Developing Practical Early Countermeasures to Wildfires: An Explainable AI Approach

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Smoke develops in the early stages of a wildfire and is vital to early prevention, but a new detection method is needed because smoke tends to be challenging to spot. This study used an image-based approach to smoke. A promising method is to train an object detection model powered by a deep neural network (DNN) employing images from vantage point surveillance systems, including HPWREN and ALERTWildfire. State-of-the-art object detection models for this task suffer from low data diversity and quantity, making them susceptible to hidden biases; moreover, they are black boxes, making it challenging to locate and explain the bias. Therefore, this study used Explainable AI (XAI) algorithms on an object detection model's two most prominent components to systematically identify which hyperparameters should be adjusted; targeted hyperparameters would be automatically optimized using Bayesian Optimization (BO), making the model improvement process procedural rather than guesswork. Saliency maps from the first step of XAI analysis revealed that the model had correctly captured smoke, but high confidence thresholds inhibited its accuracy. In the second step, a low-dimensional embedding technique revealed that an optimal threshold exists. In the third step, the confidence threshold was optimized with a BO algorithm, which was shown to produce a ~23% increase in true positives ($p<0.05$) and a ~14% decrease in false negatives ($p<0.05$). This is the first known instance where a generalized three-step XAI analysis procedure is used to efficiently develop human-in-the-loop wildfire smoke detection models, which could help prevent wildfires and save lives.