Comparing UAS and Pole Photogrammetry for Monitoring Beach Erosion

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Abstract

Sandy beaches are vulnerable to extreme erosion, especially during hurricanes and other extreme storms, as well as gradual seasonal erosion cycles. Left unchecked, coastal erosion can put people, homes, and other infrastructure at risk. To effectively manage beach resources, coastal managers must have a reliable means of surveying the beach to monitor erosion and accretion. Traditionally, these surveys have used standard ground-based survey methods, but advancements in remote sensing technology have given surveyors new tools to monitor erosion. Structure from Motion (SfM) photogrammetry presents an inexpensive, fast, and reliable method for routine beach surveying. Typically, SfM utilizes photos taken by unmanned aerial systems (UAS), but weather conditions and government regulations can make flying difficult or impossible, especially around crowded areas popular with beachgoers. Photos taken from a tall pole on a mobile platform can also be used for SfM, eliminated the challenges posed by weather and UAS regulations. This poster compares UAS SfM and "photogrammetry on a stick" (POAS) for monitoring beach erosion. Three surveys were conducted on a barrier Island in South Carolina, at monthly intervals, using both UAS SfM and POAS. Both techniques show promise, but POAS is more difficult to generate quality reconstructions from, while UAS provides a faster, smoother workflow.

Objective

The goal of this study is to conduct 3 monthly surveys of a beach using both UAS and POAS SfM. These photogrammetry platforms will then be compared and evaluated based on their relative performance and feasibility.

POAS track and study area

Study Area & Materials

The study area is an approximately 200m section of beach on Capers Island, South Carolina. Three surveys were conducted, in September, October, and November at low tide, as close to the tidal maximum as weather allowed. For UAS surveys, a DJI Mavic 2 Pro was used, and a GoPro Hero 8 Black and 4m telescoping pole were used for the POAS system. All photogrammetric processing was done with Pix4D. Emlid RS2 and RS+ RTK-GNSS units were used for a control survey and ground control points.

Methods

Photogrammetry on a Stick

POAS surveys were done with 4.5m line spacing, which ensures that images from adjacent transects overlap by at least 70%. The camera was set to 0.5s photo interval, giving sequential images over 90% overlap. All imagery was processed using Pix4D, using every image, every other image, and every third image to find a balance between image overlap and processing time. Latitude and longitude data were taken from the GoPro's onboard GPS, but altitude was estimated from RTK data, as the GoPro's GPS has very poor vertical accuracy relative to the ground variation.

UAS surveys

Multiple flights were flown to vary altitude, camera angle, and flight pattern. Flight altitudes ranged from 50m to 115m, and camera angle from 0-15 degrees. All imagery was processed with Pix4D.

RTK-GNSS surveys

The RS2 unit was used as a base station with the RS+ as the rover. Three cross-beach transects were surveyed, with 6m point spacing. For each survey, an additional 5-10 ground control points were collected as well. All points were then corrected using a nearby CORS station.

Evaluation criteria

UAS and POAS were evaluated based on performance and feasibility. Important metrics are the required skill, both for conducting the survey as well as post-processing, time, computing, and equipment costs, external limitations (e.g., weather, government regulations), and the quality of output.

POAS system in action

DJI Mavic Pro 2 and Emlid RTK-GNSS

POAS photo (left) vs drone crop of the same area (right)

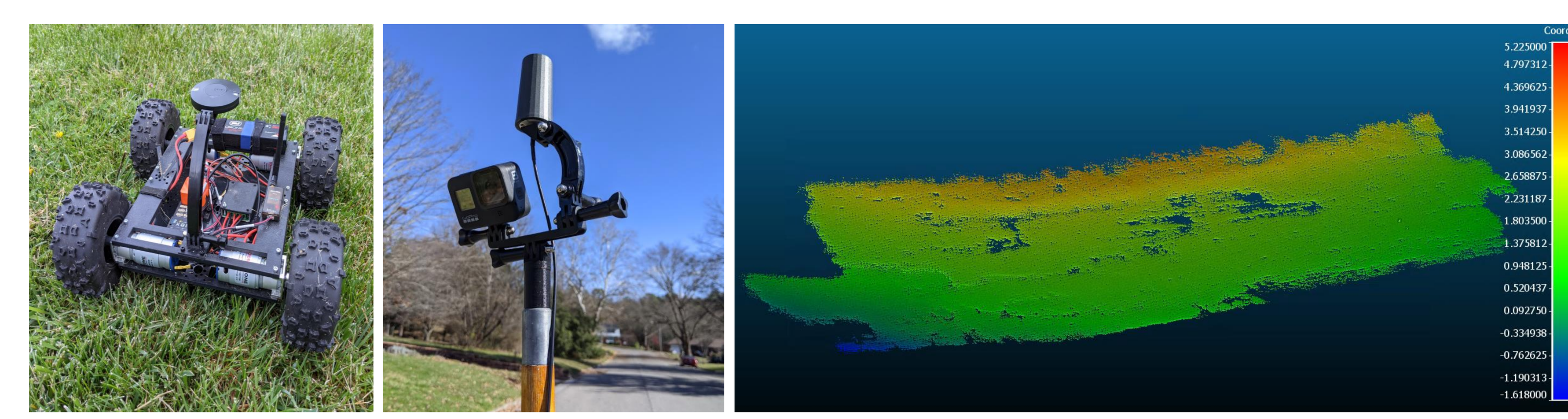
Future work

The next steps for this project are to georeference and directly compare DSMs and point clouds produced by UAS and POAS SfM. This will allow for a better analysis of performance. Once point clouds are georeferenced, they can then be used to quantify monthly beach change, and compared to lidar surveys. POAS collection can be improved by mounting a camera on an autonomous rover and/or pairing it with an RTK GPS receiver.

