An Investigation of the Optimal Resolution for Landslide Monitoring Using Terrestrial Laser Scanner

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Commission: 5 and 6

Presentation Outline

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Introduction

- **Landslide** is a general term referring to the **various processes of downslope movements** of earth materials **under the influence** of ground **water, soil composition, gravity and human activities**.
- Landslide is one of the **major natural disasters** for all countries over the world.
- Nowadays, the **method** used for landslides data acquisition is **slowly changing** from the conventional method such as tacheometry and precise leveling to more efficient methods of using modern technology like Global Positioning System (GPS), Photogrammetry, Laser Scanner and Unmanned Aerial Vehicle (UAV) system.

Introduction

- The **accuracy of this technology is also acceptable** for slope deformation monitoring with **millimetre (mm)** and **centimetre (cm)** level accuracy (Miller et al., 2008; Abellan et al., 2009; Barbarella et al., 2013).

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Aim

- One of the aspects that require **attention in the data acquisition** is the **optimum scan resolution** (Miller et al., 2008; Monserrat and Crosetto, 2008).
- Required ensure the **balance** between the **time** used for data collection and the **quality** of the captured data.
- The **resolution of the DTM** that can be generated for deformation analysis is **directly influenced** by the point cloud density.
- The **aim** of this study is to **investigate the optimum scan resolution for land slope deformation detection**.

Study Area

- **Cut hill slope** besides the new building for Faculty of Biosciences and Medical Engineering (Block T02) in Universiti Teknologi Malaysia (**UTM**), Skudai, Malaysia.
- **The dimension of the land slope:** 80m × 25m approximately.

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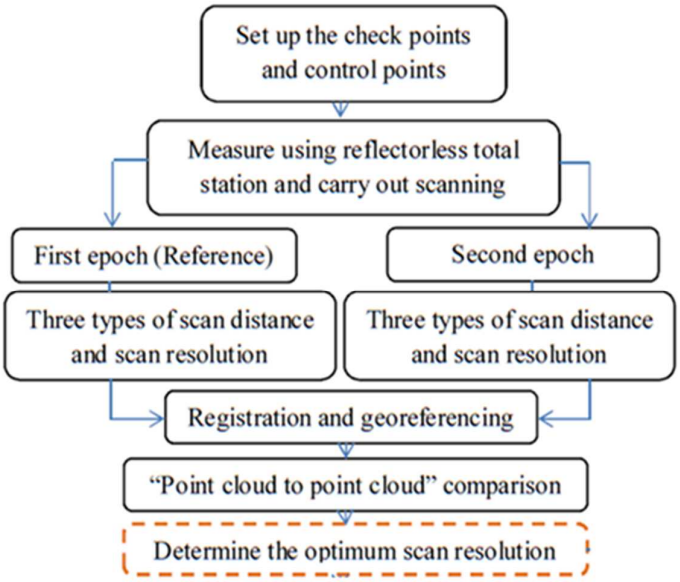
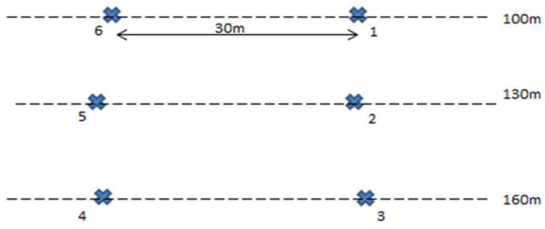
Methodology



- All the **control points and check points are well established.**
- The **observations points** are established **on the tar** and **concrete surface** opposite the land slope.
- **TLS and reflectorless TS** were used for **data collection**.
- Three types of scan resolution (**Low, Medium and High**) and three types of scan distance (**100m, 130m and 160m**) were tested for TLS.
- **Two scan stations** with difference perspective view were occupied for **each** type of **scan distance**.
- The reflectorless TS (Topcon ES-105) will be used for the purpose of validation.

