RGB-D Mapping and Tracking in a Plenoxel Radiance Field

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APPENDIX

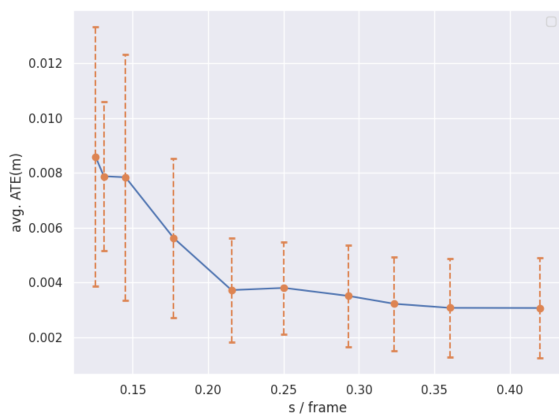

Figure 1. Average ATE error on Replica subsets regarding to the tracking speed. Standard deviation of error along 5 sequences are displayed in dotted line.

Appendix A

We explain the derivative of a tri-linear interpolated grid function with respect to a sample location as is present in equations 8 and 9 from the paper Let $p_i = (x_i, y_i, z_i)$ be the sample location and let the function $f(p)$ represent the tri-linearly interpolated grid function (Either $\vec{c}$ or $\vec{\sigma}$ in our case) where $[v_{000}, ..., v_{111}]$ are the eight closest vertices of p_i. Further let (x_0, y_0, z_0) represent the lattice points below, and (x_1, y_1, z_1) represent the lattice points above the location (x_i, y_i, z_i). The trilinear interpolation can then be described by the equation:

$$f(p_i) = f(x, y, z) = v_i$$
$$\approx a_0 + a_1 x_i + a_2 y_i + a_3 z_i + a_4 x y_i + a_5 x_i z_i + a_6 y_i z_i + a_7 x_i y_i z_i$$

where

$$\begin{bmatrix} 1 & x_0 & y_0 & z_0 & x_0 y_0 & x_0 z_0 & y_0 z_0 & x_0 y_0 z_0 \\ 1 & x_1 & y_0 & z_0 & x_1 y_0 & x_1 z_0 & y_0 z_0 & x_1 y_0 z_0 \\ 1 & x_0 & y_1 & z_0 & x_0 y_1 & x_0 z_0 & y_1 z_0 & x_0 y_1 z_0 \\ 1 & x_1 & y_1 & z_0 & x_1 y_1 & x_1 z_0 & y_1 z_0 & x_1 y_1 z_0 \\ 1 & x_0 & y_0 & z_1 & x_0 y_0 & x_0 z_1 & y_0 z_1 & x_0 y_0 z_1 \\ 1 & x_1 & y_0 & z_1 & x_1 y_0 & x_1 z_1 & y_1 z_1 & x_1 y_0 z_1 \\ 1 & x_0 & y_1 & z_1 & x_0 y_1 & x_0 z_1 & y_1 z_1 & x_0 y_1 z_1 \\ 1 & x_1 & y_1 & z_1 & x_1 y_1 & x_1 z_1 & y_1 z_1 & x_1 y_1 z_1 \end{bmatrix} \begin{bmatrix} a_0 \\ a_1 \\ a_2 \\ a_3 \\ a_4 \\ a_5 \\ a_6 \\ a_7 \end{bmatrix} = \begin{bmatrix} v_{000} \\ v_{001} \\ v_{010} \\ v_{011} \\ v_{100} \\ v_{101} \\ v_{110} \\ v_{111} \end{bmatrix} \quad (1)$$

As all voxels are locally independent we can treat the lower lattice points (x_0, y_0, z_0) as $(0, 0, 0)$ greatly simplifying the equations.

Then if the partial derivatives of these equations are computed with respect to $p_i = (x_i, y_i, z_i)$ we get:

$$\begin{aligned} \frac{\partial v_i}{\partial x_i} &= a_1 + a_4 y_i + a_5 z_i + a_7 y_i z_i \\ \frac{\partial v_i}{\partial y_i} &= a_2 + a_4 x_i + a_6 z_i + a_7 x_i z_i \\ \frac{\partial v_i}{\partial z_i} &= a_3 + a_5 x_i + a_6 y_i + a_7 x_i y_i \end{aligned} \quad (2)$$

Appendix B

Fig. 1 displays the speed-accuracy trade-off curves obtained by testing different settings across the eight sequences from the Replica dataset. Comparing the result of NICE-SLAM in table 2, it indicates that even if we reduce the allotted tracking time of our method to just 0.075s per frame, our method still outperforms NICE-SLAMs results attained using double the computation time.

*Authors contributed equally to this work.