In this dissertation, we propose efficient 3-D geometry representation and compression algorithms based on triangular meshes and point clouds. First, we propose a unified approach to rate-distortion (R-D) optimized compression and view-dependent transmission of 3-D normal meshes. A normal mesh is partitioned into several segments, which are then encoded independently. The bitstream of each segment is truncated optimally to minimize the geometry distortion subject to the constraint on a total rate with the Lagrangian multiplier method. A geometry distortion model is also developed based on the semi-regular subdivision hierarchy of normal meshes. It is shown that the proposed compression algorithm yields a higher coding gain than the conventional algorithm. Moreover, to facilitate interactive transmission of 3-D data according to a client's viewing position, the server can allocate an adaptive bitrate to each segment based on its visibility priority. Simulation results demonstrate that the view-dependent transmission technique can reduce the bandwidth requirement considerably, while maintaining a good visual quality.

Secondly, we propose a lossless compression algorithm for 3-D point data in QSplat representation. In QSplat representation, each point is treated as a sphere and its geometry and normal data are stored in the hierarchical structure of bounding spheres. The proposed algorithm sorts child spheres according to their positions to reduce the index sets for radii and positions. Moreover, each position index is adaptively encoded using the parent normal to further improve the coding gain. Also, the proposed algorithm compactly encodes normal data by exploiting high correlation between parent and child normals. Simulation results show that the proposed algorithm saves up to 60% of storage space, while providing a lossless representation of original point data.

Thirdly, we investigate a lossy compression algorithm of 3-D point geometry based on QSplat hierarchy and vector quantization (VQ). The positions of child spheres are transformed to local coordinates, where the center and an axis are determined by the position and the normal vector of the parent sphere, respectively. Then, one of the other two axes is set by projecting a child position onto the perpendicular plane to the parent normal vector. The coordinate transform makes positions more compactly distributed in 3-D space, facilitating effective quantization. The transformed positions of child spheres are grouped into an input vector, and quantized per each parent sphere using VQ. The generalized Lloyd algorithm (GLA) is employed to design VQ codebooks. By encoding a group of points jointly, the proposed algorithm can achieve a higher coding gain. Moreover, the radius is quantized as a scalar such that the quantized sphere is larger than the original one, in order to guarantee hole-free surface reconstruction at the decoder side.

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