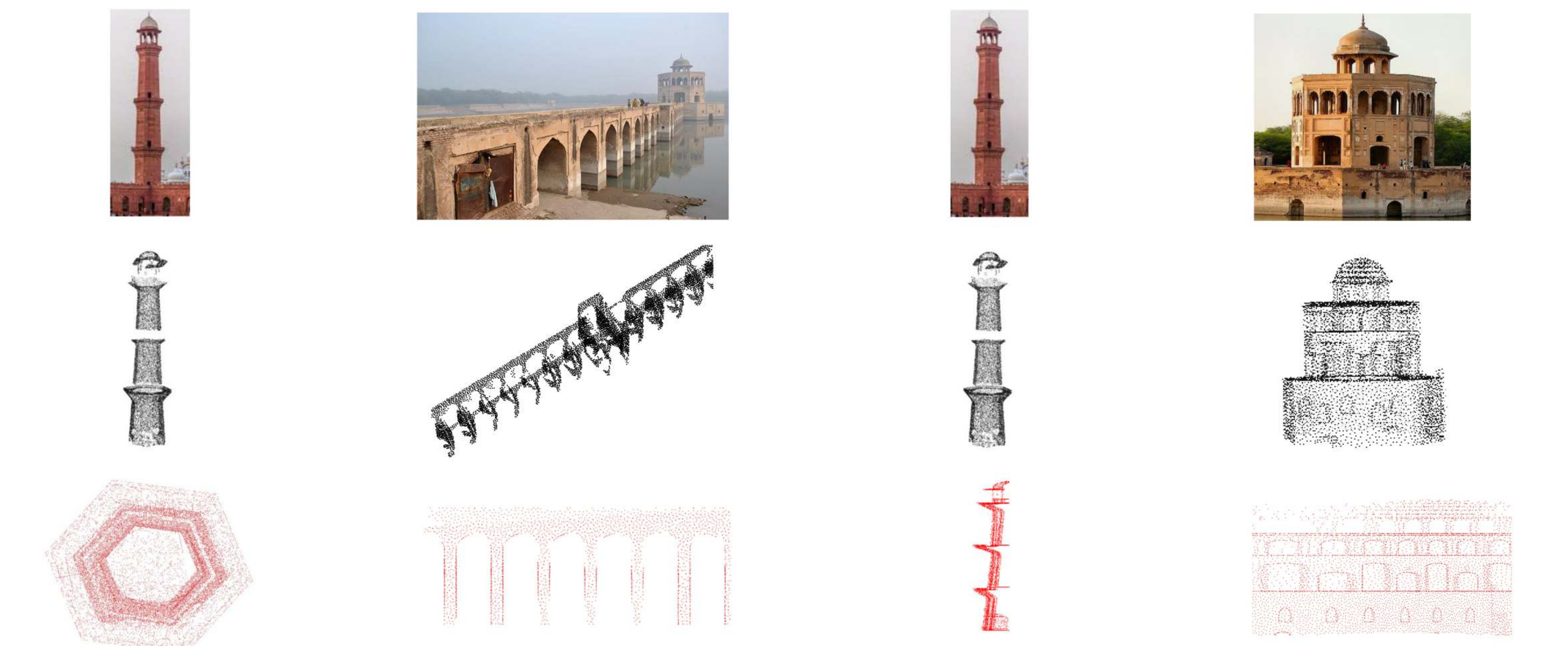
(b) Coarse Segmentation

(c) Spatial Clustering

(d) Hierarchical Segmentation

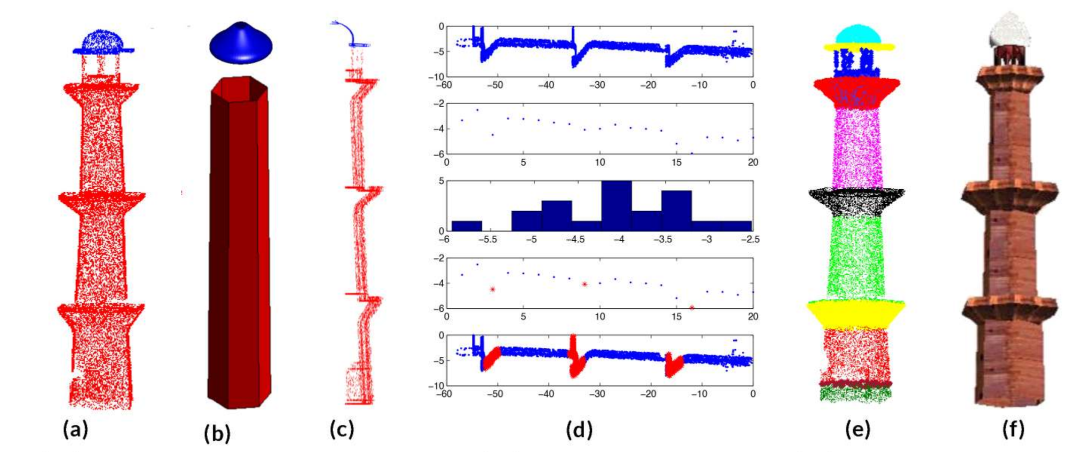
The initial pointcloud was preprocessed and cleaned before performing coarse segmentation on it. Course segmentation was done using the Schnabel algorithm [Schnabel, 2007] which creates coarse segments by performing normals based RANSAC. Using DBScan, the corase segments are further divided into spatial clusters. These spatial clusters are then fed into our hierarchical segmentation algorithm which gives us the final classified segments as output.

