Porównanie metod cieniowania rzeźby terenu (badania z użytkownikami)

praca pod opieką: dr I. Gołębiowskiej oraz dr inż. I. Karszni

przy współpracy z naukowcami ze St. Zjednoczonych i Szwajcarii

Celem pracy będzie ocena różnych metod cieniowania rzeźby terenu (ang. *relief shading* oraz *shadowing*) DTM pod kątem użyteczności dla odbiorcy mapy. Metoda *shadowing* opisana i rozwinięta przez G. Trantham i P. Kennelly (2022) zostanie porównana z dotychczas stosowanymi metodami cieniowania, dostępnymi standardowo w oprogramowaniu typu GIS, np. ArcGIS lub QGIS.

Prace będą realizowane we współpracy międzynarodowej: z dr G.Tranthan i Prof. P. Kennelly (Penn State University, Long Island University, USA) oraz Prof. A. Çöltekin (University of Applied Sciences and Arts Northwestern Switzerland, Szwajcaria).

Szczegóły zakresu pracy zostaną ustalone ze studentem. Przykładowo, ocenie mogą podlegać: różnice w widoczności niewielkich form ukształtowania bądź też poprawność szacowania różnic wysokości.

Dodatkowe informacje znajdują się poniżej.

User studies for relief shading and shadowing

Relief shading (also known as shaded relief or hillshading) is a method of terrain representation that gives the perception of three-dimensionality to 2D maps. While previous studies have explored topics such as relative height of peaks, direction of illumination (Biland and Çöltekin 2017) and terrain reversal/inversion with direction of illumination (Çöltekin and Biland 2019), two enhancements to relief shading methods allow for expanding on this research or exploring additional hypotheses.

The first method is using models of sky illumination and multiple weighted illumination directions such as the clear day model to use both relief shading and shadowing to approximate more natural representations of terrain (Kennelly and Stewart 2014). A comparison for Mt Hood Oregon is shown in Figure 1.

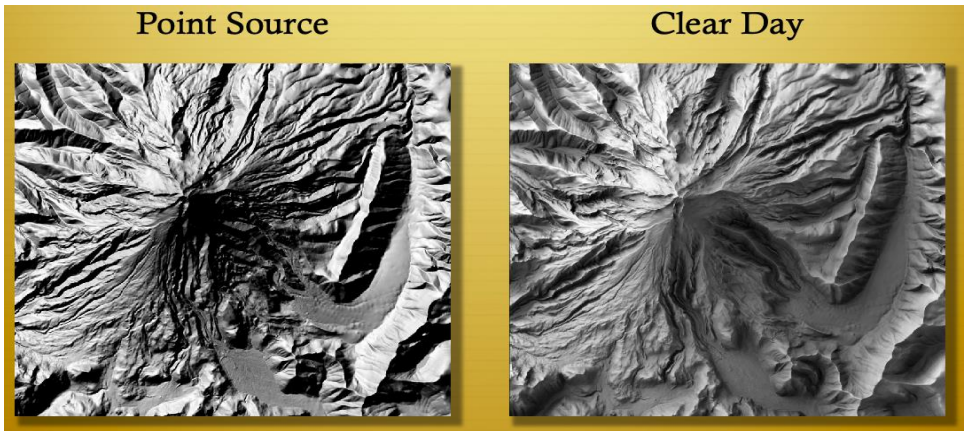

Figure 1: Relief shaded maps of Mt Hood using the ArcGIS hillshading tool (left) and a clear sky model with 250 directions of illumination weighted with sky brightness.

This technique could be used to address research questions such as:

1) Since sky models use illumination from numerous directions, are they equally susceptible to terrain reversal?
2) Is there an optimal sky model or associated directions of illumination for particular areas, such as mountains or deep canyons?
3) Do relief shaded maps with sky model illumination assist users in determining differences in elevation between various points?

One perceptual study begins to address these questions by comparing clear sky models to various other advanced relief shading techniques using only subjective opinions of participants (Farmakis-Serebryakova and Hurni 2020).

The second resource is the ability to render terrain using sky models with relief shading only, shadows only, or a combination of shading and shadows (Trantham and Kennelly 2022). With such capabilities, two observations were apparent. One observation is that using shadows seems to create terrain maps with more of a 3D effect, and that shadows alone are capable of producing this effect with all of the detail of a relief shaded map (Figure 2).

