Using Photogrammetry and Lidar data for landslide risk analysis

Annotated Bibliography

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1. Brunsdon, C., & Comber, A. (2020). Opening practice: Supporting reproducibility and Critical Spatial Data Science. *Journal of Geographical Systems*, *23*(4), 477–496. https://doi.org/10.1007/s10109-020-00334-2
    - This paper discusses the importance of critical data science and why opensource practices are beneficial. When software and methods are concealed in a black box it is difficult to very information and reproduce methods.
    - The primary goal of my project is to make landslide risk analysis affordable and accessible to the public by showing the potential of drone assisted lidar and photogrammetry. I agree with the author's vision and hope to make my methods transparent for anyone that would like to reproduce the data or methods with no black boxes on any step of the way.

2. Laribi, A., Walstra, J., Ougrine, M., Seridi, A., & Dechemi, N. (2015). Use of digital photogrammetry for the study of unstable slopes in urban areas: Case study of the el biar landslide, Algiers. *Engineering Geology*, *187*, 73–83. https://doi.org/10.1016/j.enggeo.2014.12.018
    - This paper focuses on the landslide of El Biar in Algiers to demonstrate the practicality of digital Photogrammetry in the study of landslides in urban areas.
    - Photogrammetry is a tool that is easy to use and affordable today in the world of remote sensing. This paper demonstrates the pros and cons of photogrammetry, which is important for me to know before conducting my story. Knowing the limitations of the technology allows me to focus on other methods than can complement my data such as geological / geotechnical data.

3. Leshchinsky, B. A., Olsen, M. J., & Tanyu, B. F. (2015). Contour connection method for automated identification and classification of landslide deposits. *Computers & Geosciences*, *74*, 27–38. https://doi.org/10.1016/j.cageo.2014.10.007
    - The Contour Connection method is used on lidar data to not only identify landslide deposits and other different landscape features. This method uses the geometry of the landscape to identify landslide prone areas.
    - This goal of this paper alight with mine which is to create a method to provide a landscape risk analysis tool with quick results and low manual input. Similar to the methods from this paper I will be using a combination of lidar and photogrammetry to get my data but I will be using a contour isopleth map for analysis in addition to bedrock geologic data.

4. Van Den Eeckhaut, M., Kerle, N., Poesen, J., & Hervás, J. (2012). Object-oriented identification of forested landslides with derivatives of single pulse LIDAR data. *Geomorphology*, *173-174*, 30–42. https://doi.org/10.1016/j.geomorph.2012.05.024
    - This paper investigates the potential of object oriented analysis using single pule lidar derivates in densely vegetated areas. This paper also delves into the different parts of a landslide and the patterns that can be used for landslide risk analysis.

- In densely vegetated areas photogrammetry can not be used to get accurate results but this paper demonstrates the the ability for a simple lidar system to penetrate dense vegetation to create slope gradients, roughness and curvature. The methods used for landslide identification is also very useful and I will be using its results to my analysis (which uses contour maps from lidar data)

5. Bulut, F., Boynukalin, S., Tarhan, F. *et al.* Reliability of landslide isopleth maps. *Bull Eng Geol Env* **58**, 95–98 (2000). https://doi.org/10.1007/s100640050002
    - This paper looks at the landslides in north-east Turkey on Juley 1983 and the feasibility of isopleth maps. This paper finds the methods at the time to be costly but if done in a high enough resolution can be used to delineate general 'hazard zones'
    - This paper was one of the inspirations for my project as was limited by the technology of its time. It proves that isopleth maps can be used to do a landslide risk analysis. Using a similar method my goal is to use remote sensing drones with Lidar to get topographic data necessary for isopleth maps in a cost effective and efficient manner.

6. Carvajal, F., Agüera, F., & Pérez, M. (2012). Surveying a landslide in a road embankment using unmanned aerial vehicle photogrammetry. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XXXVIII-1/C22,* 201–206. https://doi.org/10.5194/isprsarchives-xxxviii-1-c22-201-2011

    - Photogrammetric models, Digital Elevation Models and 3D contour lines are made using drones in Almeria, Spain. This paper demonstrates a low-cost alternative to field surveying.
    - This paper demonstrates the capabilities and limitations of Photogrammetry along with the range of error. It claims that even with the errors it was still accurate enough to characterize landslides. I want to see how well the method fares in a more densely forested setting and for identifying landslide prone areas.

7. Dering, G. M., Micklethwaite, S., Thiele, S. T., Vollgger, S. A., & Cruden, A. R. (2019). Review of Drones, photogrammetry and emerging sensor technology for the study of dykes: Best practises and future potential. *Journal of Volcanology and Geothermal Research*, *373*, 148–166. https://doi.org/10.1016/j.jvolgeores.2019.01.018

    - This paper uses drones capture high resolution images of dykes and create a photogrammetry models with centimeter accuracy. A point to raster technique is used to measure the spatial error in the raster of the photogrammetric model.
    - Though this study looks at dykes I am interested on the method used. This paper discusses best practices and the future potential for drone photogrammetry which will be a great resource for the data collection part of my study.

8. Du, J.-C., & Teng, H.-C. (2007). 3D laser scanning and GPS technology for landslide earthwork 7volume estimation. *Automation in Construction*, *16*(5), 657–663. https://doi.org/10.1016/j.autcon.2006.11.002

    - This study uses lidar in addition to GPS to map out landslide data. It also describes the method, operation and results of using GPS.

- For my project I will need to geolocate point sand this study gives great insight on how GPS can be utilized to get accurate positions of lidar data. This will come into handy while mapping out the drone imagery data for my project.