3 Three Fundamental Projections



(a) Vertical projection of a minaret. (b) Horizontal projection of arched bridge. (c) Circular projection of a minaret. (d) Planar unwraping of octagonal pavilion.

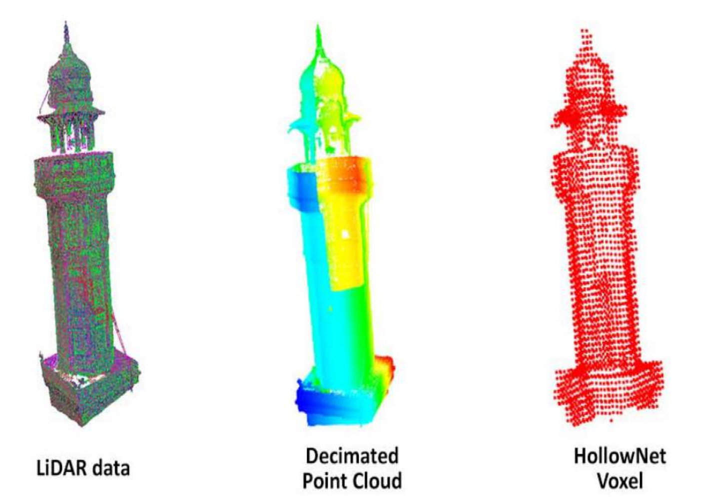
Peak Finding



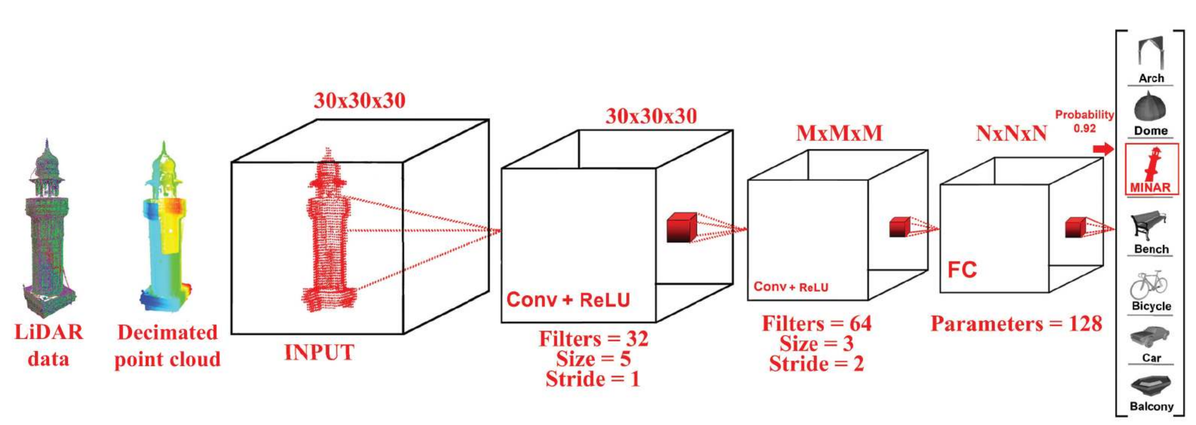
(a) Coarse segmentation. (b) Coarse model. (c) Profile curve. (d) Peak finding on profile curve. (e) Detailed segmentation. (f) Detailed model.

