Uniform Subdivision of Omnidirectional Camera Space for Efficient Spherical Stereo Matching - Supplemental Document -

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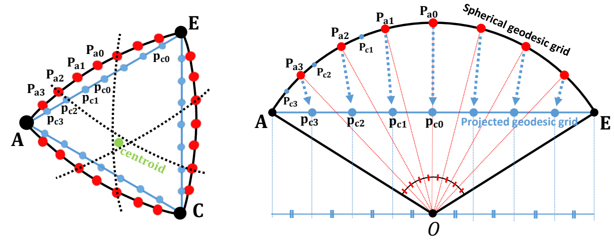
1. Subdivision Scheme Comparison

There are three well-known Class 1 subdivision schemes of the spherical geodesic grid by intersecting equal-chord, mid-arc, and equal-arc reference points. Equal-arc and equal-chord reference points are defined on the edges of the spherical PPT and the planner PPT, respectively (see Figure 1b). Three different methods are:

- The equal-chord-based spherical geodesic grid ($\mathbf{p}_{\mathbf{a}_{0\sim4}}$) is obtained by projecting intersection grid points ($\mathbf{p}_{\mathbf{c}_{0\sim4}}$) generated by connecting the equal-chord reference points with straight lines. The equal-chord approach results in unequal arc lengths between edge reference points when projected to the sphere's surface. It is an equally subdivided grid in projected plane and a distorted grid in spherical plane ($\mathbf{P}_{\mathbf{c}_{0\sim4}} \neq \mathbf{P}_{\mathbf{a}_{0\sim4}}$).

- The mid-arc spherical geodesic grid is obtained by iterative projection of midpoints of the planar PPT's edges on a sphere. This method is the most frequently used subdivision scheme because of its intuitively simple implementation in the 3D world [1–5]. However, there are no similar triangles on the spherical geodesic grid because of the iterative subdivision of pentagons and hexagons, and the level of subdivision is limited as powers of two. Above all, because the grid is constructed based on the hierarchical triangles created by iterative subdivision, we have to calculate and save all the 3D coordinates of cells for the spherical geodesic grid.

- The equal-arc subdivision method is based on equal-arc reference points. Three great circles are intersected, but they do not meet at a single point. Instead, they meet at three different points on the spherical PPT. Centroid points of small triangles made by three points are projected to the surface of the sphere (Figure 1b). The equal-arc-based spherical geodesic grid is known to be an almost uniform grid because in-between distance and area of cells are almost the same when using a sufficiently large subdivision level ($\mathbf{P}_{\mathbf{a}_{0\sim4}}$). As shown in Figure 1a, the equal-arc subdivision needs an iterative process of taking centroid points of intersecting triangular points. Therefore pre-calculated LUT is needed to define a projected spherical to planar correspondence.



(a) (b)

Figure 1. (a) Equal-arc subdivision on the spherical PPT. Three great arcs that are parallel to the edges of the PPT do not meet in a point. A centroid point of the triangle is defined as a vertex of the geodesic grid. (b) The transformation method of the geodesic grid using equal-arc subdivision. There is no formulated relationship but a projection algorithm using a neighboring relative position of pixels on each grid plane.

2. Additional Results

Figure 2 qualitatively compares more synthetic results of our method with those of the LL-based stereo matching. Compared with the ground truth maps, our method outperforms the LL-based stereo matching method particularly near pole regions at the leftmost and rightmost ends, showing less disparity errors and noise.

References

[1] Taco S Cohen, Maurice Weiler, Berkay Kicanaoglu, and Max Welling. Gauge equivariant convolutional networks and the icosahedral cnn. *arXiv preprint arXiv:1902.04615*, 2019. 1

[2] Hao Guan and William AP Smith. BRISKS: Binary features for spherical images on a geodesic grid. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*, pages 4516–4524, 2017. 1

[3] Chiyu Jiang, Jingwei Huang, Karthik Kashinath, Philip Marcus, Matthias Niessner, et al. Spherical CNNs on unstructured grids. *arXiv preprint arXiv:1901.02039*, 2019. 1

[4] Yeonkun Lee, Jaeseok Jeong, Jongseob Yun, Wonjune Cho, and Kuk-Jin Yoon. SpherePHD: Applying CNNs on a spher-

