Open-source Estimation of Shade Availability at Military Bases in the United States

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Introduction

Acute occupational exposure to heat and chronic occupational exposure to ultraviolet (UV) radiation threaten force health and readiness, causing health issues such as:

- Heat exhaustion
- Heat stroke
- Skin cancer
- Dehydration

Heat stroke victim evacuation during Desert Shield 101st Airborne, Saudi Arabia, photographer unknown, public domain.

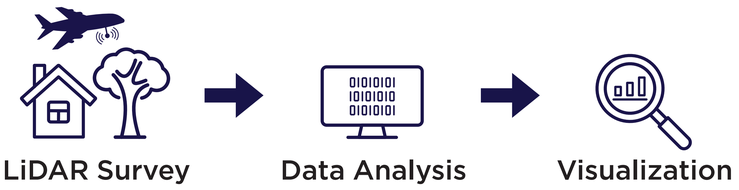
Shade is effective for cooling and UV protection; it can reduce air temperature by up to 20 degrees. Characterizing opportunities for shade access can improve force health and readiness.

Goal

We outline a novel open-source approach to estimate shade availability for military populations based on publicly available topographic data to inform operational and medical planning.

Methods

Our approach uses data captured by Light Detection and Ranging (LiDAR) technology collected via low-flying aircraft to perform: (1) identification of natural and built obstacles, (2) computation of shadow footprint cast by obstacles, and (3) estimation of hourly total area and proportion of base shaded.



As a proof-of-concept, we obtained the most recent (2004) three-dimensional point cloud data of the U.S. Naval Academy from the U.S. Geological Survey (USGS) 3D Elevation Program (3DEP) database. We computed the shadow footprint cast by obstacles ≥3 meters (m; ≥9.5 feet) tall at a 4 m^2 resolution on June 21, 2004, at 3 pm EST (i.e., peak heat hour). The pipeline uses R Language software version 4.5.1.

Results

Figure 1: Imagery of the U.S. Naval Academy (March 2004) from Google Earth and Maxar Technologies.

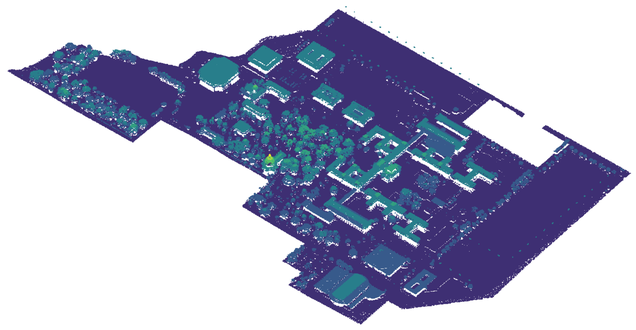


Figure 2: Point cloud data from USGS 3DEP (April 2004) with normalized height. Warm colors indicate taller heights.

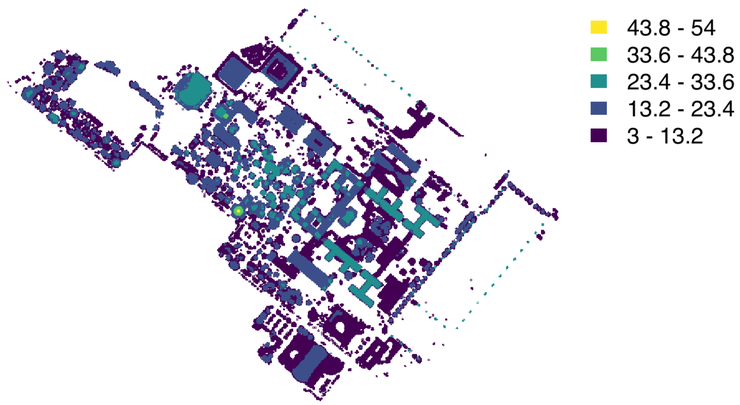


Figure 3: All 4 m^2 obstacles on the U.S. Naval Academy ≥3 m tall. Warmer colors indicate taller heights.

Figure 4: Obstacles (light grey-colored) and their shadow footprints (dark grey-colored) on the U.S. Naval Academy at 3 pm EST on the summer solstice.

Of the 739,446 m^2 area of the U.S. Naval Academy, obstacles ≥3 m tall covered 321,460 m^2 and casted a 48,496 m^2 shadow footprint during peak heat (3 pm EST) on the summer solstice (2004) for an additional 11.6% open area covered by shade.

Conclusion

Shade assessment at military facilities can help identify locations with higher risk of heat-related illnesses and focus mitigation actions (e.g., shade structures) to improve force readiness.

Further Research

The process could be improved with more recent spatially and temporally resolved data. DLH can apply this process to additional U.S. Military facilities before and after shade improvement projects to assess their effectiveness.

DLH could also apply this process to point cloud data converted from imagery collected via unmanned aerial vehicles (i.e., drones) to support broader site planning and operational assessments to improve troop health and readiness across all environments: at home, in training, and in theater.

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