CLAIMS

What is claimed is:

1. A method of point cloud attribute compression using at least one processor, the method comprising:

obtaining a plurality of three-dimensional (3D) patches of a point cloud, each 3D patch comprising a set of 3D points, each point having associated therewith corresponding attribute information;

generating, for each of the plurality of 3D patches, a two-dimensional (2D) attribute image of the 3D patch, to obtain a plurality of 2D attribute images of the plurality of 3D patches, wherein for at least a first 3D patch of the plurality of 3D patches, the 2D attribute image of the first 3D patch is generated based on a first attribute image generation process;

generating a 2D attribute image of the point cloud based on the plurality of 2D attribute images of the plurality of 3D patches; and

compressing the 2D attribute image of the point cloud based on a 2D image codec to obtain a compressed 2D attribute image of the point cloud,

wherein the first attribute image generation process comprises:

a point linearization stage configured to transform a set of 3D points of an input 3D patch inputted thereto into a one-dimensional (1D) point sequence of the input 3D patch; and

a first 2D space filling stage configured to map the 1D point sequence of the input 3D patch to a first 2D image pixel grid to generate a 2D attribute image of the input 3D patch, wherein the point linearization stage comprises:

partitioning the set of 3D points of the input 3D patch into a first point subset and a second point subset of the set of 3D points of the input 3D patch; and

partitioning, for each point subset of the first and second point subsets, a set of 3D points of the point subset into a new first point subset and a new second point subset to replace the point subset in the set of 3D points of the input 3D patch, wherein for said partitioning, for each point subset of the first and second point subsets, the set of 3D points of the point subset, a first 3D point of the second point subset which is nearest to a first pivot point of the first point subset is set as a first pivot point of the second point subset; wherein for said partitioning the set of 3D points of the input 3D patch, the method further comprises:

setting a first 3D point of the set of 3D points of the input 3D patch which is farthest from a centroid of the set of 3D points of the input 3D patch as a first pivot point of the set of 3D points of the input 3D patch; and

setting a second 3D point of the set of 3D points of the input 3D patch which is farthest from the first pivot point of the set of 3D points as a second pivot point of the set of 3D points of the input 3D patch, and

wherein said partitioning the set of 3D points of the input 3D patch comprises assigning each 3D point of the 3D points of the input 3D patch, except the first and second 3D points, to its nearest pivot point amongst the first and second pivot points of the set of 3D points to form the first point subset and the second point subset, the first point subset comprising the 3D points assigned to the first pivot point of the set of 3D points and the second point subset comprising the 3D points assigned to the second pivot point of the set of 3D points.

2. The method according to claim 1, wherein for said partitioning, for each point subset of the first and second point subsets, the set of 3D points of the point subset, the method further comprises:

setting a first 3D point of the first point subset corresponding to the first pivot point of the set of 3D points as a second pivot point of the first point subset;

setting a second 3D point of the first point subset which is farthest from the second pivot point of the first point subset as the first pivot point of the first point subset;

setting the first 3D point of the second point subset which is nearest to the first pivot point of the first point subset as the first pivot point of the second point subset; and

setting a second 3D point of the second point subset which is farthest from the first pivot point of the second point subset as the second pivot point of the second point subset.

3. The method according to claim 2, wherein said partitioning, for each point subset of the first and second point subsets, the set of 3D points of the point subset, comprises:

assigning each 3D point of the 3D points of the first point subset, except the first and second 3D points of the first point subset, to its nearest pivot point amongst the first and second pivot points of the first point subset to form the new first point subset and the new second point subset to replace the first point subset in the set of 3D points of the input 3D patch, the new first point subset comprising the 3D points assigned to the first pivot point of the first

point subset and the new second point subset comprising the 3D points assigned to the second pivot point of the first point subset; and

assigning each 3D point of the 3D points of the second point subset, except the first and second 3D points of the second point subset, to its nearest pivot point amongst the first and second pivot points of the second point subset to form the new first point subset and the new second point subset to replace the second point subset in the set of 3D points of the input 3D patch, the new first point subset comprising the 3D points assigned to the first pivot point of the second point subset and the new second point subset comprising the 3D points assigned to the second pivot point of the second point subset.

4. The method according to any one of claims 1 to 3, wherein

the point linearization stage further comprises, for each point subset in the set of 3D points of the input 3D patch iteratively until all point subsets therein have only one 3D point in each, partitioning a set of 3D points of the point subset into a new first point subset and a new second point subset to replace the point subset in the set of 3D points of the input 3D patch, to obtain a processed set of 3D points of the input 3D patch comprising ordered point subsets, each having only one 3D point therein, and

the 1D point sequence of the input 3D patch is generated based on the processed set of 3D points of the input 3D patch.

