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SFB TRR 109 Discretization in Geometry and Dynamics

Freie Universität Berlin

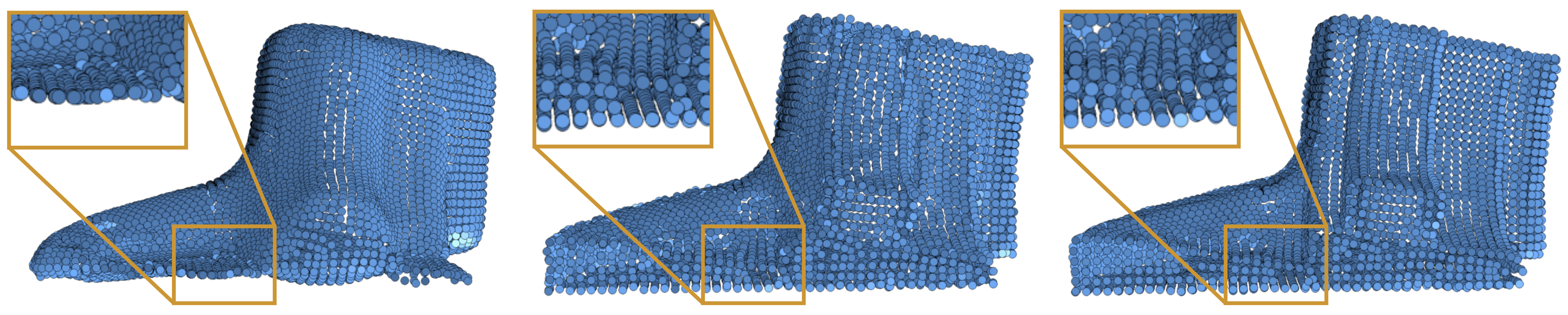
Processing of Point Set Surfaces

Aspects Of The Point Set Processing Pipeline

Point Sets are acquired as representations of surfaces in $\mathbb{R}^3$ e.g. via laser-scanning or LiDaR. At first, they are unstructured and neighborhood relations have to be established. Then, noise added during generation has to be removed robustly also on non-uniform input while retaining features. The obtained cleaned point set can then be used for e.g. surface reconstruction and subsequently for 3D printing.

