Deep learning-based methodology for smoke plume segmentation of wildfire images

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Abstract

Physics based models used to predict wildfire behavior and smoke plume rise need to be validated against empirical datasets. The acquisition of data pertaining to the evolution of smoke plume envelopes from wildfires presents significant challenges due to the highly variable 3D dynamics of the plume and associated optical properties involved. Besides the use of active remote sensing sensor like lidar [1], capturing still images or videos of smoke plume from multiple perspectives can be coupled with novel computer vision techniques to obtain comprehensive measurements of the plume as a three-dimensional entity. The first step to approach the 3D smoke plume reconstruction is being able to accurately segment the smoke from each image frame. In this study, we explore the effectiveness of deep learning-based methodologies, with particular emphasis on the UNet architecture [2], for tasks related to smoke image segmentation. We aim to leverage the UNet architecture to enhance segmentation performance and provide reliable analysis of smoke plumes in real-world scenarios.

Fig. 1. Predictions of the developed UNet model on images of the test dataset

The UNet model is a convolutional neural network based on the structure of autoencoders with skip connections, which develops self-learning tasks to finally obtain a prediction of the class trained, in this case smoke plumes. Different backbones in the UNet architecture were introduced to modify the encoder structure in order to obtain better performance. Tests of different architectures and hyperparameters configurations are done. This segmentation approach demonstrates promising results in accurately segmenting smoke plumes from wildfire images (see Figure 1). Results show that with the ResNet50 [3] and MobileNetV2 [4] backbones, the output obtained is similar in terms of performance, but MobileNetV2 has less computational cost. A validation accuracy of 93.45 % is achieved. The successful application of the UNet architecture enables the detection and segmentation of smoke plumes with high precision.

References

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