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AI-BASED WILDFIRE RISK ASSESSMENT FROM LOW-COST MULTISPECTRAL DATA: COLLECTION, PROCESSING, AND ANALYSIS FOR SUB-6U CUBESAT MISSIONS

Abstract

With the recent spread of wildfires at alarming rates, protection agencies worldwide require appropriate risk metrics to make data-driven decisions. To increase accessibility to predictive data, this paper presents a complete image collection, processing, and analysis pipeline for wildfire risk assessment aimed at sub-6U CubeSat missions. This relies on Deep Neural Networks (DNNs) throughout both space and ground segments to achieve satisfactory performance at a reduced cost.

To provide meaningful data, the Normalized Difference Vegetation Index (NDVI) and Normalized Difference Moisture Index (NDMI) are proposed as main and auxiliary measures of burn risk respectively. NDVI indicates generic vegetation health, including hydration and density; it is calculated from the red and near-infrared (NIR) bands, and therefore inexpensive to collect. NDMI specifically indicates plant water content, but additionally requires short-wave infrared (SWIR) data, making it significantly more expensive to collect. Therefore, to reduce costs, this proposal relies on data collection of the green, red, and NIR bands, and extrapolation of the SWIR band from these; the resulting data can then be used to calculate both indices.

A Complementary Metal-Oxide-Semiconductor (CMOS) sensor with custom light filters and zoom lens is proposed as the remote sensing payload. CMOS technology is sensitive to both visible and NIR light, and therefore suitable for directly obtaining high-accuracy green, red, and NIR data. A set of sharp-cut filters allows precise selection of the wavelengths to be measured, as informed by atmospheric absorption; the zoom lens enables a finer ground sample distance. Atmospheric distortion is then corrected using state-of-the-art algorithms such as the darkest pixel method.

A multi-stage architecture is proposed for the processing pipeline, performing data reduction steps on board to relax the link budget, and data extrapolation and fusion steps on the ground to generate meaningful final products. On board, a lightweight segmentation DNN is used to extract vegetated image segments and discard the rest. These are then compressed with state-of-the-art algorithms such as JPEG-XL. On the ground, a Masked Auto-Encoder DNN is used to synthesise SWIR data from the collected channels. This is then used to calculate the NDMI. Subsequently, data is analysed with a Geographic Information System (GIS) to produce hazard maps of wildfire likelihood and severity. This fuses remote-sensed NDVI and synthetic NDMI with third-party data such as population density and weather conditions. Land use/cover data is also used, as extracted by upstream state-of-the-art segmentation DNNs based on Sentinel data.