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 \( \hat{c} \) or \( \hat{d} \) 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:

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

where

\[
\begin{bmatrix}
1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\
1 & 0 & 1 & 0 & 1 & 0 & 1 & 0 \\
1 & 1 & 1 & 1 & 0 & 0 & 0 & 0
\end{bmatrix}
\begin{bmatrix}
0 \\
a_0 \\
a_1 \\
a_2 \\
a_3 \\
a_4 \\
a_5 \\
a_6 \\
a_7
\end{bmatrix}
= \begin{bmatrix} v_{000} \\ v_{001} \\ v_{010} \\ v_{011} \\ v_{100} \\ v_{101} \\ v_{110} \\ v_{111} \end{bmatrix}
\]

(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 \( p_1 = (x_1, y_1, z_1) \) we get:

\[
\frac{\partial v_i}{\partial x_i} = a_1 + a_4 y_i + a_5 z_i + a_7 y_i z_i \\
\frac{\partial v_i}{\partial y_i} = a_2 + a_4 x_i + a_6 z_i + a_7 x_i z_i \\
\frac{\partial v_i}{\partial z_i} = a_3 + a_5 x_i + a_6 y_i + a_7 x_i y_i
\]

(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.