Shape-Aware Neighborhoods

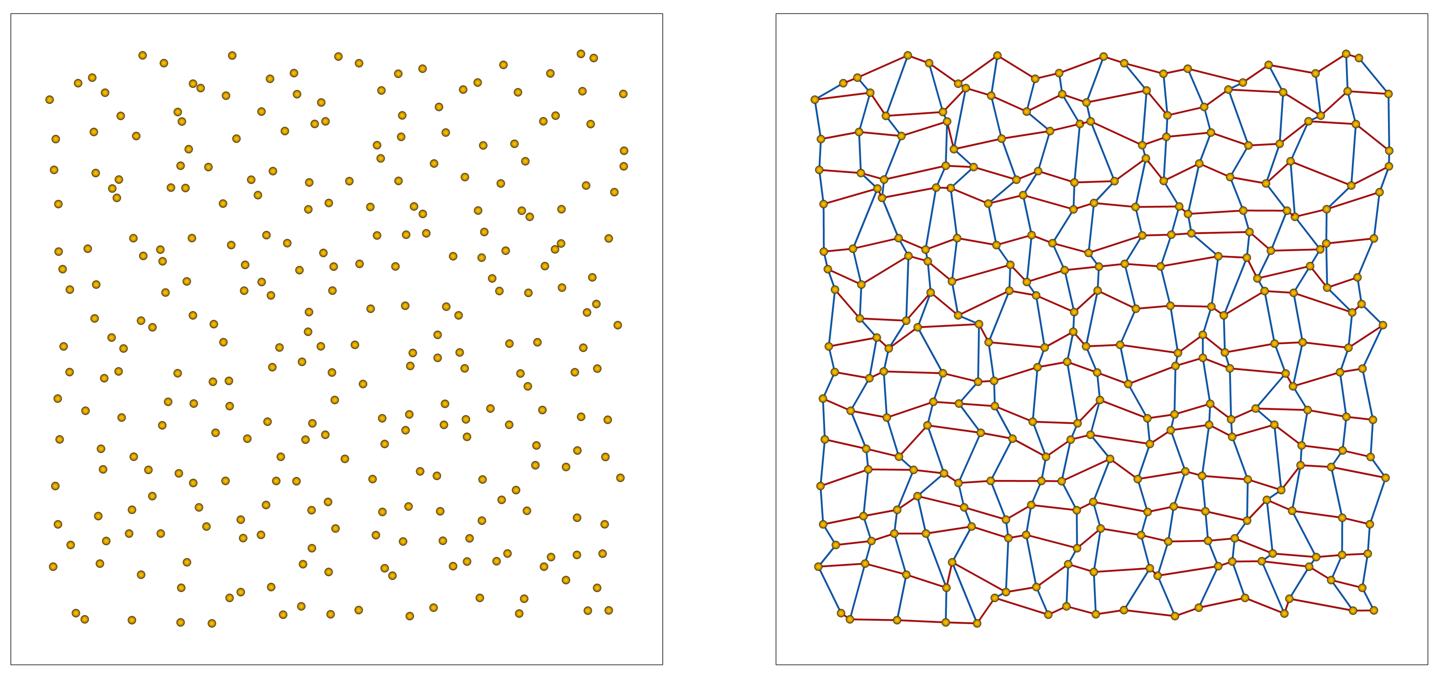
Use normal information as weights in (iterative) neighborhood computation: $\omega_{ij} = \operatorname{sig}\left(\frac{\langle n_i, n_j \rangle + 1}{2}\right)$ for some sigmoid continuously interpolating between 0 and 1 over $[0, 1]$.



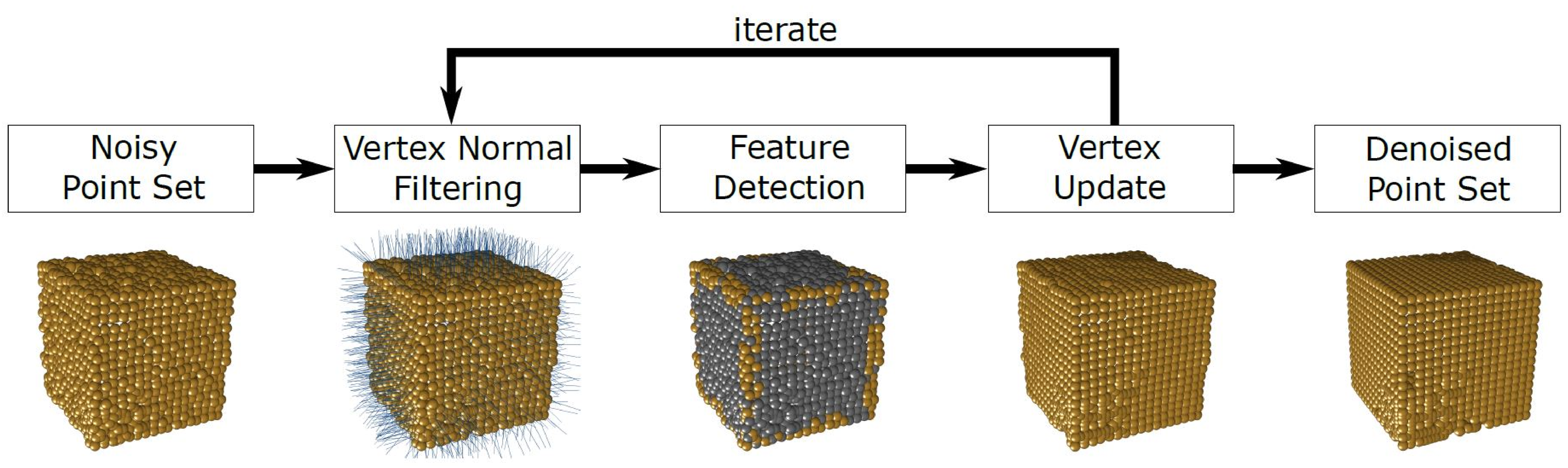
Comparison of Moving Least Squares (MLS, left), MLS with shape-aware neighborhoods (center), and Robust Implicit Moving Least Squares (RIMLS) (right).

