Cloud Observation by 3D Modeling Based on Camera Images

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Current weather radars used for short-term precipitation forecast mostly detect rain/snow droplets, which prevents from fully observing rapidly growing cumulus clouds that could cause severe weather until rain/snowfall starts. Phased array radars and other new radars have gradually been enabling to detect clouds but building and operating such radars would be expensive. In order to develop inexpensive methods to observe clouds before precipitation starts, images of the clouds captured with visible light cameras could be used to locate and make measurements of clouds. Previous studies have succeeded in locating clouds by calibrating cameras using various objects and landmarks, such as topographic features, locations of an airplane, the sun and stars. However, for the practical monitoring of clouds, it is important to investigate the proper conditions when capturing images to observe the clouds without any external calibration.

In order to observe the clouds, 4 images of the same cloud will be captured simultaneously at different locations using digital cameras (Nikon D5500). The images will then be imported into the 3D modeling software PhotoScanPro to align the photos, build dense cloud, and build 3D mesh model with which the location and size of the cloud will be calculated by tagging GPS location data. Up to now (15 Feb 2017), several experiments have been conducted using a lump of cotton as an object visually similar to clouds. (a) 4 images were captured with different dihedral angle between cloud-camera planes to examine the viability to generate 3D models and the accuracy of the calculated distance and surface area. Also, (b) another 4 images were captured with different light source position to examine the influence on the resulting models.

The results of the experiments are as follows: (a) as the dihedral angle increased, we reached a specific point where the software could not produce 3D models due to insufficient number of points matched by the software among multiple images. Also, as the angle widened, the accuracy of the calculated distance between the object and cameras got fairly high, covering the decent area of the cotton surface. This suggests that the specific angle is ideal even in the real photo-capturing situation. (b) The resulting 3D models did not vary with different locations of the light, which suggests that the slight change in the brightness and contrast caused by different location of the sun does not greatly affect the 3D models. The results demonstrate some aspects of the proper conditions when capturing images. For further investigation, we are planning to examine the accuracy of volume measurements using a piece of clay and we will keep on looking into other conditions that might affect the resulting 3D models and the accuracy of measurements. Another experiment is also planned to take actual photos of clouds and generate 3D models using them in order to evaluate the validity of the experiments. Finally, we will apply the above optimal conditions to the actual photo-capturing situation to acquire consecutive cloud images to construct 3D models and will make measurements, the accumulation of which helps determine criteria for the future forecast of precipitation and severe weather.

Keywords: Cloud Observation, Cumulus Cloud, 3D Models, Camera Images, Severe Weather Forecast