LOW-ALTITUDE DIGITAL PHOTOGRAMMETRY TECHNIQUE TO ASSESS EPHEMERAL GULLY EROSION

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1. INTRODUCTION

Ephemeral gully erosion is the main source of sediment from the agricultural landscape, unfortunately, it has been overlooked in traditional soil erosion assessment. Since an ephemeral gully, by definition, can be easily alleviated or filled by normal tillage, the difficulty in making the ephemeral gully erosion assessment is the lack of well-defined channel morphology such as classical gullies and river channels. The width and depth of the ephemeral gully are too small (+/- 0.5 m) to be detected by general topographic surveying and mapping. The intermittency of ephemeral gully, i.e., the removal by tillage operations, adds to the difficulty in its quantification.

The analysis of time lapsed aerial photos or digital elevation model (DEM) to quantify gully erosion has been well documented, especially aided by geo-spatial data processing techniques in recent years [1]. These studies are mainly conducted on well-incised gullies with depths in the order of 1 to 10 meters or greater. There is still a need to develop an accurate and rapid tool to assess rill or ephemeral gully erosion in the order of 0.5-1.0 m wide and 0.1 to 0.2 m deep in cultivated fields. In other words, we seek to develop a close-range DEM technology that can be deployed at the field scale to assess rill and ephemeral gully development.

2. LOW ALTITUDE PHOTOGRAMMETRY

Using low cost digital cameras to acquire 8 to 10 mega pixel images has made photogrammetry a much more feasible technique to generate DEM for gully erosion assessment. Although a remote controlled blimp has been successfully used to acquire low-attitude photo images, it is not a technique that can be easily adopted [2].

In this research, we developed software that will merge overlapping digital photos with ground control points to estimate DEM. We first tested the photogrammetry software by comparing generated DEM with laser scanned DEM in meter size areas in the laboratory. We then conducted two field trials: with the first test conducted at a relatively flat farm field using a unmanned aerial vehicles (UAV) to acquire photographs at approximately 50 m altitude and the second test performed at a steep, i.e., 30 degree, loess hillslope with the camera suspended 8 m above ground. A ground-based Light Detection and Ranging (LIDAR) system was also deployed during the second test.

3. IMAGE ACQUISITION AND PROCESSING

Two different camera configurations are supported. The first uses two cameras mounted on an aluminum beam. The distance between the cameras can be changed depending on the scale of work. This configuration is primarily for laboratory work. The second configuration uses a single camera to capture multiple overlapping images. The fixed dual camera system is advantageous at the laboratory scale to provide quick depth maps. This requires more initial calibration and care in positioning the cameras. The dual camera system is more suitable for close range work (1m-2m). For outdoor field assessment the single camera approach of taking multiple pictures of the scene from different perspectives has the advantage of being able to vary the camera placement based on the scale of the area.

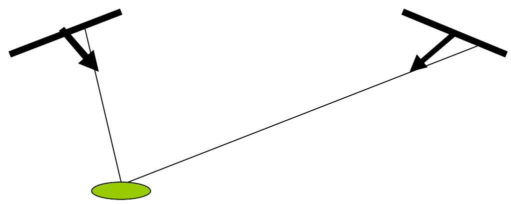

Figure 1. Camera image planes and principle rays intersecting with object point rays

After the images are captured, a point location in the actual space can be determined by identifying the corresponding points in two image frames (Figure 1). The distance from the camera to the object point is related to the amount of pixel shift between the images – closer points have a larger shift.

The open source OpenCV image processing library [3] and custom software written in C++ are used to calibrate the cameras, perform image rectification, generate disparity images and reproject pixels to three-dimensional coordinates. After the images have been rectified searching for corresponding points is done along rows of the images using the method described by Birchfield and Tomasi [4]. Dense stereo is achieved by matching as many pixels as possible from the overlapping images.

Using the disparity map, internal camera parameters and camera orientations, the actual 3D location of the pixels can be determined. This involves transforming the points from the camera reference plane to the ground reference plane. The resulting point cloud of X-Y-Z data can be exported to be used by other software.

Accuracy is determined by several factors during the processing of DEM. The most common source of error is inaccurate camera position with respect to the ground control points. This is the result of inaccurate calibration. The second most common source of error is inaccurate point matching. This can be the result of sharp changes in elevation or occlusions which prevent points from being identified in both images. Since the point matching is based on grayscale intensity values the scene lighting can also be a cause of incorrect point matches.

4. ASSESSMENT OF CLOSE RANGE DEM TECHNOLOGY FOR EPHEMERAL GULLY DELIENATION

The feasibility of using the close range DEM technology for ephemeral gully delineation was conducted using GIS topographic analysis tools. We compared the channel network derived from close range DEMs with those visually identified from the photographs. We found the following: 1) the regular topographic DEM is not accurate enough to delineate ephemeral gully channel; 2) ground-based LIDAR system is capable of generating accurate DEM and gully channels at steep hillslopes; and 3) at gentle slope situations, low altitude photogrammetry is most feasible. Nevertheless, proper deployment of a camera at a suitable height to have sufficient aerial coverage while maintaining the resolution at the Z (elevation) scale to assess rill ephemeral gully development is still a challenge.

5. REFERENCES

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