Parallelized Approximated Neighborhoods

Impose a grid-structure on a set of points for easy parallelized sorting and approximate neighborhood lookups based on [2], [3].



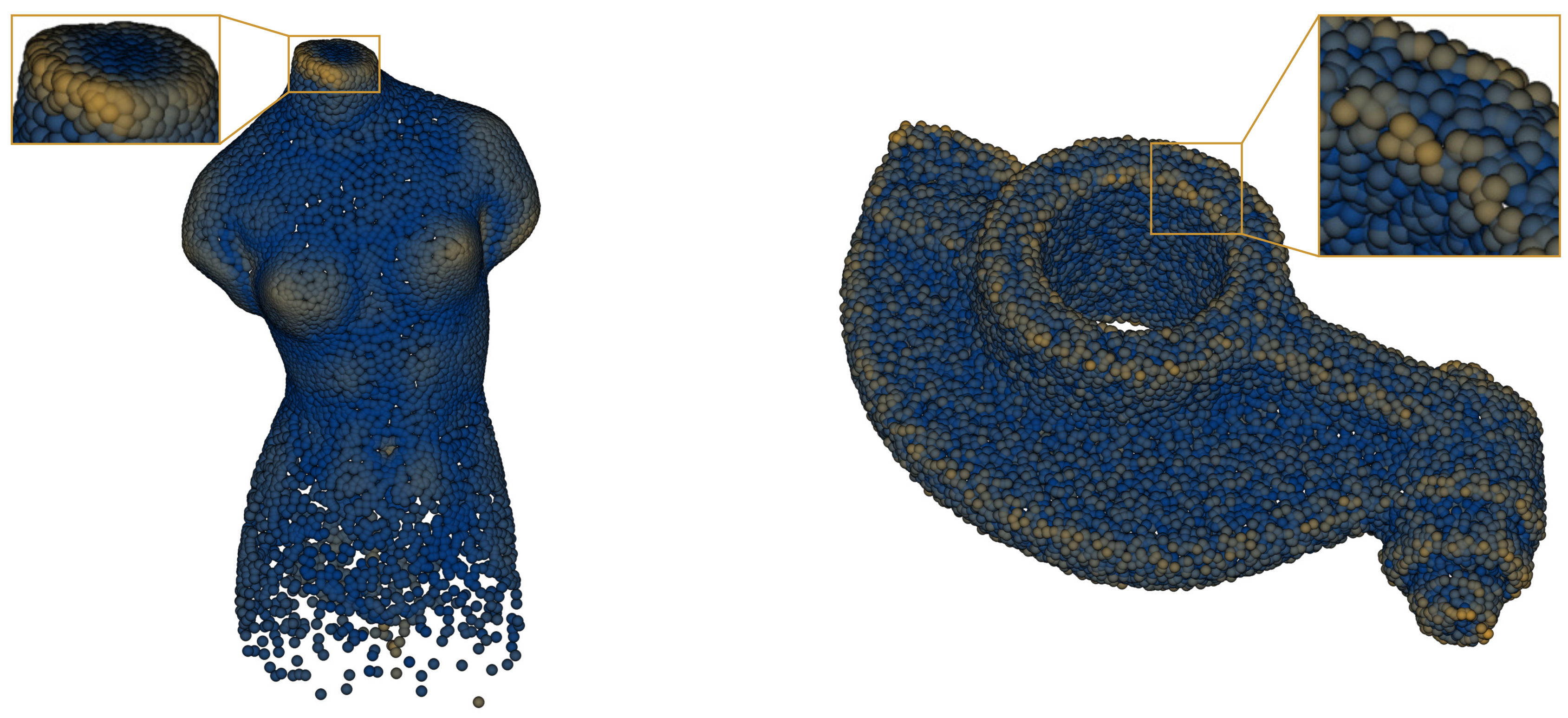
Vertex-Based Normal Voting Tensor (NVT) Denoising



