

### A295204 .526 Photogrammetric 3D models for 1345.5 engineering geologic mapping and stability analyses of rock slopes

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### Introduction



#### • What is a photogrammetric 3D model?

- Generation
- Structure
- Registration

#### • How does the geologist map on a 3D model?

- Tools
- Automatic helpers
- Audit

#### • Examples

#### **3D model generation**







### **3D model registration**



Georeferencing using Ground Control Points





Scaling & orientating



 Georeferencing using drone GNSS (RTK)

### **Geologic mapping tools for 3D images**

#### **Orientations**

#### Traces

- Mean orientation around single point
- Dip direction
- Dip angle



- Open polygon following the joint trace along the 3D surface
- Position
- Mean dip and dip direction of plane forming the trace



#### **Areas**

- Mean dip and dip direction of area assigned to exposed joint surface
- Position (important e.g. for block analysis)
- Automatic region growing



### **Discontinuity maps**



#### On a bench scale

Spatial structural-geologic condition

Software & Measurement

Number of discontinuity sets

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### **Discontinuity maps**



#### • On a pit scale



- 250 m deep open pit in Western Australia
- Model built from over 700 UAV photographs in <2 hours</li>
- Over 350 geological structures mapped in 3 hours

### **Discontinuity maps**



#### • On a pit scale





# Automatic assessment guided by the expert user

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### **Guided mapping of areas**



#### Bench 3D image



### **Guided mapping of areas**



Seed point and roughness / evenness



### **Guided mapping of areas**



Repeated application – expert user decides upon application



### **Discontinuity set orientations**







### **Discontinuity set spacing**





	Spacing	Trace length
Measurements:	14	7
Frequency [1/m]:	0.32	
Total [m]:		129.43
Mean [m]:	3.17	18.49
Median [m]:	3.07	19.95
Std dev [m]:	2.20	9.75
Minimum [m]:	0.0	7.25
Maximum [m]:	8.21	34.41

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#### **Discontinuity set spacing**







#### What about traces?

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#### Bench 3D model





#### Define start and end point – trace is formed along texture path





#### Repeated application by the expert user





#### Trace map with rock mass characteristics





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#### Bench 3D image



Software & Measuremen



#### Analysis zones



 Analysis parameters are similar within analysis zones

Software & Measurement

- Exclude unwanted regions (muck, vegetation, equipment, etc.)
- Exclusions zones are also possible ("Masks")



#### Colour overlay



#### Surface patches with similar orientation





Discontinuity area polygons and discontinuity sets



Generation of polygons



- Audit of the automatically generated patches by the expert user
- Efficient auditing tools are necessary





#### Spacing analysis – Analysis zones











#### **Discontinuity set clustering**



- Similarity in orientation ("Fuzzy k-means")
- Weighted by size of fracture





#### **Discontinuity set clustering**



- Similarity in orientation ("Fuzzy k-means")
- Weighted by size of fracture









- Observations and measurements are modelled to interpreted discontinuities
- Extrapolation and projection into the rock mass
- Intersections of discontinuities
- Integration of various measurements / observations of the same structure



- Joint trace
- Orientation
- Modelled discontinuity
- Changing size extrapolation











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#### Rock fall area







Data acquisition by drone survey







- Drone flight specifics
- Complex geometry, size of object and visibility in the area called for flying the drone interactively
- Requires some experience
- Live observation of actual camera view on the ground





#### **3D model**

- 750 m x 250 m
- 740 photos á
  36 Megapixels
- GSD < 1 cm / px
- Data acquisition approx. 1 hour
- Processing time appox. 3 hours









#### **Assessment of a slide in an open pit**

Bar, N. et al. (2020). Rapid and robust slope failure appraisal using aerial photogrammetry and 3D slope stability models. Int. J. Min. Sci. & Tech. 30. 651-658.

#### Convex slope profile

• 24 m high, approx. 15 000 tons

excerbated by rainfall

**Planar slope failure triggered** 

by undercut shale bands and









### **Open pit slide**



#### Photogrammetric reconstruction

- 284 photos á 20 Megapixel
- < 1 h processing time</p>
- 3D model
  - 7 Mio points
  - GSD < 2 cm / px



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### **Open pit slide**



#### Geologic mapping and modelling

- 198 mapped discontinuities
- Modelling failure planes as discrete, meshed elements
- 3D limited equilibrium method







### **Open pit slide**



- Failure area with events and tension cracks
- Back-analysis (left)
- Re-evaluation of future pit slope design (right)







Product



### ShapeMetriX 3D ShapeMetriX UAV



Rock mass characterization Geologic mapping Volumetrics Change detection





#### www.3gsm.at



## 429520.4.5265 Photogrammetric 3D models for 1345.5 engineering geologic mapping and stability analyses of rock slopes Thank you!

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