nD-PointClouds

Peter van Oosterom
Delft University of Technology

Abstract:

The nD-PointCloud model is proposed for handling massive multidimensional point cloud data sets in the whole range from data ingestion, data management, to data analytics and visualisation. The data represent space, time and added information such as colour, material properties, velocity, etc. The proposed nD-PointCloud model facilitates continuous instead of fixed levels of importance. The continuous level of importance (cLoI) value of a point can be regarded as an added dimension to space and time.

The n organizing dimensions, usually a subset of space, time and cLoI, define the location of a point in the nD Organizing Space. In addition, and depending on specific domain and data set, there are m additional property dimensions (e.g. colour, flow direction, surface normal, different spectral channels, temperature, pressure, classification, object identity, light intensity, uncertainty, velocity, content descriptors, etc.), which together conceptually define points in a k=n+m dimensional space. Deep integration offers a range of benefits: spatio-temporal consistent models, efficient selection (on organizing dimensions), new types of spatio-temporal computations, use of continuous importance, and integration of point cloud data from multiple sources.

State of the art spatio-temporal representations are based on either gridded (raster, voxel) or object (vector) models. In many cases these representations are organized in a fixed number of levels of importance (detail/scale), which introduces serious limitations: fixed level choices and data density jumps between levels. Original and novel aspects of our nD-PointCloud model:

1. defining organizing and property dimensions,
2. offering attribute granularity: from individual point to group level,
3. obtaining the continuous level of importance value for a point,
4. aggregating points to higher level points,
5. representing and assessing effect of different coordinate reference systems: spherical or Cartesian.

In order to realize the deep integration of space, time and importance, nD space filling curves (and perhaps nD tree structures) are explored. In the future, by enabling operations directly on the raw point cloud data, nD-PointCloud largely avoids and/or alleviates the extract, transform, load hurdle, which is an increasingly serious problem in the era of big data.

As state above, today the importance, scale or LoD is at best at discrete level. The importance value (discrete or continuous) could be treated as a dimension and influences data organization (clustering and indexing) for efficient storage and fast retrieval. Different options and algorithms for determining the actual importance value of a point are presented (for discrete levels), each with it own advantages and disadvantages. It will be analysed how these importance value functions can be modified to support conious imortance value (according to a proper distribution).