LML



Abstract

Covid restrictions accelerated and expanded a project we were already working on: creating a collection of 3D models of rocks and outcrops to be used as a training aid in the classroom. Travel restrictions, which at our institution included a yearlong complete ban of all field courses (including one-day trips), spurred us to expand the original concept to include also a full 3D virtual environment for students to carry out field trips and mapping exercis-

In choosing our tools, we considered three factors: costs, time, and level of difficulty. That meant finding commercial software and hardware that was affordable and intuitive to use, did not require programming or engineering skills, or special licenses (e.g. pilot license for large drone), using areas for which we already had a significant amount of material, and storing our 3D models on public platforms. Most educational institutions do not have dedicated programmers for writing and maintaining for example viewing platforms, and funding (including for extra field time to acquire imagery) is usually quite limited. 1

We created 3D models of hand samples and of key outcrops at several field locations that we normally visit in both Spain and Germany by acquiring photos and movies in the field using hand-held cameras and a small drone (which in Europe only requires insurance and operator's registration). We then processed imagery to produce georeferenced models with Metashape Pro. We used 3DVista Pro, originally designed for real estate showcasing, to produce immersive and interactive virtual field trips (VFTs). This software allowed us to link 3D models, which are stored on either Sketchfab or V3Geo, with videos, animations, photos, maps, text, and realistic sounds for each field scene. An e-learning module in the form of quizzes and game-like features can be incorporated too. 2

The georeferenced models can also be used for exercises involving structural measurements, which can be carried out with software like GeoVis3D or LIME. In such cases students are provided with standalone files for each model, separately from the VFT environment. LIME can also access the V3Geo georeferenced models database directly. 3

We put together different types of VFTs:

- Show-and-tell standard VFTs
- VFTs with a specific theme (e.g. unconformities)
- Field exercises where students carry out measurements and observations both virtually and later in the field
- Complementary material for remote, computer-based mapping courses

The reception from students has been positive, so we have kept using virtual tools after lockdown ended.

Resources

Hardware

Quadcopter drones: DJI Mavic Mini, DJI Mini 2 Compact camera, cellphone camera Mac (or Windows PC) with at least 16GB RAM

3D modeling software

Metashape Pro (academic license), https://www.agisoft.com

VFT software and VFT server

3DVista Virtual Tour Pro (academic license), https://www.3dvista.com (VFT hosting also possible on own web server or Moodle)

3D model hosting platforms (free, with limitations) Sketchfab, https://sketchfab.com V3Geo, https://v3geo.com



GeoVis3D (freeware), https://ausgeol.org/geovis3d/ LIME (academic license), https://virtualoutcrop.com/lime

Publicly-accessible samples of virtual field trips (QR codes in figure to the right)

- Cabo de Gata (Spain): https://cloud.3dvista.com/hosting/7324807/13/index.htm
- Lainbachtal (Germany): https://cloud.3dvista.com/hosting/7324807/16/index.htm Las Negras (Spain): https://cloud.3dvista.com/hosting/7324807/1/index.htm
- Sierra Alhamilla (Spain): https://cloud.3dvista.com/hosting/7324807/14/index.htm
- Sorbas Basin (Spain): https://cloud.3dvista.com/hosting/7324807/15/index.htm





Virtual Geology and Virtual Field Trips

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The web-based version of VFTs shows up in the default language of the user's browser, if translation files are supplied (the "Cabo de Gata" VFT, for example, can switch between English and German). A VFT's SCORM package can be integrated into Moodle, allowing saving of scores, and the VFTs can be optimized for mobile devices, or embedded in a webpage (e.g. the "T-Rex courtyard tour"). The same VFTs can also be distributed to users as standalone apps (Windows or Mac) to be run on a computer: no language switching is available in this form, but it is better for people who have outdated browsers or limited bandwidth.



Measuring fold limb dips in LIME on an outcrop hosted on V3Geo. Yellow patches are measured planes. The measurements were then exported, and the plotting and fold axial plane calculation done with Stereonet3D. In LIME it is possible to hide the model texture (here hidden in the top third), making it easy to evaluate the quality of the plane being measured. Texture always captures more detail than actual 3D mesh.

LIME is more research-oriented than GeoVis3D: less intuitive for students to use, but easier for instructors to produce compatible models for.



Measuring bedding surfaces, joints, fault surface, and slickenlines. Measurements are plotted "live" within the program, which is convenient, as problems with specific measurements can be spotted right away. This is important because the texture cannot be hidden and may mask a locally low-quality mesh. GeoVis3D has pre-set categories of geological features (e.g. fault, joint, slickenline, axial surface, etc.) to choose from, which makes it easy to organize data. Measurements can also be exported to be analyzed elsewhere.

computer game.

- 51, 193-205.
- ployment. ISBN 978-1-76051-956-8

Structural Measurements with GeoVis3D

GeoVis3D is built with the Unity game engine, which makes it especially easy to use for students, as it behaves like a

Main drawback for instructors: making a model compatible with it and small enough to load without crashing.

References

• LIME: Simon J. Buckley, Kari Ringdal, Nicole Naumann, Benjamin Dolva, Tobias H. Kurz, et al., 2019. LIME: Software for 3-D visualization, interpretation, and communication of virtual geoscience models. Geosphere, 15, 222-235. • Stereonet3D: Nestor Cardozo and Richard W. Allmendinger, 2013. Spherical projections with OSXStereonet. Computers and Geosciences

• GeoVis3D: Michael Roach, Sandra McLaren, Kevin Welsh, Charles Verdel, Stephen Cox, Penelope King, and Annette George, 2020. Immersive visualisation for field-based sciences. AusGeol Project Final report. Australian Government, Department of Education, Skills and Em-