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NEIGHBORHOOD SELECTION FOR DIFFERENTIAL COORDINATES OF 3D POINT CLOUDS

Jyun-Yuan Chen and Chao-Hung Lin

Department of Geomatics
National Cheng-Kung University
Tainan, Taiwan
slanla@gmail.com; linhung@mail.ncku.edu.tw

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Abstract. *Many digital geometric processes that handle three-dimensional (3D) polygonal models benefit greatly from the differential coordinate and its associated Laplacian operator. The differential coordinate is an intrinsic surface representation that encodes each vertex as a local coordinate relative to its neighboring vertices. Given a point cloud data sampled from an unknown surface, the critical problem in the point cloud preprocessing is how to determine the vertex topological neighborhood. In this paper, we introduce a novel neighborhood selection approach aimed at obtaining accurate differential coordinates for point clouds. The neighborhood selection is regarded as an optimization problem and solved by a genetic algorithm. The fitness function, or called objective function, in the genetic algorithm is defined according to the properties of the differential coordinates. Therefore, we obtain not only the vertex neighborhood but also the accurate differential coordinates. The experimental results show that the differential coordinates generated by our approach can faithfully represent the geometry of 3D point cloud. Thus, they are helpful in related applications such as meshless smoothing, parameterization, and modeling.*
Keywords: Neighborhood selection, Differential coordinates, Genetic algorithm, Laplacian operator

1. **Introduction.** In the last decade, point clouds scanned from high-precision digital scanners have drawn a lot of attention in the fields of topography, reverse engineering, scientific visualization, and digital archiving. One of the critical steps in these applications is to organize an unstructured point cloud into an organized intrinsic surface representation. Recently, the differential coordinate, i.e., an intrinsic surface representation, and its associated Laplacian operator have proven very useful in many applications such as smoothing [1,2], editing [3,4], parameterization [5,6], watermarking [7-10], airborne light detection and ranging (LiDAR) data preprocessing [11], and classification [12]. In contrast to the global Cartesian coordinate, the differential coordinate directly represents geometric details and thereby allows a detail-preserving reconstruction of the modified mesh. This makes the differential coordinate a useful surface representation in the aforementioned applications. For a polygonal model, the differential coordinates can be obtained from the vertex coordinates and the connectivity. However, for a point cloud (without any connectivity information), selecting a proper vertex neighborhood for differential coordinate calculation is still an important and interesting problem.

The most common approaches in the neighborhood selection are the k-nearest neighborhood approach (k-NN) and the fixed-distance neighborhood approach (FDN). In the k-NN and FDN approaches [13-18], neighboring vertices are defined as the k-nearest vertices and the vertices within the neighboring region of fixed distance r, respectively.