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Cross-modal Feature Based Structural Deformation Monitoring Using Colored Point Clouds

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1. Introduction

Terrestrial laser scanning (TLS) is widely used in geodetic monitoring (including structural deformation monitoring) because of its direct 3D measurement capability and independence from natural light sources or supplementary illumination during scanning. However, methods rely merely on point clouds may perform poorly when scanned surfaces have repetitive or even no distinct geometric features, where RGB images can complement to some degree. The fusion of point clouds and RGB images is underutilized, especially in structural deformation monitoring. Therefore, this research aims to investigate how structural deformation monitoring can benefit from image-assisted TLS point cloud processing using both geometric and radiometric information.

2. Research questions

i. How can one evaluate the alignment quality between a terrestrial laser scanner and its built-in cameras at the user level, and how good of an alignment is required to use the colored point clouds further?

ii. In which cases can radiometric information (Lidar intensity and RGB) assist geometric information to establish feature correspondences?

iii. To what extent can RGB images contribute to TLS-based structural deformation monitoring, and how good is structural deformation monitoring without images, and how much can images contribute?

iv. How can high-resolution images be used to augment relatively low-resolution TLS point clouds, and how can TLS-based structural deformation monitoring benefit from the augmented point clouds?

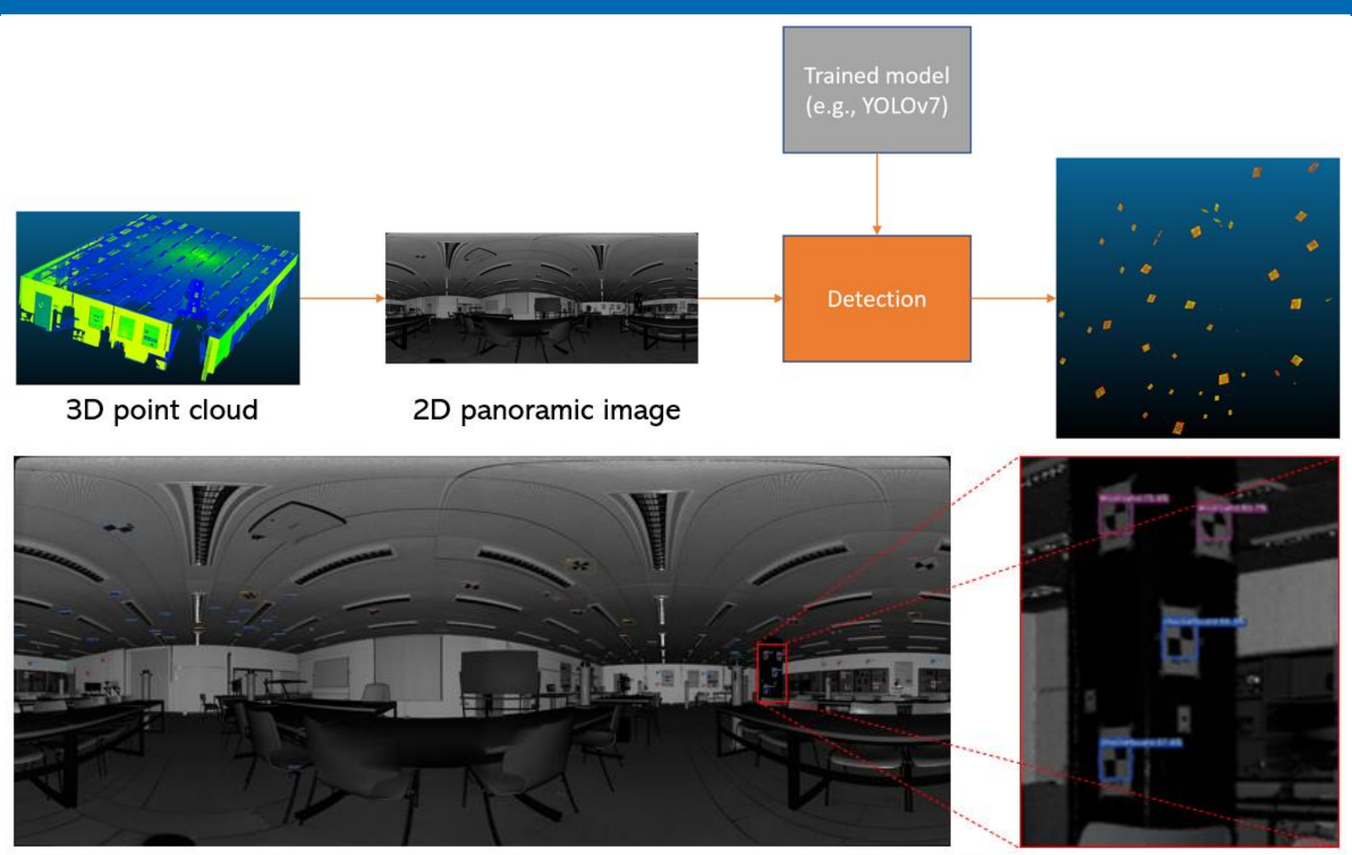
3. Pixel-to-point alignment quality assessment