Methodology



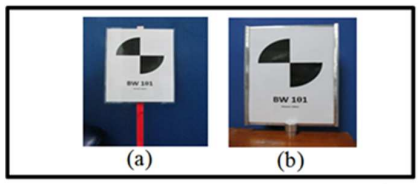
Symbol	Description
	Control Point
	Check Point
	Observation Station

Overall layout of the control points, check points and observation stations

Methodology

- The control points are shown in red triangles while the check points are shown in light blue hexagon.

The distribution of the control points and check points on the land slope



Type of targets used for (a) check points and (b) control points

Methodology

(a) Leica Scan Station C10 is used to scan the land slope surface and
(b) Reflectorless Total Station Topcon ES-105 is used for validation

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Methodology

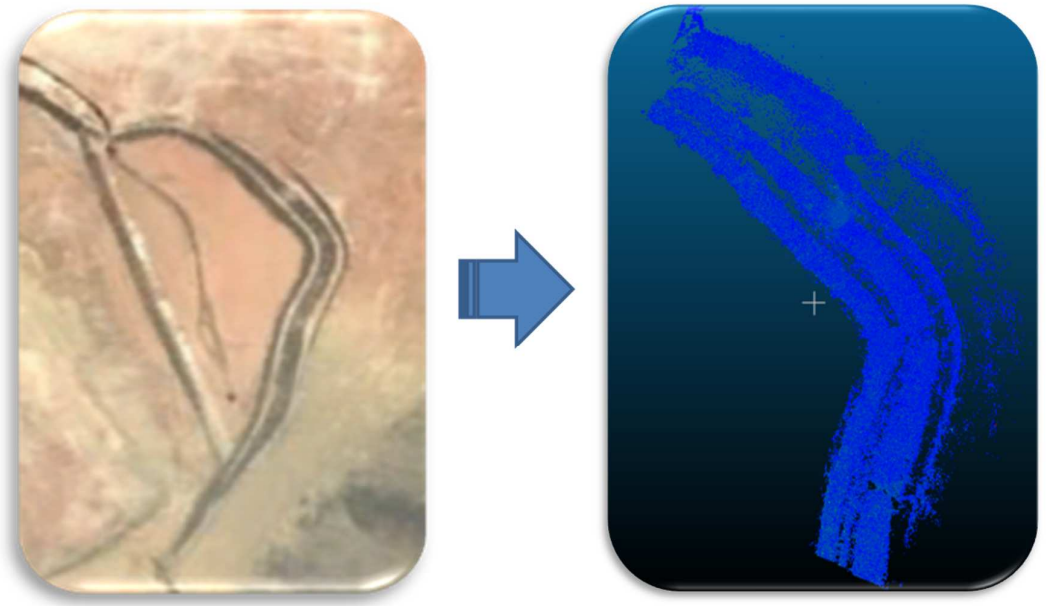
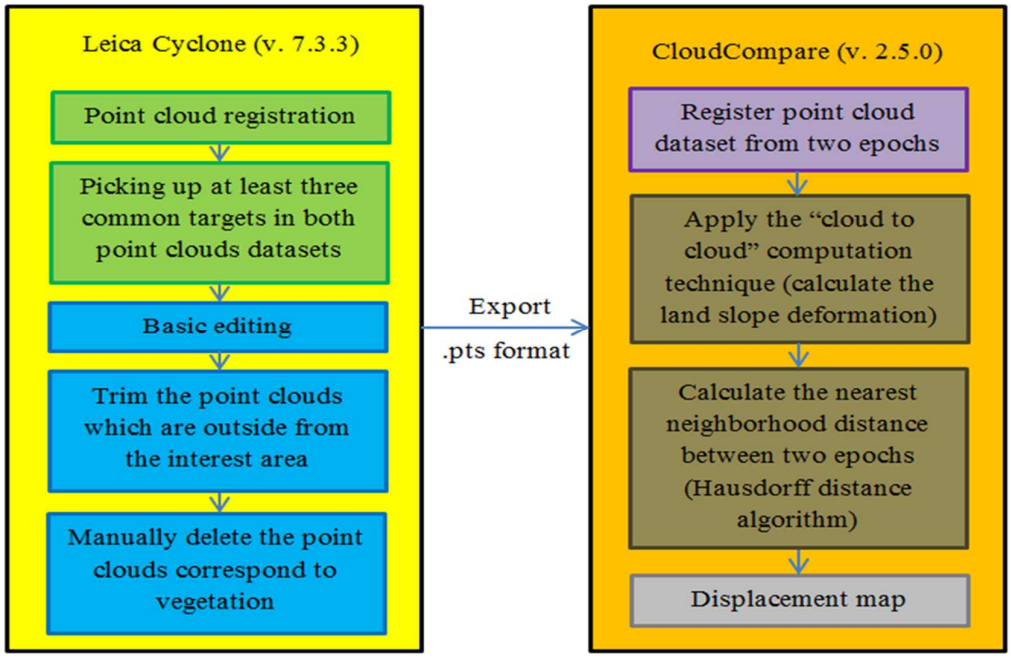


