EGU21-12330, updated on 23 Mar 2022
https://doi.org/10.5194/egusphere-egu21-12330
EGU General Assembly 2021

Wildfire detection and monitoring by using PRISMA hyperspectral data and convolutional neural networks

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Over the last few years, wildfires have become more severe and destructive, having extreme consequences on local and global ecosystems. Fire detection and accurate monitoring of risk areas is becoming increasingly important. Satellite remote sensing offers unique opportunities for mapping, monitoring, and analysing the evolution of wildfires, providing helpful contributions to counteract dangerous situations.

Among the different remote sensing technologies, hyper-spectral (HS) imagery presents nonpareil features in support to fire detection. In this study, HS images from the Italian satellite PRISMA (PRecursore IperSpettrale della Missione Applicativa) will be used. The PRISMA satellite, launched on 22 March 2019, holds a hyperspectral and panchromatic payload which is able to acquire images with a worldwide coverage. The hyperspectral camera works in the spectral range of 0.4–2.5 μm, with 66 and 173 channels in the VNIR (Visible and Near InfraRed) and SWIR (Short-Wave InfraRed) regions, respectively. The average spectral resolution is less than 10 nm on the entire range with an accuracy of ±0.1 nm, while the ground sampling distance of PRISMA images is about 5 m and 30 m for panchromatic and hyperspectral camera, respectively.

This work will investigate how PRISMA HS images can be used to support fire detection and related crisis management. To this aim, deep learning methodologies will be investigated, as 1D convolutional neural networks to perform spectral analysis of the data or 3D convolutional neural networks to perform spatial and spectral analyses at the same time. Semantic segmentation of input HS data will be discussed, where an output image with metadata will be associated to each pixels of the input image. The overall goal of this work is to highlight how PRISMA hyperspectral data can contribute to remote sensing and Earth-observation data analysis with regard to natural hazard and risk studies focusing specially on wildfires, also considering the benefits with respect to standard multi-spectral imagery or previous hyperspectral sensors such as Hyperion.

The contributions of this work to the state of the art are the following:

- Demonstrating the advantages of using PRISMA HS data over using multi-spectral data.
- Discussing the potentialities of deep learning methodologies based on 1D and 3D convolutional neural networks to catch spectral (and spatial for the 3D case) dependencies, which is crucial

when dealing with HS images.
- Discussing the possibility and benefit to integrate HS-based approach in future monitoring systems in case of wildfire alerts and disasters.
- Discussing the opportunity to design and develop future missions for HS remote sensing specifically dedicated for fire detection with on-board analysis.

To conclude, this work will raise awareness in the potentialities of using PRISMA HS data for disasters monitoring with specialized focus on wildfires.