4 HollowNets

Hollow Voxel



HollowNet Architecture



5 Hierarchical Segmentation

Point Density $\epsilon_1 = 1 - \frac{\sigma([N_1, N_2, \ldots, N_s])}{\sigma([1, N_p - 1])}$

Segment Population $\epsilon_2 = \frac{\min(N_p, N_{min})}{N_{min}}.$

Number of Segments $\epsilon_3 = 1 - \sim \mathcal{N}(s|\mu, \sigma^2).$

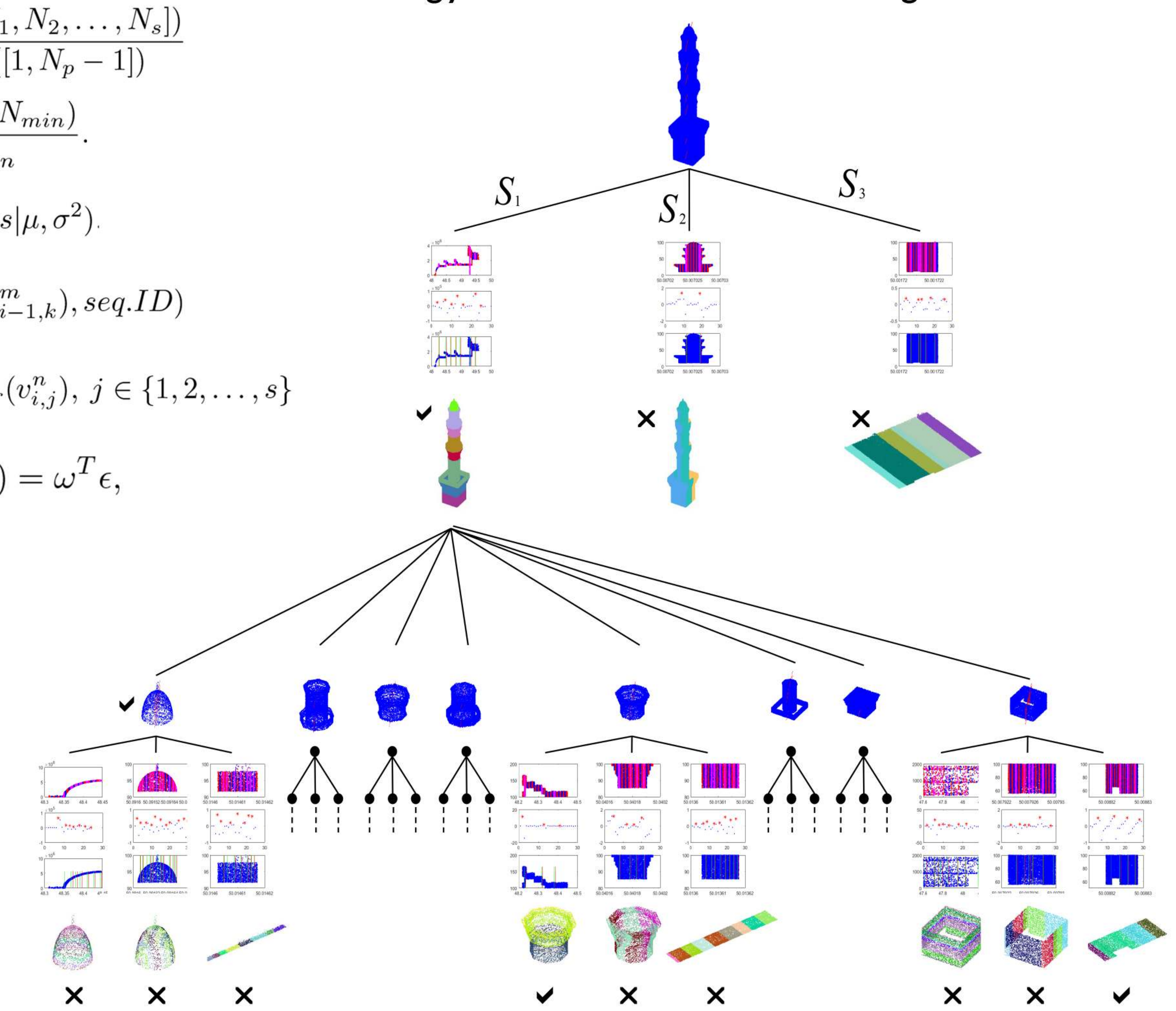
Path Probability $\epsilon_4 = W(r_{ID}(v^m_{i-1,k}), seq.ID)$

Classification Score $\epsilon_5 = \frac{1}{s}\sum r_{scr}(v^n_{i,j}),\ j \in \{1, 2, \ldots, s\}$

Energy $\xi(v^n_{i,j}, v^m_{i-1,k}) = \omega^T \epsilon,$

The spatial clusters from coarse segmentation populate a hierarchical tree, where each segment of the data follows three distinctive sequential paths. The selection of the correct segments has been automated using our novel energy function which utilizes 5 deterministic criteria to evaluate the correct selection of a segment and hence, the worth of a sequence.

