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Wildfires detection and segmentation using deep Convolutional Neural Networks and Tranformers

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Abstract

Every year, wildfires destroy 350 million to 450 million hectares (Dimitropoulos, 2019). This natural disaster causes multiple damages such as air pollution, human death, and financial losses. In the last decade, researchers focused on improving firefighting by employing systems for fire detection at an early stage. More recently, vision-based deep learning techniques have been proposed to detect the position of the fires in images (Ghali et al., 2018). Furthermore, fire segmentation based on deep learning methods were developed to locate the fire pixels and segment the fire areas (Akhloufi et al. 2018). Nonetheless, these techniques are still limited in identifying the precise fire's shape as well as small fire areas. For such, we present in this work a forest fire segmentation framework based on recent deep learning methods. Three deep convolutional neural networks: EfficientSeg, U^2-Net, and U-Net are employed to segment fire pixels and detect fire areas. In addition, two vision Transformers, MedT and TransUNet, are also developed and adapted to this task. The proposed Transformers determine the global dependencies between input and output sequences using the self-attention mechanism in order to segment fire pixels and detect the precise shape of the fire areas. These deep models, EfficientSeg, U^2-Net, U-Net, TransUNet, and MedT obtained high F1-score values of 95.0 %, 92.0 %, 94.0 %, 97.7 %, and 96.0 %, respectively, using the CorsicanFire dataset (Toulouse et al., 2017), which is composed of 1135 RGB wildfire images with their corresponding binary masks. The experimental results show the high performance of the proposed models outperforming some recent state-of-the-art techniques and classical machine learning models such as colour fusion methods (Dzigal et al., 2019). These results also proved the reliability of deep learning methods in segmenting fire pixels and detecting the precise shape of the flame. More specifically, the analysis of the results showed that deep learning models (deep CNNs and Transformers) correctly distinguish between fire and non-fire pixels and reduce the false alarms and fire pixels misclassifications. Finally, this work shows that the deep vision Transformers techniques are very efficient in segmenting wildfire pixels and detecting the precise shape of the fire, especially for small fire areas under various conditions of weather, presence of smoke, different distances to the fire, and environment brightness.

Keywords: Forest fires, fire detection, fire segmentation, deep learning, Transformers

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