

Use of LiDAR in Landslides Detection and Hazard Assessment

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LiDAR generate High Resolution Digital Elevation Model will be used to detect and characterized landslides in a case study area (Portland) and to evaluate potential landslides risks and its damages.



Methods

- ✓ Data search and download
- ✓ Create a Geodatabase
- ✓ Create Models
- ✓ Prepare layers for analysis (Select, Clip, Mask, Project, Resample, Dissolve, Reclassify, Rasterization, Vectorization)
- ✓ Analysis
 - Surface Raster Toolsets (Hillshade, Slope, Curvature)
 - Raster Calculation
 - Focal Statistic
 - ArcHydro Tools (Flow Direction, Flow Accumulation)
 - Infinite-slope stability analysis
- ✓ Editing

Introduction

Slides - downslope movement of soil or rock on a surface of rupture

Common Landslides trigger

- ✓ intense rainfall
- ✓ rapid snow melt
- ✓ freeze/thaw cycles
- ✓ earthquakes
- ✓ volcanic eruptions
- ✓ human changing natural slope, concentrating water



1996 Dobson landslide closed I-84, rail and river traffic

During 1996-1997 winter storms, about 9,900 slides was recorded in Oregon with a direct damages over \$100 million

Geographic Extent



Portland West Hills

Projected Coordinate System: State Plane Oregon North FIPS 3601 Datum: NAD 1983 HARN Projection: Lambert Conformal Conic Unit: International Feet Geographic Extent North: 694080.40 ft South: 677870.82 ft East: 7637831.16 ft West: 7621643.43 ft Area: 5704.2 acres

Data

✓ Metro Pilot LiDAR Project

Portland, Oregon 2004 - Bare Earth LiDAR DEM. Puget Sound LiDAR Consortium.

http://pugetsoundlidar.ess.washington.edu/lidardata/metadata/pslc2004portland/portland04_be_dem.htm

File Type	GRID
Columns, Rows	5397,5404
Number of Bands	1
Cellsize	3, 3
Uncompressed Size	111.26 MB
Format	FGDBR
Pixel Type	Floating point
Pixel Depth	32 Bit

- ✓ Spatial digital database for the geologic map of Oregon. Edition: 2.0 Open-File Report 03-67. U.S. Geological Survey http://geopubs.wr.usgs.gov/open-file/of03-67
- ✓ RLIS. Metro Data Resource Center 2010

Landslide LiDAR Applications

- (1) Detection and characterization
- (2) Hazard assessment and susceptibility mapping
- (3) Modelling



(4) Monitoring

Landslides Detection

- ✓ Manually (e.g. expert criteria)
- ✓ Automatically

Identifying landslide's morphological features (scarps, mobilized material, foot)

Curvature



Spreading of topographic orientations within a landslide is higher than that in undisturbed area

Slope Roughness







Landslide Hazard Assessment

- ✓ Modeling slope stability using an infinite-slope stability analysis
- ✓ Failure of a infinite slope is characterized by the ratio of resisting basal friction (material properties) to gravitionally induced downslope basal driving stress (terrain properties)



 $\checkmark\,$ This ratio is called Factor of Safety (FOS)

Factor of Safety (FOS)



Material Properties

- c' = Cohesion
- ϕ = Angle of Internal Friction
- Y = Soil Density (unit weight)
- Υ_w = Ground Water Density (62.4 lb/ ft ³)

Terrain Variables

- Z = Depth to Failure Surface (15 f)
- h= Saturation Factor (12 f)
- Θ = Slope Angle
- X = Horizontal Grid Distance
- Y = Vertical Grid Distance



Material Properties

MAP LITHOLOGY INTERNAL COHESION UNIT 6 UNIT FRICTION (φ) (C') WEIGHT (degrees) (lb/ft³) (lb/ft³) Columbia River Basalt Group Тс 40 10 96 Qs Lacustrian/Fluvial 0 8 102 QTs Sedimentary 37 7 90 Qal Aluvial Deposit 30 93 0 TS Tuff/Tuffaceous Sedimentary 26 6 83 QTba Basalt/Basalt Andesite 45 9 95 QTb Basalt 43 10 97 Lithology

Shear strengths of geologic units





Map Algebra Expression

"Litho_Cohesion" + ((("Litho_Weight" * 15)-{12 * 62.4}) * Cos("Slope") * Tan("Litho_Friction")) / "Litho_Weight" * 15 * Cos("Slope") * Sin("Slope")





Conclusions

- ✓ High resolution LiDAR data improve landslide inventory mapping and hazard assestment, fundamentaly because landslide's morphological features (scarps, mobilized material, foot) are easy to delineate based on HRDEM.
- ✓ Spatial analysis, terrain modeling and 3D rendering are valuable tools in detection and evaluation of landslides and its potential damages.
- ✓ 7.4% of the study area presented high susceptibility to the occurrence of landslides.
- ✓ Further refinement and field validation is necessary for model improvement and accurate hazard classification and evaluation.

References

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