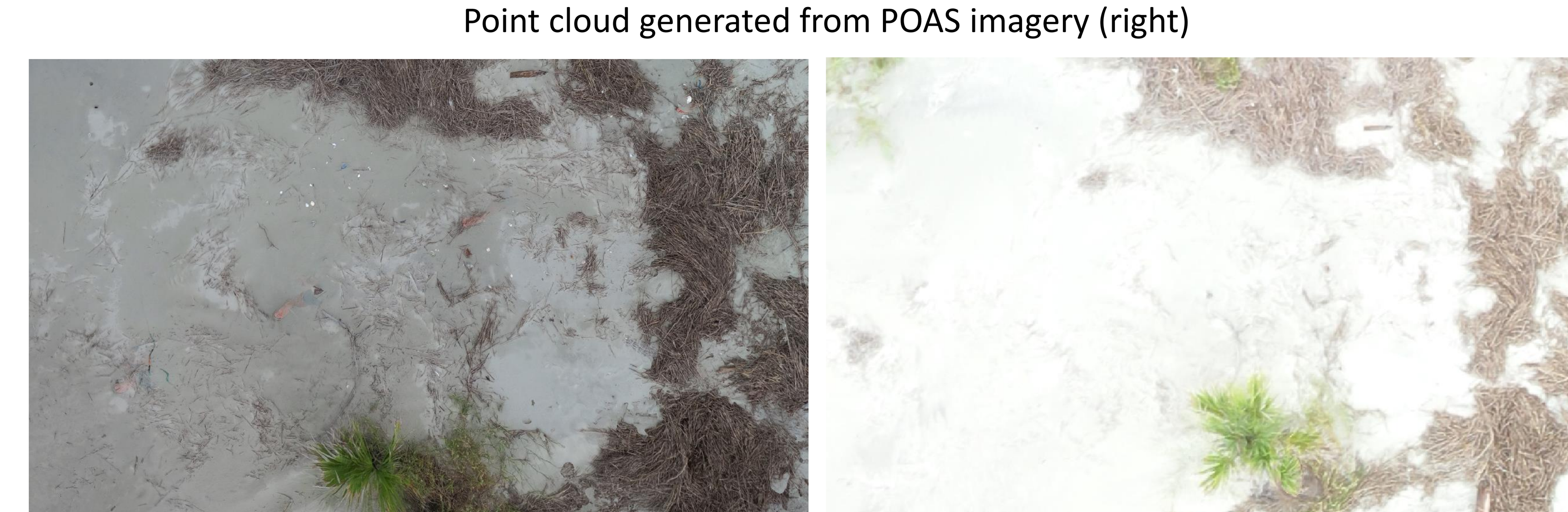
POAS	UAS
Extremely low equipment cost and training	Moderate equipment cost, requires an FAA Part 107 certified pilot
Many images need to be taken due to the low camera altitude, leading to long survey times (~1.5hrs in this example)	High camera altitude and drone speed leads to fast surveying times (~20 min in this example)
Large image sets lead to long post processing times and requires more experience with post-processing software	Post processing goes much faster with fewer images, typically with fewer challenges and errors
The current hand-held POAS system requires careful attention to ensure correct spacing, and ~4.5 miles of walking for this study area	Flights can be pre-planned, flown autonomously, and repeated
Much more capable in poor weather, only limited by thunder/lightning or extreme weather events. Not affected by government regulations.	Limited by poor weather, especially visibility and high windspeed. FAA regulations prohibit flying over populated areas (such as a crowded beach)
Surveyable area limited by time; battery life is very long	Surveyable area limited by battery life (~20 min flight time for DJI Mavic 2 Pro)
Poor geolocation information, especially altitude. Requires an external source of altitude information to reconstruct well.	Images tagged with acceptable geolocation information, as well as camera roll, pitch, and yaw. Drones with onboard RTK-GNSS are now commercially available as well
Extremely high maximum resolution, as fine as 3mm	Resolution depends on flight altitude, but can be as fine as 1cm

Conclusions

While both techniques can produce a high-resolution DSMs, UAS surveys reconstruct in Pix4D much more easily than POAS. This is likely due to a combination of better geolocation information, camera pose information, and fewer images. UAS surveys are also much faster to conduct and process. A single flight takes about 20 minutes, while a POAS survey of the same area takes 1.5 hrs on foot, walking over four miles. Despite the difficulty of POAS, it is a viable alternative if flight is not an option. In addition to the advantage of being free of flight restrictions, POAS can produce extremely high-resolution DSMs and orthophotos, resolving even small pieces of debris and seashells. The POAS system here is very simple, but would greatly benefit from a more accurate GPS, such as the Emlid Reach M2, and being mounted on an autonomous rover to automate the survey process, similar to a preplanned drone flight.



Autonomous rover under construction (left), GoPro with Emlid Reach M2 RTK-GNSS antenna (middle), Point cloud generated from POAS imagery (right)



Comparison of orthophoto resolution from POAS (left) and UAS (right)