Motivation:

- Radiometric information can complement geometric information, where:
  - geometry is locally smooth
  - radiometry has higher resolution
- In addition to RGB values, for multi-wavelength Lidar scanning, multiple Lidar intensities are also radiometric information
- But for TLS scanners, how good of the alignment quality between the scanner itself and corresponding built-in cameras?

Output:

- Propose an automated artificial target-based assessment method to quantify the misalignment between TLS scanners and corresponding built-in cameras



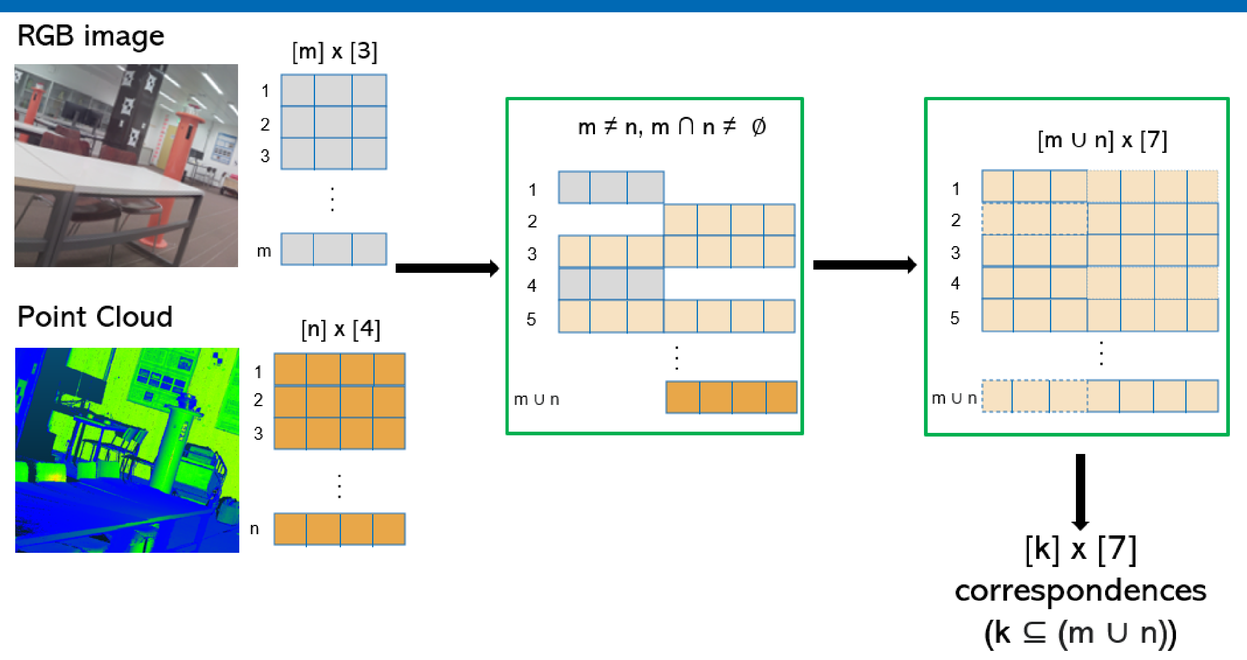
4. Cross-modal feature based correspondence establishment

Goal:

- Explore how structural deformation monitoring can benefit from the combination of geometry and radiometry (e.g., RGB, Lidar intensity)

Steps:

- Pixel to point alignment -- > derive the result with N x 7 dimensions
- 7-dim feature correspondence establishment, which is useful for:
  - colored point cloud registration within one epoch
  - deformation analysis between multiple epochs



5. Point cloud augmentation and completion via RGB images

Motivation:

- Dense point cloud acquisition is relatively slow, but high resolution image acquisition is quite fast
- Image can also complement the regional occlusion of point cloud to some degree

Ideas:

- Use higher resolution images to augment / complete lower resolution point clouds
- Do structural deformation monitoring on the new point cloud