Analysis of NVT-based Point Set Denoising in Parameter Space

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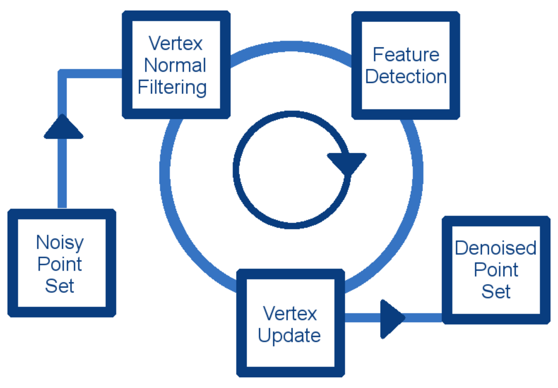
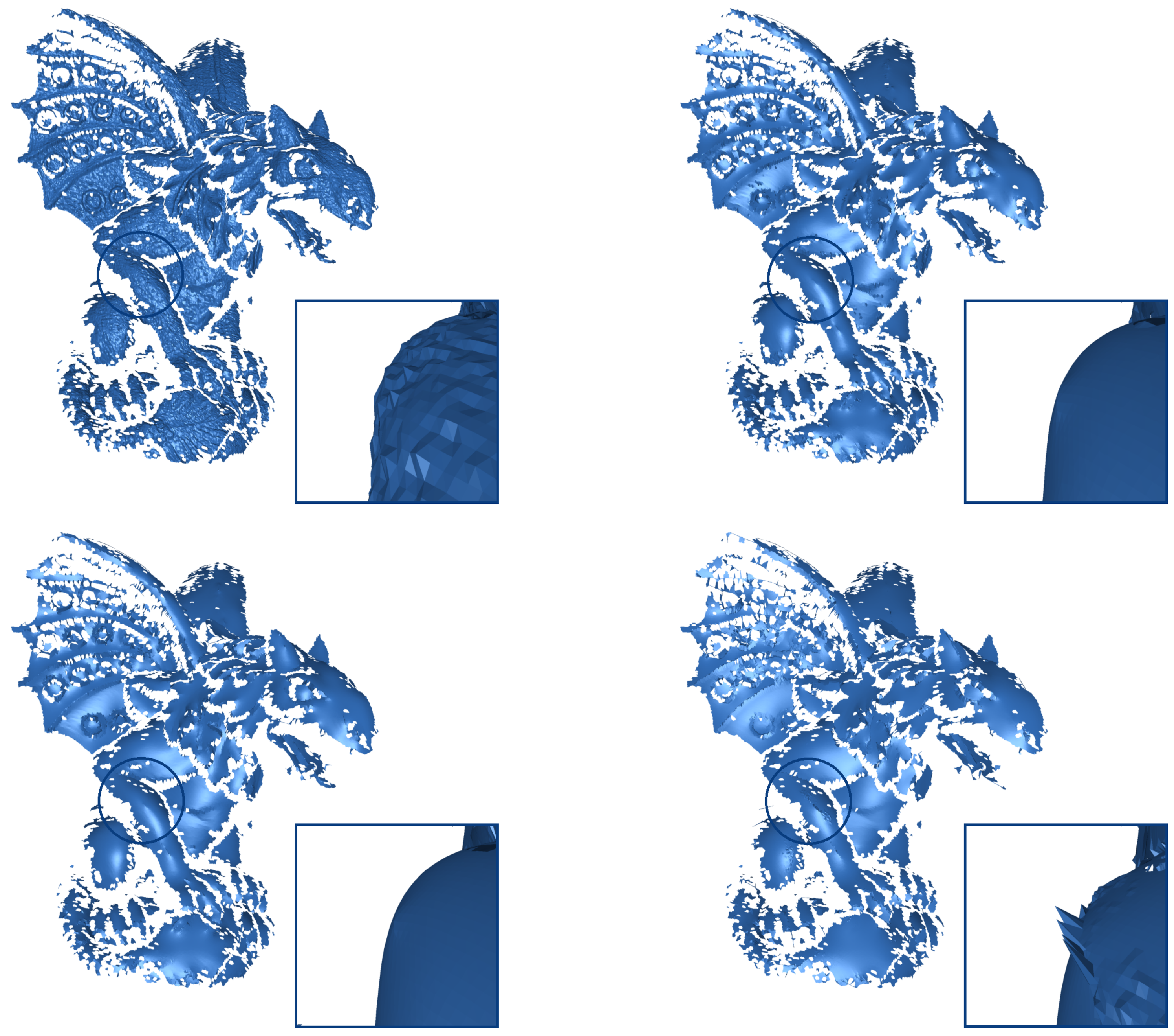
Point Set Denoising

