Monitoring in-cave Resources with Reduced Impact and increased Quantitative Capacity: Developing Photogrammetry Methodologies for in Cave Environments

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Introduction

Photogrammetry is a methodology developed to use photographs in order to accurately measure the size, location, and context of 3D objects (Mikhall et al. 2001). The use of photogrammetry is becoming an increasingly popular tool to document geologic resources. Most uses of this technique have occurred in surface environments with very few studies documenting resources in low-light, sub-surface environments. Those that have been conducted in cave environments often involve use of other related technologies, such as Terrestrial laser scanning (Lerma et al. 2010) to develop these 3D models. These added methodologies increase cost, need for technical expertise, and amount of gear needed to document resources. Photogrammetry, as a stand alone methodology, holds the possibility of decreasing the impact while increasing the quantitative nature of both research and monitoring efforts within cave environments if it's limitations can be mitigated. Here we present developing techniques for performing photogrammetry in the unique conditions of caves in order to improve our ability to document and monitor resources in these environments.

Figure 1: Image of an entrance area photogrammetry set up at GRCA. To reduce the amount of equipment brought into the cave, the authors use trekking poles and caving lights to illuminate the site.

Methodology

The National Park Service has been leading the efforts to adapt these methodologies for in-cave use. Recent software developments allow for reduced field equipment in order to create accurate 3D models, however dark and damp conditions can hamper the quality of the model output (Tsakiri et al. 2007). In order for photogrammetry to provide the necessary information, these two factors need to be addressed. Newer digital cameras can minimize the impact of dampness on the final model, however lighting needs to consistent and bright to provide the data necessary for the software. Additionally, the remote nature of many in cave sites, means lightweight and compact options are necessary to provide this lighting. At Grand Canyon National Park, modifications to minimize weight while maximizing light have included using common caving/hiking equipment to reduce the weight of materials brought into the caves (Figure 1). Trekking poles are often used as light stands and caving lights are used in conjunction with lightweight video lights to maximize the amount of light available. To further adjust for reduced light in the cave environment, cameras are set to a slower shutter speed, with a wide focal range, set on a timer, and placed

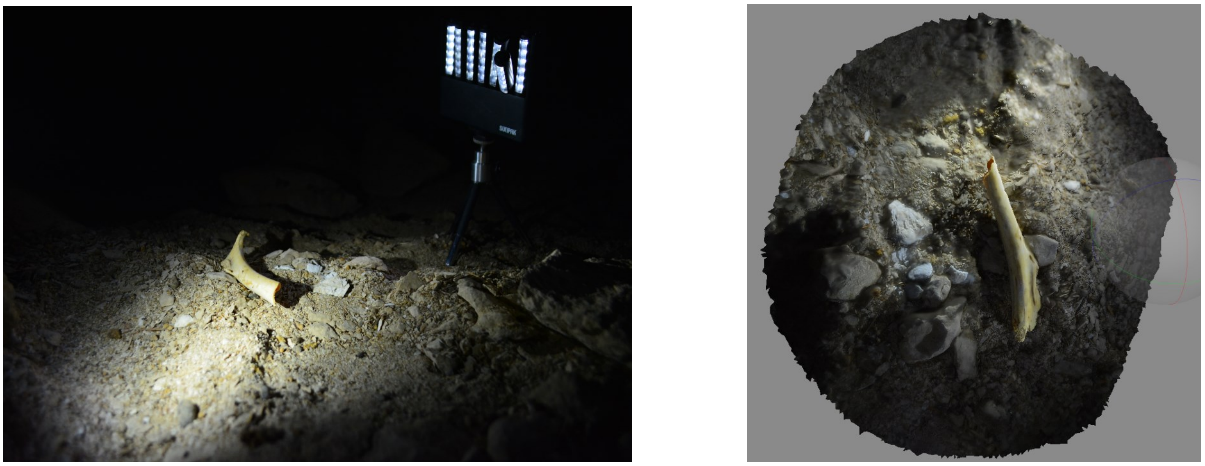

Figure 2: Proximal tibia photographed in cave is illuminated using a lightweight, portable video light (above). Resulting 3D model of the tibia (right).

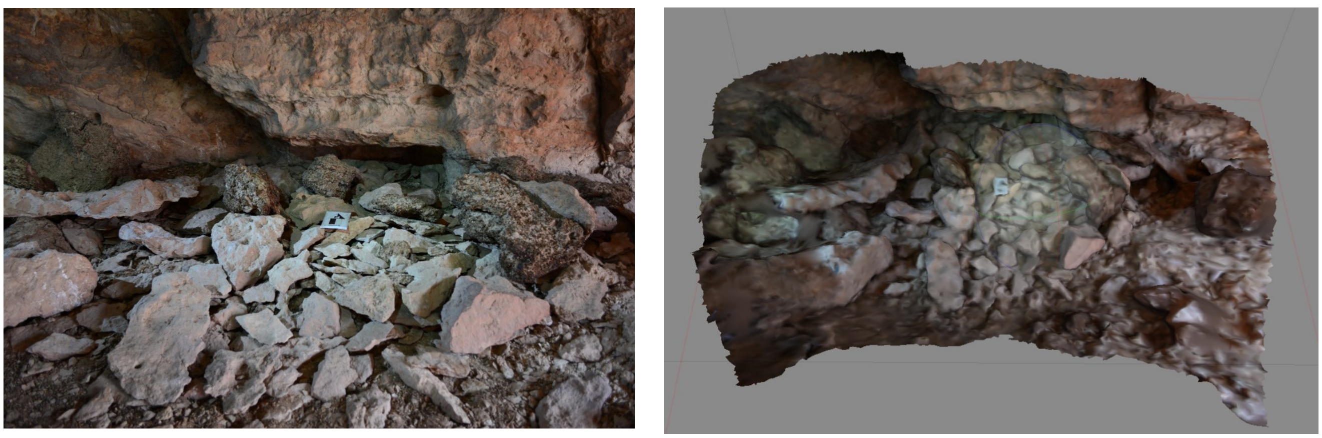

Figure 3: Photo of a monitoring site in GRCA (left). Resulting 3D model of this monitoring site (right)

on a tripod to reduce camera movement. In order to collect enough data for the models, a minimum of 30 photos are taken for small, individual objects (see Figure 2) and 50 or more photos are taken for larger monitoring sites (Figure 1 and 3).

Results

Examples of preliminary in-cave methodologies have been used to produce models of paleontological resources (Figure 2), archeological artifacts, and as a method for establishing quantitative photo monitoring (Figure 3) . Additional models have been created for resources in Oregon Caves National Monument.

Conclusion

Due to the inherent nature of conducting research in caves within a national park setting, it is preferred to leave all resources in-situ while still providing as detailed documentation of these resources as possible. Additionally, long-term monitoring is often necessary to determine the impact of human use and improve protection of these resources. Photogrammetry provides a means of quantifying this change over time by comparing models created at different time periods to determine differences in preservation and protection of these resources. These methods are relatively low impact, when compared to typical resource-focused studies, such as paleontological digs, and provide a means of documenting impacts and change over time that is much more quantitative than standard photo monitoring efforts. Additionally, the light-weight nature of these developing methodologies provide a means of getting high quality data while increasing feasibility and minimizing impacts of data collection in remote cave environments.

References

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