Point Cloud Quality Assessment(PCQA) in AR/VR through Graph Encoding and Classification

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Abstract(Non-technical)

Point clouds are collections of 3d-points. In AR/VR(Augmented and Virtual Reality), each point can represent the 3d equivalent of a pixel(voxel), and with a collection of them, they represent a 3d image. Our work seeks to create a machine learning model that can look at any colored point cloud and output a quality score. Accurate determination of this allows quality assessment of compressed point clouds, and alongside storage constraints, would help determine compression ratios in AR/VR. We do this by converting the point cloud into a data structure that represents data without a rigid structure and the connections between said data—a graph. A graph can be represented in a format known as an adjacency-matrix, which is basically a square matrix. Now, we use a technique called resampling to find the important points and make three smaller graphs (for red, green, and blue) and weight the connections between points on our new graphs by color and distance differences between the nodes it connects. Graphs themselves usually represent data that can't be represented in traditional structures like lists. Graphs consist of node data points and edges connecting nodes, thus a collection of points naturally can be represented through graphs. Our work trains an AI(convolutional autoencoder) to compress each graph into a much smaller set of features. Once compressed, a traditional machine learning classifier model learns to map each point cloud to a quality score from 1-5 where 1 is the worst quality and 5 is the most. As there is low data, minimizing the number of classification input features helps make a better classification model. The implications of an effective quality assessment metric for point clouds would primarily be in AR/VR model quality assessment and compressed point cloud quality assessment. As work is ongoing, results aren't yet available.

Abstract(Technical)

Point clouds (PCs) are used to represent images in AR and VR settings through voxels (3d pixel). As image quality is inherently subjective, point cloud quality assessment seeks to recreate the human quality ratings through quantitative and machine learning frameworks. Firstly, we propose a novel method for feature extraction. Secondly, we hypothesize that better point cloud quality assessment can be done through a classification-based model instead of regression after feature extraction. Our approach is to first convert the colored point cloud into a graph through mesh-reconstruction techniques. Then, using existing deep-based resampling, pick a "skeleton" of a collection of the original points. Drawing inspiration from signal processing, we create three smaller skeleton graphs and weight edges based on node distance and node color similarity for each of the RGB signals. Afterwards, we average the adjacency matrices of all three. Using this new adjacency matrix, we draw inspiration from image processing and train a convolutional autoencoder mapping each PC to a lower-dimensional encoding. Recent and existing research on PCQA focuses on extraction of features with a regression model at the end to quantify the features extracted into a quality score. Our work takes a different approach, and after extracting features, we classify the encodings based on a labeled dataset of the encodings and their corresponding quality scores. For instance, with quality scores from 1-5(with 1 being the worst quality and 5 being the best), we classify each point cloud embedding as its respective quality score. Thus, the encodings are fed into a classification model. The implications of an effective quality assessment metric for point clouds would primarily be in AR/VR model quality assessment and compressed point cloud quality assessment. As work is ongoing, results aren't yet available.
The finished code and results will be available at:
https://github.com/C0smicCrush/Point-Cloud-Quality-Assessment