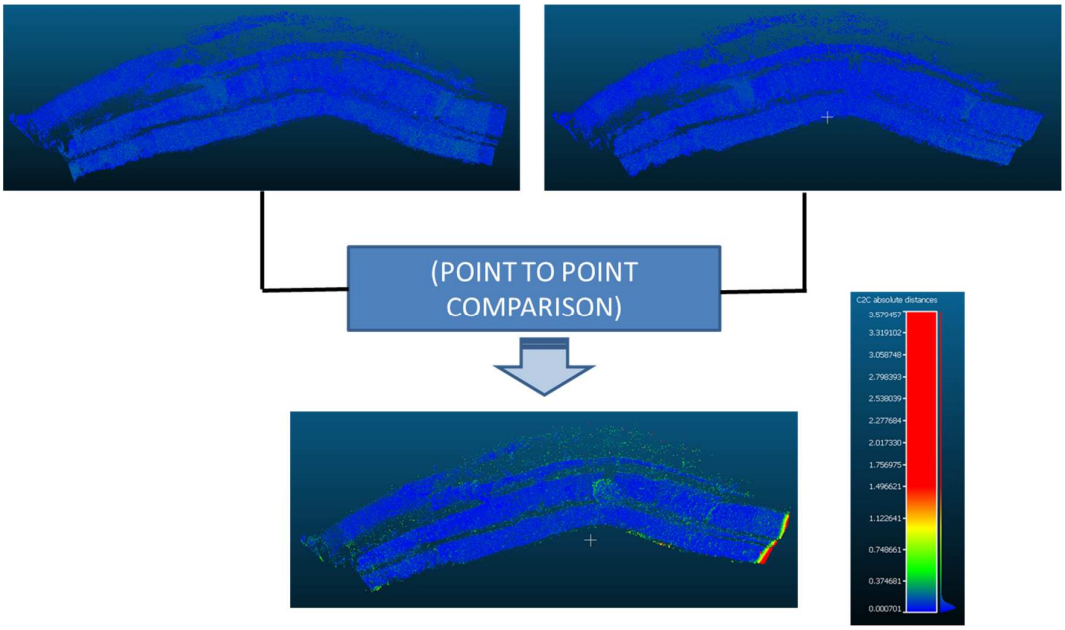
IMAGE (GOOGLE MAP)

IMAGE (POINT CLOUDS)

Methodology



Methodology



Result

- The **3D coordinates** for the **control points** and **check points were compared**.
- The **values for Root Mean Square (RMS)** were computed.
- **Nine sets of colour-coded displacement map** for point clouds comparison of two epochs were produced which corresponding to three different scan resolutions and three different scan distances.
- **Plot** for **mean of displacement distribution versus scan distance for three different scan resolutions produced**.

