Opportunity Title: Metrics in Three-Dimensional Point Cloud Data
Opportunity Reference Code: IC-16-19

Organization Office of the Director of National Intelligence (ODNI)

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Application Deadline 4/15/2016 6:00:00 PM Eastern Time Zone

Description The goal of this research is to advance the reliability of the automated processing of 3-D point cloud data, by improving the capability to assess the quality of processing steps.

Today's earth and environment technologies rely, in an unprecedented and increasing manner, on the precision of 3-D coordinates. These surveys produce data sets of various types and of increasingly large sizes. The automated monitoring of the environment relies on fusion and change detection as the most prevalent data tasks.

Three-dimensional point cloud data sets, such as LiDAR (Light Detection and Ranging) collections, give a great advantage to civilian and industrial applications, and environmental studies, like climate monitoring, etc. Thus, the precision of the 3D data is essential for accuracy of reports that enter important studies and decisions, at scales varying form local organizations, state governments, and non-governmental organizations. Here the focus is on LiDAR data, as its precision makes it the best to develop a strategy for general 3D point clouds. From the collection of the raw data, LiDAR data sets are processed to deliver a friendly and searchable format, visualized with software that gives three-dimensional views. The first processing step for LiDAR data is denoising, to remove points in the cloud that are the result of various sources unrelated to the true observables. The denoising usually follows the methods of statistics; as a result, points in the cloud may be displaced or unjustifiably removed. Compression techniques that are based on domain-knowledge may also discard points in the cloud. Thus, the resulting point-cloud may or may not be satisfactory for a desired precision. Metrics to assess the quality of denoising and compression can validate these data processing techniques to achieve precisions consistent with various standards. These metrics could also help validate data processing of the point clouds, such as fusion. Two different collections of a city must have the same coordinates for vertical targets such as antennas, yet in reality these extreme points may be slightly different. What is the mathematical way to express globally that two point clouds are "close" or "equal"? Previous attempts to answer

these questions involve voxelation techniques, yet these techniques involve in turn truncation of data - i.e., loss of precision - that makes automation of fusion and comparisons of two point clouds prone to uncontrollable errors, or in need of a human to assess the compliance with, for example, ASPRS standards.

Example Approaches

Possible research may include an extension of the metrics for the fusion of LiDAR with other remote sensing data types. This research could develop in parallel in two directions. First, a mathematical exposition of the approach could describe the measure-theoretical support to devise three-dimensional metrics for assessing how "close" two point clouds are in a 3-D space. Second, a computational implementation plan should accompany the theoretical findings.

Areas for possible research:

- Asses the development of 3-D point cloud metrics to compare and assess distance between two 3-D structures defined by points.
- Point-by-point comparison, and potentially develop tractable and realizable algorithms for such comparison.
- Software tools could be devised to assist the experts with a core automation of data processing quality assessment.
- Develop an ontology that starts with a database of targets and proposed metrics, with the aim to unify the approach for any point cloud.

Eligibility Requirements

- **Citizenship:** U.S. Citizen Only
- **Degree:** Doctoral Degree.
- **Discipline(s):**
  - **Business** (11 👁)
  - **Chemistry and Materials Sciences** (12 👁)
  - **Communications and Graphics Design** (6 👁)
  - **Computer, Information, and Data Sciences** (16 👁)
  - **Earth and Geosciences** (21 👁)
  - **Engineering** (27 👁)
  - **Environmental and Marine Sciences** (14 👁)
  - **Life Health and Medical Sciences** (45 👁)
  - **Mathematics and Statistics** (10 👁)
  - **Other Non-Science & Engineering** (13 👁)
  - **Physics** (16 👁)
  - **Science & Engineering-related** (1 👁)
  - **Social and Behavioral Sciences** (28 👁)