9. Eeckhaut, M. V., Poesen, J., Verstraeten, G., Vanacker, V., Nyssen, J., Moeyersons, J., Beek, L. P., & Vandekerckhove, L. (2007). Use of LIDAR-derived images for mapping old landslides under forest. *Earth Surface Processes and Landforms*, *32*(5), 754–769. https://doi.org/10.1002/esp.1417

    - In heavily forested areas like the Flemish Ardennes in Belgium a lot of past earthquakes happen under the foliage and make it difficult to study using arial photography. The survey done for this paper concluded the Lidar assisted maps greatly improved the field survey-based inventories of landslides.
    - I picked lidar in addition to photogrammetry for its ability to penetrate trees and get data on the surface. This study compares the accuracy of lidar with observations from multiple experts which makes me confident on its methods. I will be using a similar method for obtaining Lidar data for my project.

10. Jaboyedoff, M., Oppikofer, T., Abellán, A., Derron, M.-H., Loye, A., Metzger, R., & Pedrazzini, A. (2010). Use of lidar in landslide investigations: A Review. *Natural Hazards*, *61*(1), 5–28. https://doi.org/10.1007/s11069-010-9634-2

    - This paper goes in depth on the history and lidar technology for making digital elevation models (DEMs) and 3D models. The four main topics of the paper are; 1) Detection and characterization of mass movement, 2) Hazard assessment and susceptibility mapping, 3) Modeling, and 4) Monitoring.
    - I will be looking into the 1) Hazard assessment and susceptibility mapping section of this paper primarily. This paper also has useful information on using 3D maps from lidar for risk analysis of not just landslides but also weak-points in the geometry of the landscape. I will be using a similar method for both my lidar and photogrammetry data.

11. Kellner, J. R., Armston, J., Birrer, M., Cushman, K. C., Duncanson, L., Eck, C., Falleger, C., Imbach, B., Král, K., Krůček, M., Trochta, J., Vrška, T., & Zgraggen, C. (2019). New Opportunities for Forest Remote Sensing through ultra-high-density drone lidar. *Surveys in Geophysics*, *40*(4), 959–977. https://doi.org/10.1007/s10712-019-09529-9

    - This paper uses different commercially available lidar drones to compare their measurements. Drone lidar data produces point clouds at much higher resolution from traditional airborne platforms with an accuracy of around 2.4cm. This paper also demonstrates the kind of 3D models and data that can be utilized from the point-cloud.
    - This paper was really important as it compares the different lidar options available commercially and demonstrates the kind of data I will be dealing with in my project. Knowing the kind of drone and the proper method of obtaining lidar data will be crucial for my project. This paper also demonstrates the different kind of data I can extract from lidar and its limitations which I will take into account while working on my project.

12. Sarkar, S., & Kanungo, D. P. (2004). An integrated approach for landslide susceptibility mapping using remote sensing and GIS. *Photogrammetric Engineering & Remote Sensing*, *70*(5), 617–625. https://doi.org/10.14358/pers.70.5.617

    - This paper uses Satellite data, topographic maps, field data for spatial data analysis in GIS. The main focus is in the Darjeeling Himalayas where areas susceptible to landslides are classified into 'high, moderate, low and very low' risk and then validated by comparing it to existing field instability conditions.
    - Coming from Nepal this study hits close to home and is the kind of study I would like to do in the future. This study incorporates multiple thematic maps such as DEMs, lithology maps, lineament density maps, draining density maps, etc which I would like to incorporate into my map as well to improve accuracy.

13. Xiaoye Liu. (2008). Airborne lidar for DEM generation: Some critical issues. *Progress in Physical Geography: Earth and Environment*, *32*(1), 31–49. https://doi.org/10.1177/0309133308089496

    - This paper is a detail study on how high resolution DEMs can be generated using Lidar data. It also discusses best practices for cleaning up data to make it easier to study and process.
    - My study will be using lidar to create DEMs prior to doing a landslide risk analysis and it is important that the DEMs are not only accurate but also easy to analyze. The goal of my paper to to show landslide risk analysis can be done is a cost effective and efficient manner.

14. Ralph A. Haugerud and Rowland W. Tabor. (n.d.). *Geologic map of the North Cascade Range, Washington*. USGS Publications Warehouse. Retrieved December 3, 2022, from https://pubs.usgs.gov/sim/2940/
    - This is a study on the geologic past of the cascade mountains in Washington conducted by the USGS. It explains the mechanisms for the geology we see in the area and the lithologic layers that lay underneath.
    - A contour map of the area of study may not be sufficient to be able to deduce the susceptibility of landslides so I will be using the study from this paper to understand the geologic history of the area. Knowing this along with the bedrock map would be useful in determining areas more prone to landslides. The geometry of the land may be determined by the underlying layers.

15. *Surface geology: WA - DNR*. WA. (n.d.). Retrieved December 3, 2022, from https://www.dnr.wa.gov/programs-and-services/geology/geologic-maps/surface-geology

    - The Washington state department of natural resoucres website contains a detailed geologic map of the surface geology and the type of rock underneath. This website also has the geologic map database public.

- The database in this website will be a core part of my project. I will be incorporating it to the isopleth map I aim to make with lidar data. Comparing the underlying geology with surface features could help identify features that help identify landslide prone areas.

16. Ralph A. Haugerud and Rowland W. Tabor. (n.d.). *Geologic map of the North Cascade Range, Washington*. USGS Publications Warehouse. Retrieved December 3, 2022, from https://pubs.usgs.gov/sim/2940/

    - The USGS database with a detailed geologic map of the cascade mountains. This website not only includes maps but also descriptions and images of the different features.
    - This will be a great resource to use as reference while importing data from the washngton state department website.The USGS website has detailed description on the features and its geologic history along with images which would be helpful to use when trying to identify underlying features. I am also hoping to have the ability to select an area from my map and display a cross section of the lithologic layers. To do that I will need to use information from this website.