Our point set denoising [1] is an iterative, 3-phase algorithm for noisy point sets. Its parameters offer a variety of tuning opportunities. Used models are the gargoyle (real, noisy, irregular), the Chinese ball and rabbit (real, noisy, many features), the fan disk (sharp features, near-flat areas, $\sigma_n = 0.28 l_e$), the sphere ($\sigma_n = 0.19 l_e$) and the cube (sharp features, $\sigma_n = 0.3 l_e$), with the last 3 being synthetic and noisy. Standard values are $k = 6$, $\rho = 0.9$, $\tau = 0.25$, $\varepsilon = 2r$, $p = 80$, $d = 3$, and $\alpha = 0.1$.



Radius r

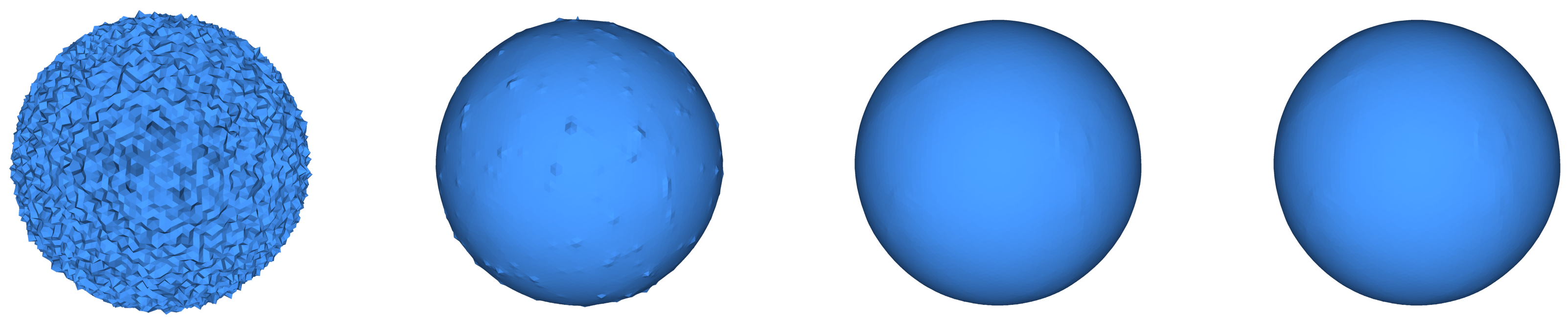
The radius $r \in \mathbb{R}^+$ is twice the average distance of the kNN-neighborhood graph (standard $k = 6$) of the point set.



The gargoyle model and denoising applied with k = 1, 6, and 30.

Distance Constraint ε

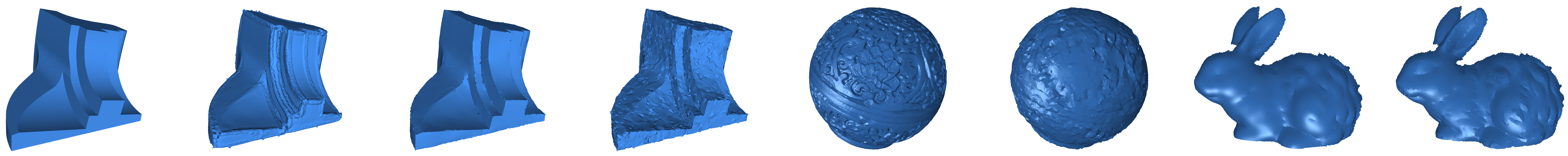
The parameter $\varepsilon \in \mathbb{R}^+$ decides, whether a vertex update takes place utilizing a movement forecast and a comparison to the moved distance (according to the initial position).