5. The method according to any one of claims 1 to 4, wherein

the first 2D image pixel grid comprises a series of macroblocks, and

the first 2D space filling stage comprises:

mapping the 1D point sequence of the input 3D patch to arrays of pixel slots of sub-macroblocks associated with the series of macroblocks according to a sub-macroblock filling pattern; and

mapping the sub-macroblocks to the series of macroblocks according to a macroblock filling pattern,

wherein the sub-macroblock filling pattern and the macroblock filling pattern are different space filling patterns.

6. The method according to claim 5, wherein the sub-macroblock filling pattern is a horizontal snake curve filling pattern and the macroblock filling pattern is a Hilbert curve filling pattern.

7. The method according to claim 5 or 6, wherein each macroblock of the series of macroblocks has a size of 4 × 4 sub-macroblocks, and the array of pixel slots of each of the sub-macroblocks has a size of 4 × 4 pixel slots.

8. The method according to any one of claims 1 to 7, wherein said generating, for each of the plurality of 3D patches, the 2D attribute image of the 3D patch comprises:

selecting one of a plurality of attribute image generation processes to generate the 2D attribute image of the 3D patch, the plurality of attribute image generation processes comprising the first attribute image generation process and a second attribute image generation process; and

generating the 2D attribute image of the 3D patch based on the selected attribute image generation process.

9. The method according to claim 8, wherein said selecting one of the plurality of attribute image generation processes to generate the 2D attribute image of the 3D patch is based on a level of uniformity of the set of 3D points of the 3D patch.

10. The method according to claim 9, wherein said selecting one of the plurality of attribute image generation processes to generate the 2D attribute image of the 3D patch comprises:

selecting the second attribute image generation process to generate the 2D attribute image of the 3D patch if the set of 3D points of the 3D patch is determined to satisfy a predetermined condition relating to the level of uniformity, and

selecting the first attribute image generation process to generate the 2D attribute image of the 3D patch if the set of 3D points of the 3D patch is determined to not satisfy the predetermined condition relating to the level of uniformity.

11. The method according to claim 10, wherein the set of 3D points of the 3D patch is determined to satisfy the predetermined condition relating to the level of uniformity if a reconstruction error associated with embedding the set of 3D points of the 3D patch into a 2D

space is less than a predetermined error threshold, and the set of 3D points of the 3D patch is determined to not satisfy the predetermined condition relating to the level of uniformity if the reconstruction error associated with embedding the set of 3D points of the 3D patch into the 2D space is more than the predetermined error threshold.

12. The method according to any one of claims 8 to 11, wherein

for at least a second 3D patch of the plurality of 3D patches, the 2D attribute image of the second 3D patch is generated based on the second attribute image generation process, and

the second attribute image generation process comprises:

a dimensionality reduction stage configured to transform a set of 3D points of an input 3D patch inputted thereto into a set of 2D points of the input 3D patch; and

a second 2D space filling stage configured to map the set of 2D points of the input 3D patch to a second 2D image pixel grid to generate a 2D attribute image of the input 3D patch.

13. The method according to claim 12, wherein the second 2D space filling stage comprises:

mapping each 2D point of the set of 2D points of the input 3D patch to a respective pixel slot of the second 2D image pixel grid based on minimizing error between pairwise distances of the set of 2D points of the input 3D patch and corresponding pairwise distances of the set of 2D points mapped to the second 2D image pixel grid.

14. The method according to claim 12 or 13, wherein the second 2D space filling stage further comprises:

adding one or more extra 2D points to one or more unfilled pixel slots in the second 2D image pixel grid remaining after said mapping each 2D point of the set of 2D points of the input 3D patch to the respective pixel slot of the second 2D image pixel grid.

15. The method according to claim 14, wherein the second 2D space filling stage further comprises:

determining a first 2D point of the set of 2D points of the input 3D patch which is farthest from a center of the set of 2D points of the input 3D patch; and

configuring the one or more extra 2D points to respectively have associated therewith attribute information that is the same as the attribute information associated with the first 2D point.

16. The method according to any one of claims 1 to 15, further comprising combining the compressed 2D attribute image of the point cloud and auxiliary information for the compressed 2D attribute image of the point cloud, the auxiliary information comprising attribute image generation type information indicating, for each of the plurality of 3D patches, the type of attribute image generation process applied to generate the 2D attribute image of the 3D patch.

17. A system for point cloud attribute compression, the system comprising:

a memory; and

at least one processor communicatively coupled to the memory and configured to perform the method of point cloud attribute compression according to any one of claims 1 to 16.

18. A computer program product, embodied in one or more non-transitory computer-readable storage mediums, comprising instructions executable by at least one processor to perform the method of point cloud attribute compression according to any one of claims 1 to 16.