LIDAR at
Input Data Sets

Objective:
- Analyze the large 3D point cloud datasets from terrestrial LIDAR
- Generate an informative deformation description to provide distinctive deformation characteristics for different partial areas

Hybrid Model Definition

Definition 1 Meta deformation:
Let \( C^I \) and \( C^{II} \) be two correspondent split 3D parts at epoch I and epoch II. Meta deformation is the geometric transformation between two correspondent parts \( C^I \) and \( C^{II} \).

\[
D^C = C^{II} - C^I = D^S(C^{II} - C^I)
\]

Definition 2 Deformation map:
\( D = \{D^A, D^4, \ldots, D^4\} \)

is the description of distinctive deformations for all of the partial areas in the complete monitored object, i.e.,

\[
D^n = M(X)
\]

\( M(X) \) is a sub-deformation model of the partial area that is composed of a group of cells \( \{C^I, \ldots, C^n\} F(M(X), \ldots, M(X)) \)

is the hybrid model with sub-deformation models for all of the partial areas on the monitored object.

Cell-based Approach

- **Split**: Divide the space of the monitored object into 3D uniform cells and capture their corresponding point clouds at epoch I and epoch II, respectively.
- **Detect**: Estimate the meta deformation (e.g., vertical displacement and slope variation) of the point cloud datasets for each cell in the monitored object.
- **Merge**: Group the adjacent cells with similar meta deformation (e.g., the magnitude of meta deformation in each cell) and estimate the sub-deformation of each partial area to generate the deformation map of the whole object.

Application on Synthetic Data – Slope Variation

Two point clouds datasets in 3D

Histogram of the points

Project in 2D

Estimation error w.r.t. noise level and cell size

Application on Real Data – Vertical Displacement

Deformation map

Displacement extracted by different estimation methods

Displacement distribution w.r.t. different cell size

Input Data Sets

- We assume that one object is chosen to deformations monitoring during a time period and two point clouds captured using terrestrial LIDAR at Epoch I and Epoch II.

\[
P^I = \{p^I_1, \ldots, p^I_n\}, p^I_i = [x^I_i, y^I_i, z^I_i]^T
\]

\[
P^{II} = \{p^{II}_1, \ldots, p^{II}_n\}, p^{II}_i = [x^{II}_i, y^{II}_i, z^{II}_i]^T
\]