The sphere model and denoising applied with $\varepsilon \in \{0.05, 0.0876, 0.3\}$.

Dihedral Angle Threshold ρ

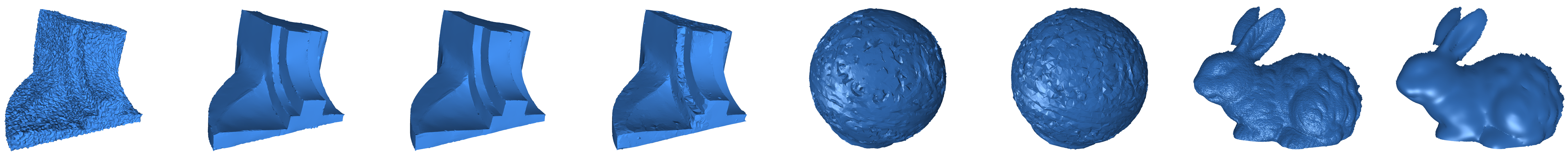
The threshold $\rho \in [-1, 1]$ decides whether a neighborhood weight gets assigned value 0 or 1 w.r.t. normal similarity during its determination in phase 1 and 2.



The fan disk model, denoised versions with $\rho \in \{0.3, 0.9, 0.99\}$, the Chinese ball, denoised with $\rho = 0.75$, and the denoised rabbit with $\rho = 0.95, 0.99$.

Eigenvalue Threshold τ

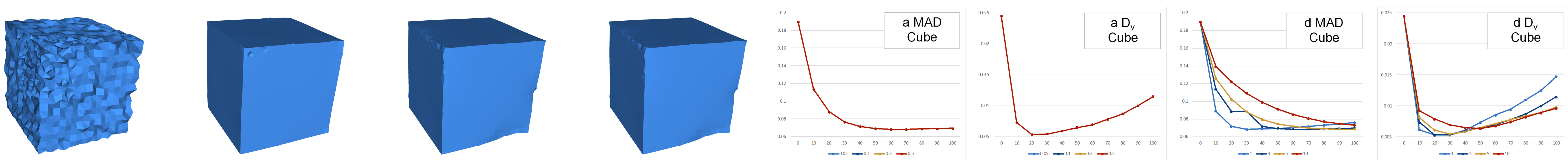
The value $\tau \in [0, 1]$ decides whether eigenvalues of the tensors in phase 1 and 2 get assigned 0 or 1. Dominant ones get strengthened, the others weakened.



The noisy fan disk, denoised versions with $\tau \in \{0.1, 0.35, 0.45\}$, denoised Chinese ball with $\tau = 0.1, 0.45$, and the rabbit model, denoised with $\tau = 0.25$.

Iterations p - Smoothing Limiter α - Damping Factor d

Finally, we consider the number of iterations $p \in \mathbb{N}$, as the point set changes dynamically, the damping factor $d \in \mathbb{N}$, controlling the impact on the updated normal in phase 1, and the smoothing limiter $\alpha \in \mathbb{R}^+$, influencing the weights applied to flat points in phase 3. The convergence analysis is taken via the mean angular deviation (MAD) and an L_2 vertex-based error metric (D_v), see [1].



The cube model, denoised versions with ($\rho = 0.95, \tau = 0.3$), $\alpha = 0.1$, $d = 3$, and the plotted error values.

Future Work

- Examining cross correlations between parameters
- Automated model-based parameter selection

References

[1] S. K. Yadav, U. Reitebuch, M. Skrodzki, E. Zimmermann, and K. Polthier, 2018, 'Constraint-based point set denoising using normal voting tensor and restricted quadratic error metrics', Computers & Graphics. DOI: https://doi.org/10.1016/j.cag.2018.05.014.