Drice: Drone-Based Real-Time Black Ice Detection System for Winter Driving Safety

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Black ice, a thin coating of ice on the road surface, is the leading cause of traffic accidents. According to the U.S. Department of Transportation, black ice accounted for 3.6 times more casualties than all other weather-related hazards combined from 2007 to 2016. Numerous studies have proposed methods for detecting black ice; however, these existing approaches frequently fail to prevent black ice accidents due to their inefficacy or high cost. To address this problem, we propose Drice, a real-time processing system that accurately detects black ice and promptly alerts drivers. The proposed system employs drones to capture input images and an embedded computing board to execute machine learning-based black ice detection. To train and evaluate the proposed system, we collected a comprehensive black ice dataset comprising 2,851 image samples from diverse settings to capture a wide range of optical characteristics associated with black ice. Through extensive experiments, we demonstrated that the proposed system achieved state-of-the-art performance, reaching 0.47AP@[0.5:0.95], while maintaining a processing speed of 27 frames per second on Nvidia Jetson Orin Nano. Additionally, we introduce a practical application for deploying the proposed system in real-life scenarios. Drice has been tested in real-world conditions, detecting 9 occurrences of black ice at an AP@[0.5:0.95] of 0.33. The dataset and source code of this research project have been released online.