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Result

Point	Difference of X (m)	Difference of Y (m)	Difference of Z (m)
101	0.01295	-0.00793	0.00024
102	0.00266	-0.00095	0.00218
104	0.00191	-0.00472	0.00245
105	0.00177	0.00272	0.00270
107	-0.00798	0.00146	-0.00244
108	-0.01383	0.00326	-0.00251
109	0.00253	0.00616	-0.00262
RMS	0.00796	0.00454	0.00231
RMS XYZ	0.00545		

3D coordinates comparison for the check points in two epochs using reflectorless TS

Result

Point	Difference of X (m)	Difference of Y (m)	Difference of Z (m)
101	0.00411	-0.00355	-0.00016
102	-0.0042	-0.0032	-0.00609
104	0.00035	0.00425	0.00907
105	0.00239	-0.01051	-0.00038
107	-0.00862	0.01184	-0.00309
108	0.00331	-0.00052	-0.01078
109	0.00131	0.00426	0.00055
RMS	0.00427	0.00665	0.00592
RMS XYZ	0.00570		

3D coordinates comparison for the check points in two epochs using TLS

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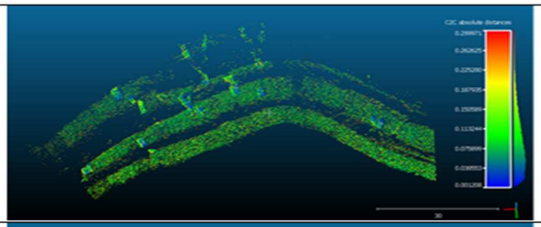
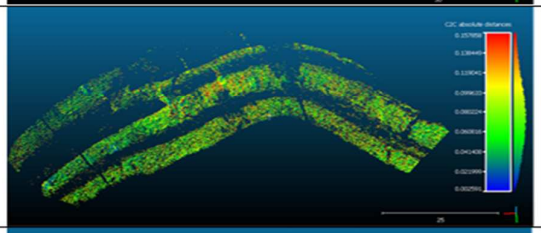
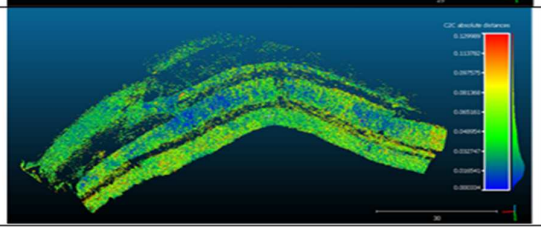
Result

Point	Difference of X (m)	Difference of Y (m)	Difference of Z (m)
CP1	0.00587	-0.00340	0.00152
CP2	-0.01707	0.00152	-0.00149
CP3	-0.00218	-0.00421	-0.00196
CP4	0.00830	0.00947	0.00179
CP5	0.00507	-0.00339	0.00015
RMS	0.00922	0.00515	0.00152
RMS XYZ		0.00616	

3D coordinates comparison for the control points in two epochs using reflectorless TS

Result

Scan Resolution	Displacement Map	Mean (m)
Low		0.0863
Medium		0.0769
High		0.0341

The generated displacement map and the mean value for displacement with respect to three different scan resolution at 100m of scan distance

