DCCVT: Differentiable Clipped Centroidal Voronoi Tessellation

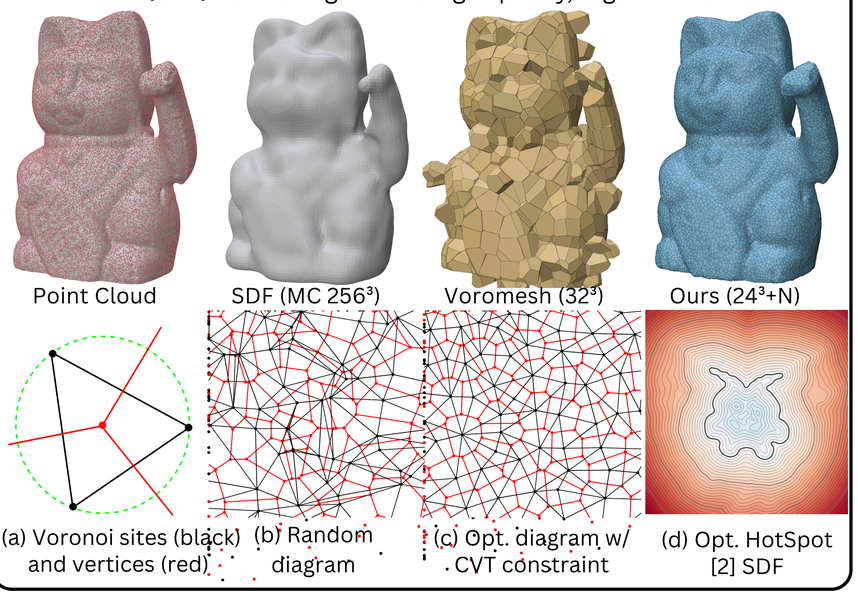
Wylliam Cantin Charawi[1], Adrien Gruson[1], Jane Wu[2], Christian Desrosiers[1], Diego Thomas[3]

1 ÉTS 2 UC Berkeley 3 Kyushu University

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Concept

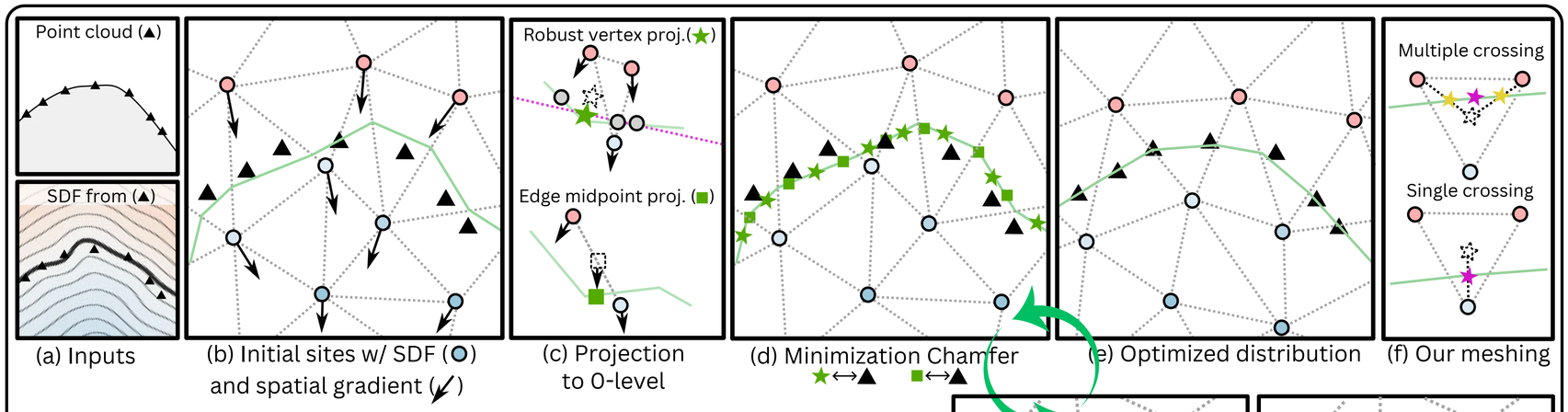
Marching Cubes (MC) and **Deep Marching Tetrahedra (DMTet)** [1] are **efficient**, but produce **irregular**, **suboptimal meshes** that are **difficult** to **integrate** into **deep learning pipelines**. DCCVT is the first **fully differentiable** algorithm for **clipped Centroidal Voronoi Tessellation (CVT)**. We **jointly optimize Voronoi site positions** and **Signed Distance Field (SDF)** values to generate high-quality, regular meshes.



