Abstract

It is easy to collect a large amount of data of 3D scenes using 3D scanners in just a few seconds in the modern era. This data consists of an unordered collection of points in 3D space sampled from the surface of a 3D object; such data is called a 3D point cloud. This groundbreaking technology results in a growing number of applications such as 3D model reconstruction, 3D broadcasting, culture and heritage reconstruction, and navigation of unmanned vehicles. These modern point cloud acquisition sensors often suffer from noise. In this thesis, we propose several novel techniques for point cloud denoising to improve their quality.

The novelty in this research work is to study the correlation between the geometry and color attributes of a point cloud and then take advantage of this correlation and employ it as a dynamic tool for various tasks, i.e., geometry denoising, color denoising, and combined geometry and color denoising. The concepts of graph theory have been used. A graph is constructed for each point cloud, where the joint geometry/color graph of each point is a node and the weighted connections between them are the edges. These algorithms are then analyzed in terms of efficiency and performance. We devised two different approaches for point cloud denoising. One is based on the convex minimization problem, and the other is on spectral graph wavelets transforms.

Conventional point cloud denoising techniques are geometrical methods based on graph representation considering only the geometry attribute of a point in a point cloud. Few successful designs include the surface estimation of the point cloud from the noisy observation. Later, the projection of the noisy points renders the point cloud on the graph and employs the graph-based regularization technique. All these procedures result in a traditional optimization problem.

In this thesis, after an introduction section where the definition and applications of a point cloud are presented, the basic concepts of neural network and graph theory are presented. The current state-of-art techniques, a study of the relationship between the geometry and color of a point cloud, and some basic graph theory concepts are summarized in later sections. The project's progress from the construction of joint geometry and color k-NN graph to the architecture presentation is explained and analyzed in detail. Finally, the performance evaluations of the proposed techniques are reported, the quantitative and qualitative analyses are done to assess the obtained results. In particular, the point-to-point distance and cloud-to-mesh distance are taken into account to evaluate the geometry denoising results and perform comparisons with other approaches. For evaluating obtained results of color denoising scheme, Mean squared error (MSE) and Peak Signal-to-noise Ratio (PSNR) are considered. The proposed methods outperform the existing state-of-art methods.

The presented algorithms contribute to the new field of digital geometry processing and help to address the demand for efficient point cloud processing techniques.