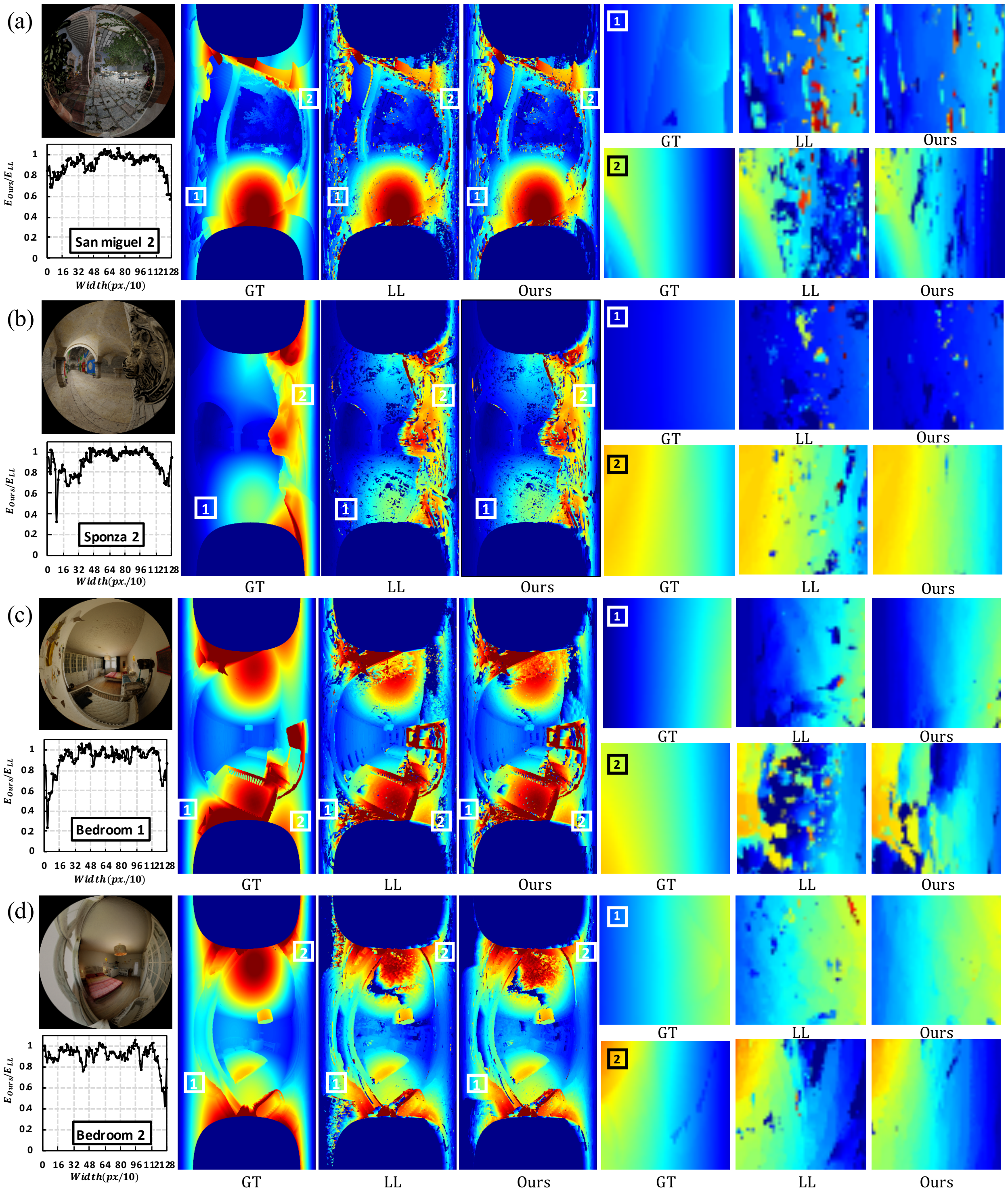


Figure 2. Results of four synthetic datasets. Left-top is the left image of fisheye stereo; left-bottom is the ratio of error pixels by 10-pixel-step in x-axis; GT disparity map; LL-based disparity map; Our disparity map; Comparison of disparity results at two identical positions.

ical polyhedron representation of 360 degree images. *arXiv preprint arXiv:1811.08196*, 2018. 1

[5] Chao Zhang, Stephan Liwicki, William Smith, and Roberto Cipolla. Orientation-aware semantic segmentation on icosahedron spheres. In *Proceedings of the IEEE International Conference on Computer Vision*, pages 3533–3541, 2019. 1