23rd IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Interactive Presentations - 23rd IAA SYMPOSIUM ON SPACE DEBRIS (IP)

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MACHINE LEARNING FRAMEWORK TO DETECT AMBIGUOUS CONTOUR OF SPACE DEBRIS CLOUD

Abstract

To evaluate the protective performance of bumpers, it is important to measure the spread velocity and angle of the debris cloud. However, debris cloud images exhibit ambiguous contours of debris clouds. Consequently, measurement errors in the spread velocity and spread angles occur because of the observer's subjectivity. Commonly used derivative-based methods can detect steep contours; however, they cannot detect ambiguous contours such as those of debris clouds. This study has three research objectives. First, this study proposes a novel method for detecting ambiguous contours of debris clouds based on supervised machine learning and a continuous wavelet transform (CWT). The ambiguous contours of debris clouds can be detected by the proposed feature vectors using contour labels generated by the BCET method. The debris cloud contour can be detected without any preprocessing and without being affected by the bright tendency of the whole image. The proposed method can also detect debris cloud contours that are more generalized than the BCET method or derivative-based methods by detecting ambiguous contours in local regions. Second, this study reduces the number of false positives in the detection of ambiguous debris cloud contours. In debris contour detection using only CWT, large areas other than debris clouds are falsely detected. A feature that focuses on the positional relationship between feature points that indicate a debris cloud contour is proposed. By combining this feature with the features extracted by CWT, only the debris cloud contour can be detected. Third, this study uniquely determines the debris cloud contour. Debris cloud contour detection is important for obtaining knowledge about debris cloud kinetic behavior by observing the debris cloud propagation velocity and propagation angles. The detected contour must be uniquely defined to determine the propagation velocity and other relevant information. However, contour detection using the proposed features results in redundant detection of contour positions. Therefore, the selection of representative detection points considering the characteristics of the support vector machine (SVM) is proposed. In conclusion, this study enables the detection of ambiguous contours in debris clouds using machine learning. This study enabled the extraction of feature points at desirable locations on ambiguous debris cloud contours. Furthermore, it was shown qualitatively and quantitatively that the proposed method adequately determines the points on the debris cloud contour even for unlearned test data.