An algorithm for detecting the onset of volcanic eruption from digital images

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Near real-time monitoring of active volcano is necessary for understanding of eruption mechanisms and mitigating of volcanic disaster. However, volcanic eruptions usually restrict access to the near-crater, which prevent scientists from setting or repairing observation devices. We aim for realizing volcanic plume observations using digital images taken from an unmanned-copter-portable device, which could be placed at a new observation point around crater in spite of dangerous volcanic activities. In this study, we developed an algorithm for detecting the onset of volcanic eruption and discriminating volcanic plume from the images. We also validated the algorithm on the images of the Aso volcano eruption on 14 September, 2015.
This algorithm is organized in two steps: detection of eruption onset and discrimination of volcanic plume areas. First, newly defined three parameters that represents scattering properties on the sky (the intensity index, small particle index, and molecular index) are calculated from the RGB (red-green-blue) digital counts of digital images with JPEG format. Empirical thresholds of six parameters including the three indices and RGB counts can roughly discriminate cloud parts, clear sky parts, and volcanic plume parts from the images. The time derivative of the volcanic plume area calculated from the succeeding images can detect an onset of eruption. Second, once an onset of eruption is detected, the pixels detected as volcanic plume gives the most appropriate threshold for detecting volcanic plume part based on statistical features in the six parameters. The detection of volcanic plume with optimized threshold is more accurate than the first discrimination based on empirical thresholds, since optimal thresholds can avoid misclassification of volcanic plumes and perform well under various solar conditions.
We applied the algorithm to the images of Aso volcano eruption captured by JMA (from 09:04 to 10:08 JST in 2 minutes, on 14 September, 2015). Until 09:44, continuous white plumes have been observed, and all the area of analyzed images have been illustrated as blue color indicating normally active. On the other hand, the algorithm detected the onset of eruption at 09:46 when explosive gray plume was observed, and the volcanic plume part and the other parts were shown as red and white, respectively. These continued as long as the volcanic plume part was above sequential calculated threshold. When the volcanic plume covered the image, the time derivative of volcanic plume part fell below the threshold, resulting in blue. This analysis shows that the algorithm appropriately detected the change of eruption style from the continuous white plume to the explosive gray plume based only on digital images. Additionally, the analysis time is a second per an image, which is applicable for near real-time monitoring.
We have already developed the device equipped with a digital camera which can be load on an unmanned multi-copter. Therefore, we plan to analyze the images captured by the device using the algorithm and validate the volcano observation system.

Keywords: volcanic plume, digital camera, near real-time

