Real-Time Image-Based Snow Avalanche Detection Using Machine Learning

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Abstract

Avalanches are one of the most serious threats in mountainous regions. They can cause problems, like accidents, damage to infrastructure, and transportation. The current avalanche detection methods usually rely on field monitoring and a few ground-based sensors, which limit the timely responses. This study introduces an image-based Avalanche Detection Technique using the YOLOv8 model, which automatically detects and categorizes snow avalanches from the images. The system was trained and tested with the UIBK Avalanche dataset, which is a collection of 4090 avalanche images. The dataset was reorganised into YOLO annotation format from the original format, and then it was split into training, validation, and testing sets. The polygon annotations were changed to normalised bounding boxes, and non-avalanche images were added to improve the model's selection strength. Real-time field images from Manali, Himachal Pradesh, India, were used to check the model's detection performance in challenging conditions. The performance of the model was assessed using standard object detection metrics. Precision was between 0.68 and 0.72, whereas recall values were between 0.52 and 0.57. The model reached a mAP@0.5 of 0.56 and mAP@0.5:0.95, ranging from 0.30 to 0.32. These outcomes show reliable detection performance for different avalanche types under challenging snow conditions.

Keywords

Avalanche detection, YOLOv8, Deep learning, UIBK Avalanche Dataset, Image-based monitoring.