Normal Filtering: Compute eigenvalues of the NVT, perform binary eigenvalue optimization, update normals.
Feature Detection: Use eigenvalues of the covariance matrix.
Vertex Update: Perform constraint movement in direction of smoothed normal field.
This generalizes the procedure of [4] to point sets.

Feature Detection from Moving Least Squares (MLS)

MLS provably produces a smooth manifold for "smooth" input. What happens for samples of sharp objects? Compare the distance of the projected points.



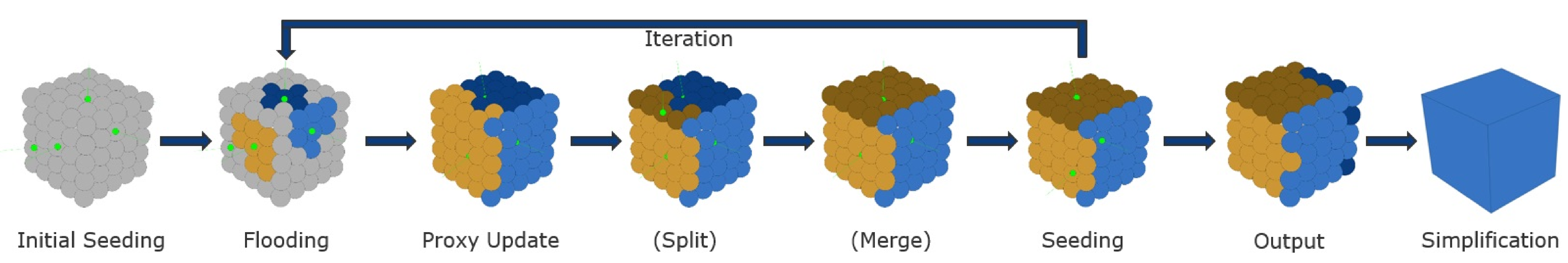
Non-Uniform Density Weights

Project neighbors onto a unit-circle on the tangent plane, assign weights $\delta(\varphi) = \frac{1}{|\mathcal{N}_i|} \sum_{p_j \in \mathcal{N}_i} \psi_j(\varphi)$ according to the angle φ where

$$\psi_j(\varphi) = \begin{cases} \exp\left(\frac{1}{r_i^{-2}(\varphi - \varphi_j)^2 - 1}\right) & \varphi \in (-r_i, r_i) \\ 0 & \text{otherwise} \end{cases}$$

with $r_i = \frac{2\pi}{|\mathcal{N}_i|}$. The weights δ can then be used in any (discrete) operator like the Laplacian, in normal computation, etc.

Variational Shape Approximation (VSA) on Points



Original VSA [1]: Identify locally flat regions of a point set by growing local flat proxies iteratively.
Split: Break a proxy in two if it violates a user-given κ.
Merge: Glue two proxies together if they still satisfy κ.

Results

The presented work is part of the dissertation "Neighborhood Data Structures, Manifold Properties, and Processing of Point Set Surfaces" by Martin Skrodzki, available online at:
https://refubium.fu-berlin.de/handle/fub188/25320
Parts published in peer-reviewed journals:
⋆ Non-uniform density weights: proceedings of GMP'2018 [6],
⋆ NVT Point Set Denoising: proceedings of SMI'2018 [7].

References

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