Unmanned aerial vehicles and structure from motion techniques and their use in protecting surface water quality

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Structure from Motion (SfM) is a technique which relies on the concept of parallax to estimate 3D surfaces from 2D images. This technique has more recently been accomplished with unmanned aerial vehicles to create digital surface models. At present, SfM is gaining acceptance as a low-cost alternative to other methods which estimate surface topography (e.g., LIDAR, terrestrial laser scanning). Recent research evaluated SfM for its potential to estimate bank erosion in agricultural drainage ditches and results were favorable for the use of SfM to not only identify eroded areas, but also to quantify sediment erosion and deposition volumes. Because erosion represents a significant detriment to surface waters, as a source of both chemical (i.e., phosphorus) and physical (i.e., sediments) pollutants, significant financial investment has been made by Federal and State agencies, as well as private entities, to install best management practices on the landscape. Erosion control will be necessary for maintaining the quality of surface water resources, and identifying and monitoring erosion in critical areas will enable stakeholders to better manage water resources by addressing a key source of degradation. Accordingly, an investigation was conducted to determine the usability of low-cost, off-the-shelf unmanned aerial vehicles to perform SfM analysis, and also the suitability of this data for decision making by water resource managers. The goal of this effort was to produce a method and best practices that end users could adopt fairly easily, affordably, and quickly. This research was conducted in the Catalpa – Red Bud Creek watershed, which was recently designated as an EPA 319(h) priority watershed based on the Watershed's status as impaired under Section 303(d) of the Clean Water Act for its sediment load, among other pollutants. The main channel of Catalpa Creek exhibits significant erosion, evidenced by channel incision and sidewall cutting; in some cases, this erosion is quite substantial and bank failure is a concern. Flights were conducted with a standard multi-rotor unmanned aircraft available, easily piloted and available for low-cost. Flights were conducted at multiple altitudes with 80% overlap of instantaneous field of view, with both north-south flights lines and east-west flight lines performed for each collection because vegetation was present in some areas of the channel (i.e., multiple viewing angles were required to see through vegetation). GPS-tagged control points were placed within the area of interest to reduce the error in the SfM digital surface model, and improved accuracy was observed. Collected data were processed with currently available, popular, image processing software packages; each had relative advantages. There were clear tradeoffs with resolution and image overlap versus processing time and storage requirements. It was also noted that higher resolution was not always desirable for images with complicated geometry; lower altitudes introduced problems with oblique views of complicated geometry. Optimal level of filtering, point cloud density, and resolution are landscape dependent, and cannot be generalized. However, acceptable digital surface models can be produced from SfM.

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