Energy based Hierarchical Tree Segmentation



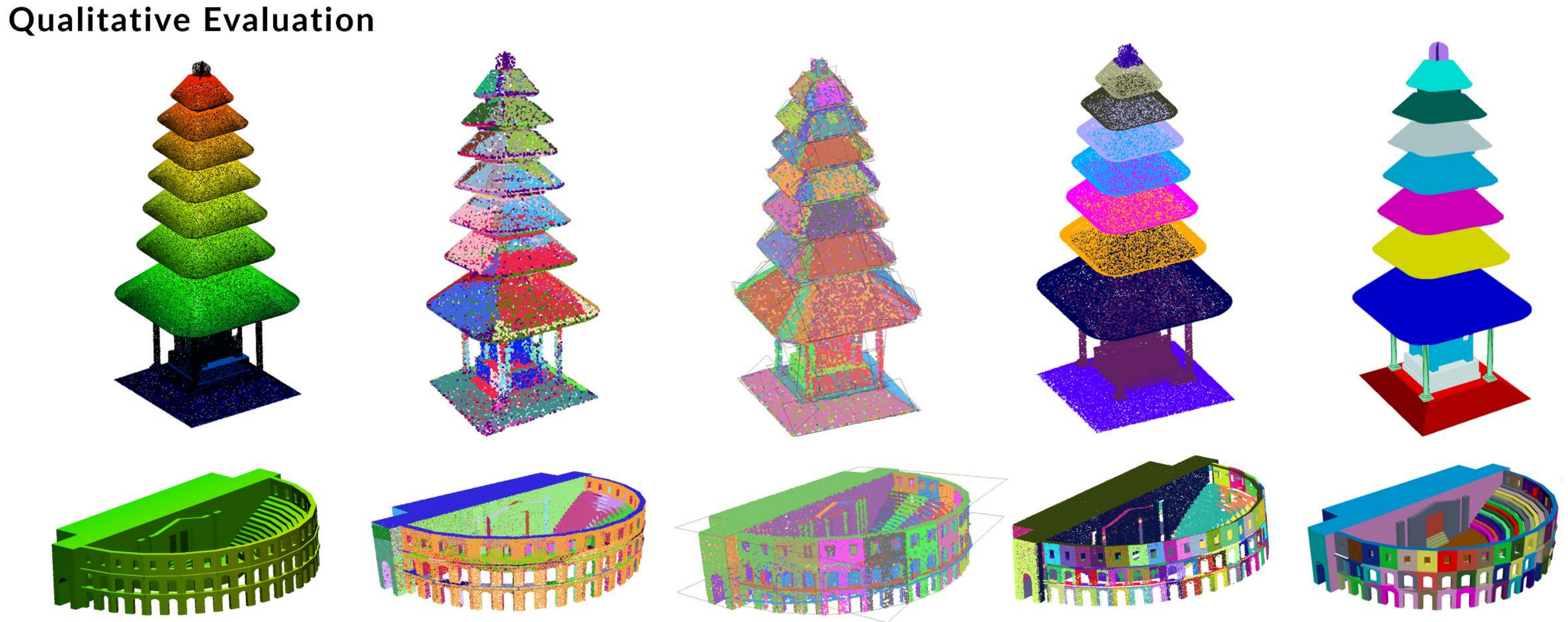
6 Results

Quantitative Evalutaion

Dataset	Points	Mean IOU		
		Schnabel	RAPter	Ours
Temple	100,031	46.89	51.04	**64.87**
Drawar Fort	550,382	48.31	56.43	**58.41**

Site	Dimensions	Points	Arches			Domes			Minarets/Pillars		
	$L \times W \times H\ m^3$	in Bn	GT	AG	Acc	GT	AG	Acc	GT	AG	Acc
Masjid Wazir Khan	$91 \times 53 \times 33$	0.288	46	19	41.30	12	12	100	6	6	100
Masjid Khuadabad	$60 \times 36 \times 16$	0.548	12	7	58.33	21	19	90.4	0	0	NA
Derawar Fort	$1500 \times 1300 \times 30$	0.43	0	0	NA	0	0	NA	38	38	100
Roman building	$20 \times 36 \times 14$	0.02548	79	77	97.44	0	0	NA	0	0	NA
Temple	$10 \times 16 \times 44$	0.0154	0	0	NA	7	7	100	4	0	0

Qualitative Evaluation



Point Cloud | Schnabel 2007 | RAPter 2015 | Ours | Ground Truth

[1] Hassaan, O., Shamail, A., Butt, M.Z., Taj, M.: Outdoor scene segmentation and reconstruction using LiDAR data. In: Pacific Graphics (2017)
[2] Bajwa, R., Gilani, S.R., Taj, M.: 3D architectural modeling: Coarse-to-fine model fitting on point cloud. In: Computer Graphics International (2016)
[3] Abdullah, A., Bajwa, R., Gilani, S.R., Agha, Z., Boor, S.B., Taj, M., Khan, S.: 3D Architectural Modeling: Efficient RANSAC for n-gonal primitive fitting. In: EuroGraphics (2015)

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