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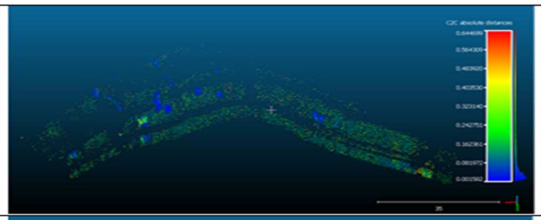
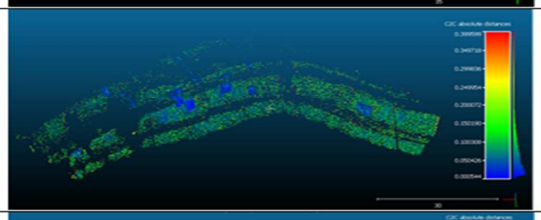
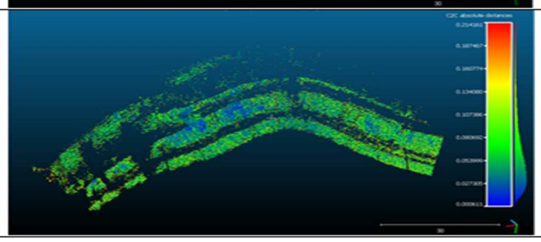
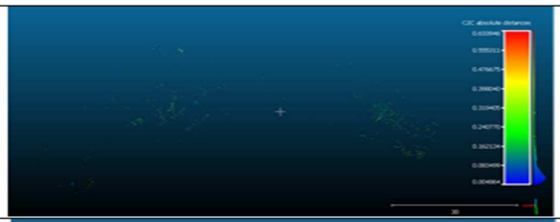
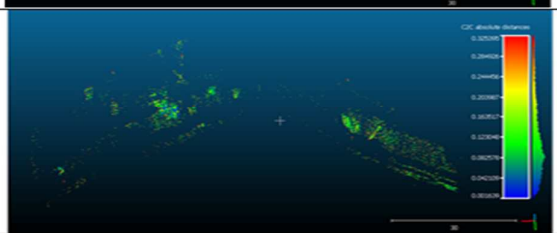
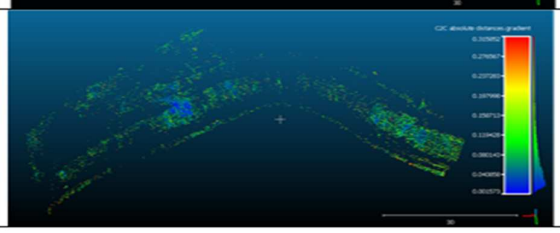
Result

Scan Resolution	Displacement Map	Mean (m)
Low		0.0968
Medium		0.0782
High		0.0587

The generated displacement map and the mean value for displacement with respect to three different scan resolution at 130m of scan distance

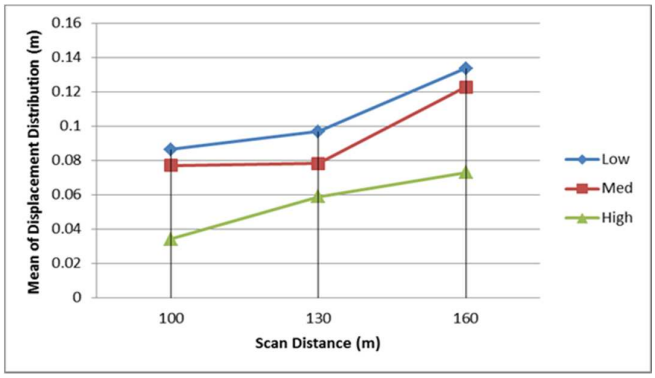
Result

Scan Resolution	Displacement Map	Mean (m)
Low		0.1335
Medium		0.1227
High		0.0729

The generated displacement map and the mean value for displacement with respect to three different scan resolution at 160m of scan distance

Conclusion

- From the results for the mean, it can be concluded that the **mean of the displacement is proportional to the scan distance**.
- In this case, the mean value of the displacement for the **high resolution is taken as bench mark for comparison**.
- It can be concluded that **both low and medium scan resolution is not suitable for scan distance** of **more than 100m for land slope deformation detection**.



Plot for mean of displacement distribution versus scan distance for three different scan resolutions

Acknowledgement

- Financial assistance from Ministry of Higher Education (MOHE), Universiti Teknologi Malaysia (UTM), Malaysia with the research grant vote No.00G23.

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Thank you for your attention!

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