Contribution

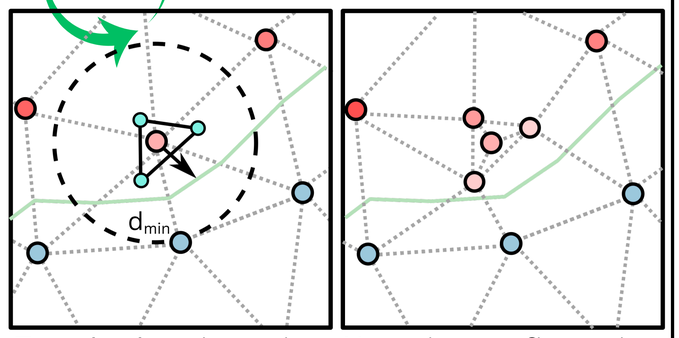
- Centroidal Voronoi Tesselation extraction from a sparse 3D point clouds;
- An expressive end-to-end optimization of Voronoi site position and their SDF values through a clipping operation;
- An iterative upsampling method improving the overall robustness of DCCVT.

Method



Starting from an unoriented 3D point cloud and an inferred SDF estimation from the point cloud (a), we initialize Voronoi sites (b), which yield a discretized SDF (zero-level shown in green). We then project zero-crossing Voronoi vertices (★) and edge midpoints (■) onto the SDF zero-level and minimize the Chamfer distance to the input point cloud (c–d).

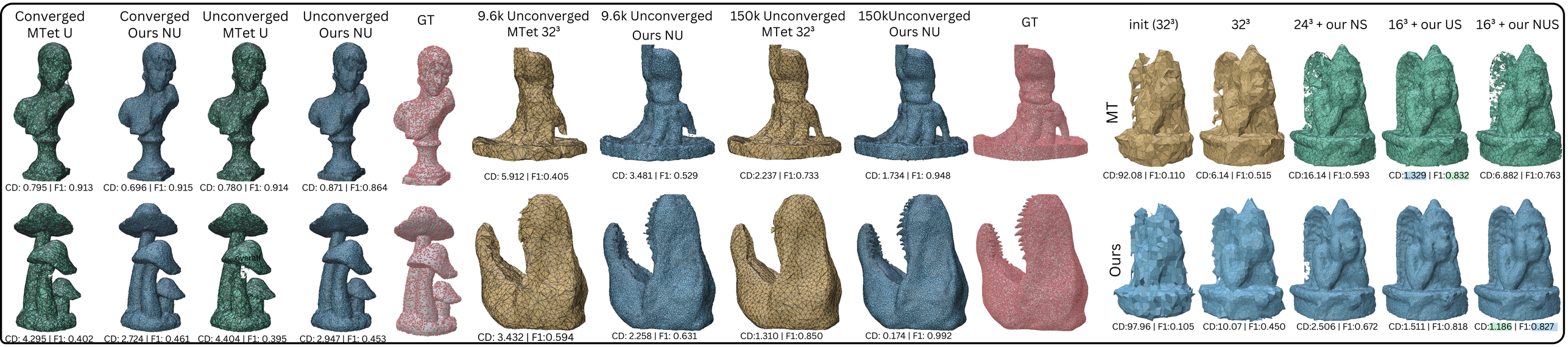
This optimization combined with an adaptive scoring function to upsample complex regions by inserting sites along the SDF gradient produces an improved site distribution and SDF representation (e), from which we extract the final mesh using our Voronoi-based meshing strategy (f), with Voronoi vertices (★).



← Code

Project Page →

Results



[1] Tianchang Shen, Jun Gao, Kangxue Yin, Ming-Yu Liu, and Sanja Fidler. Deep marching tetrahedra: a hybrid representation for high-resolution 3d shape synthesis. NeurIPS, 34, 2021. [2] Zimo Wang, Cheng Wang, Taiki Yoshino, Sirui Tao, Ziyang Fu, and Tzu-Mao Li. Hotspot: Signed distance function optimization with an asymptotically sufficient condition. CVPR, 2025.