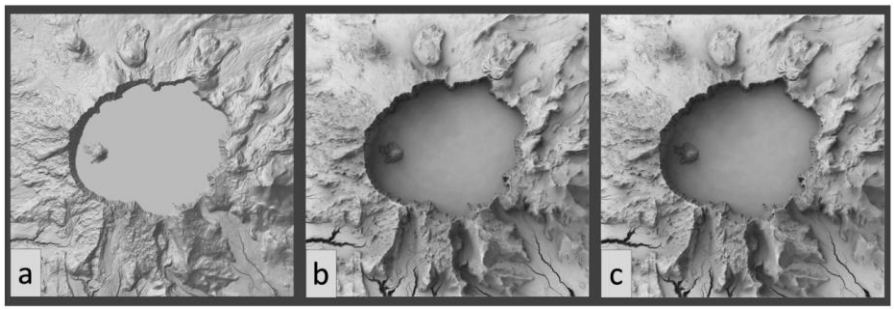

Figure 2: A comparison of maps of Crater Lake Oregon using a clear sky model (300 directions) and (a) relief shading only, (b) shadowing only, and (c) relief shading and shadowing.

This could be used to explore such questions as:

1) Are users able to see more detail in a shadowed versus relief shaded map? (a versus b in Figure 2)
2) Do shadows assist users in determining differences in elevation between various points?

The second observation is that vertical exaggeration (e.g. multiplying the actual elevation by 1, 3 and 5 times) of digital elevation models (DEMs) seems to lead to a stronger 3D effect (more depth) in shadowed maps than shaded relief maps (Figure 3).

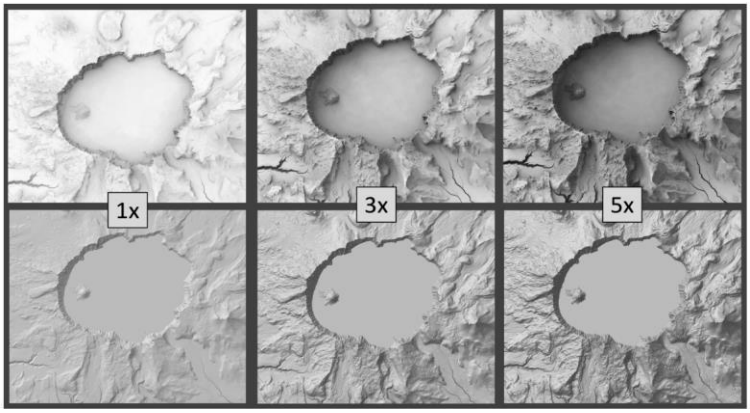

Figure 3: After applying vertical exaggeration of 1x, 3x and 5x (the three columns), the DEM was rendered with shadows only (top row) and relief shading only (the bottom row).

This could be used to formulate such research questions as:

1) Could users sort shadowed or relief shaded images in proper order of vertical exaggeration of the associated DEM?
2) Is there a preferred amount of vertical exaggeration associated with the perception of relief?
3) Are users able to determine differences in elevation better with increased vertical exaggeration and shadowing?

References:

Biland, Julien, and Arzu Çöltekin. "An empirical assessment of the impact of the light direction on the relief inversion effect in shaded relief maps: NNW is better than NW." *Cartography and Geographic Information Science* 44, no. 4 (2017): 358-372.

Çöltekin, Arzu, and Julien Biland. "Comparing the terrain reversal effect in satellite images and in shaded relief maps: an examination of the effects of color and texture on 3D shape perception from shading." *International Journal of Digital Earth* 12, no. 4 (2019): 442-459.

Farmakis-Serebryakova, Marianna, and Lorenz Hurni. "Comparison of relief shading techniques applied to landforms." *ISPRS International Journal of Geo-Information* 9, no. 4 (2020): 253.

Kennelly, Patrick J., and A. James Stewart. "General sky models for illuminating terrains." *International Journal of Geographical Information Science* 28, no. 2 (2014): 383-406.

Trantham, Gene, and Patrick Kennelly. "Terrain representation using orientation." *Cartography and Geographic Information Science* (2022): 1-13.