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Artificial Intelligence Drafted to Tackle Wildfire Risks

By: [Carsten Brinkschulte](#)

Wildfires have become a regular feature of our summer news bulletins. Once again, this year has seen loss of life in California, and fires on Greek islands contributed to a water shortage that pushed Greece's tourism sector towards crisis. And then there is the annual hit taken to efforts to manage climate change.

Trees play a vital role in absorbing carbon dioxide, arguably making them the most effective force to halt or reverse climate change effects. Wildfires not only undo all the hard work of planting and growing forests but also release huge amounts of carbon dioxide and other harmful greenhouse gases into the atmosphere. As carbon dioxide is released, temperatures rise, and the risk and frequency of wildfires grow.



Whether to safeguard the lives of humans and wildlife, or to reduce the impact on economies, or to care for the environment, finding better ways to detect and tackle wildfires is becoming an increasingly urgent issue.

Once Upon a Time

Early in the twentieth century, the U.S. Forest Service built lookout towers to spot fires. Since before the Great War to this day, the start of the fire season has seen a small army of men and women deployed to scan treetops, ever on the lookout for smoke on the horizon. As time and technology moved on, backup arrived in the form of fire-spotting aircraft and satellites. Even the towers have received upgrades with cameras performing a great deal of the treetop monitoring. And now, Artificial Intelligence (AI) has joined the fray.

Wildfire Prediction with AI Assistance

Although predicting the exact start location of a wildfire is challenging, calculating the risk can help us achieve reasonable prediction accuracy. Currently, fire risk is determined predominantly based on

weather information obtained from satellites and where available enhanced with data from local weather stations. Fire risk is then calculated on a rather coarse scale (e.g. with one square kilometer resolution) and published on news channels to alert the public of a heightened threat by wildfires.

More advanced calculations are based on VPD (vapor pressure deficit) which is the difference between the amount of moisture that's actually in the air and the amount of moisture that air could hold at saturation. From a wildfire perspective, consistently elevated VPD means that ecosystems can more easily ignite and spread fire, leading to the larger, higher-severity wildfires.

Calculating fire risk levels, taking into account various sources of information (satellite, weather stations, and potentially local sensors), and then mapping the risk on a fine-grained scale is a complex and tedious task which can be automated and enhanced in accuracy and resolution with the help of AI. Of course, adding more fine-grained information such as soil and air moisture levels measured by sensors embedded in the forest would help to take into account the microclimate of the forest. In the future, we might be able to push this even further if we could find a technical solution for measuring the fuel moisture (grass and needles), rather than just the soil moisture.

AI-based wildfire detection works by leveraging machine learning algorithms to analyze data from various sensors and detect the presence of a fire. Unlike traditional methods of fire detection that rely on human observation, AI can process vast amounts of data and identify patterns that indicate the presence of a fire.

The machine learning models used for fire detection are trained on large datasets that include both fire and non-fire scenarios to accurately identify fires based on the characteristics of smoke and other factors. The models are also rigorously trained to reduce the prevalence of false positive fire alerts.

Camera Detection and AI

Camera detection works by using a camera on a watchtower overlooking a large area of forest. Traditionally, these watchtowers were manned by people keeping a lookout, but are increasingly being monitored by cameras.

Machine learning and AI image recognition can be used to identify the presence of smoke or fire plumes rising above the canopy. Image recognition technology has been around for some time and has proven to be effective in various applications. In the context of wildfire detection, cameras are used to capture images of the forest above the canopy and analyze them for the presence of smoke. However, this method faces several challenges.

One of the main challenges with camera-based detection is the occurrence of false positives. Agricultural machinery might throw up dust during field plowing, for example, and even wind farms can be mistaken for smoke plumes from a large distance. Weather conditions, such as haze or fog, can also make it difficult for cameras to accurately identify smoke, and the time of day, particularly dawn, dusk, and nighttime,

can affect the visibility of smoke in images. By continuing to improve ML algorithms with more data, AI-enabled camera detection can reduce false positives and improve the accuracy of smoke detection. However, a key restriction remains in that even AI-enabled cameras typically are not able to see what's happening under the tree canopy. Their capabilities are limited to detecting smoke plumes only when they rise *above* the canopy. This is a significant limitation as most human-induced fires start at the forest floor, and smoke only breaches the canopy once the fire underneath has had the time to grow quite large.

The process can take up to several hours from ignition, especially if the fire starts as a smouldering fire, e.g., as a result of a discarded cigarette. The delay in detection can mean that by the time fire crews arrive on the scene, they are facing a dangerous job trying to contain the fire. While infrared technology could help to complement the shortcomings of optical cameras, the resolution of these camera systems is typically too low to provide usable images for detecting fires at a great distance.

Training Gas Sensors with Machine Learning

Another approach is to use gas sensors to detect wildfires. Gas sensors are small wireless devices attached to trees throughout the forest that can “smell” a fire, akin to a “digital nose.” Once smoke is detected, the device sends a signal across the network to alert the authorities. One of the main benefits of gas sensors is that they can be embedded in the forest and can detect fires *below* the canopy layer while the fire is still in its infancy, allowing for quicker and more effective response and enabling fire fighters to extinguish a fire before it spreads out of control.

However, the sensor-based approach to detecting wildfires also comes with its own set of challenges. To accurately “smell” smoke, the devices are using machine learning (AI) models trained with data from fires and clean air taken from the forest environment. The challenge involves training the models to distinguish between the “smell” of a fire and other ambient gases. For example, the smell of a forest can vary depending on factors such as the type of trees present, the time of day, and even the season. Collecting a broad variety of data to provide a reliable machine learning model can be a tedious challenge. Yet, by incorporating these variables into the training process, the AI models can become more resilient to false positives and more accurate in detecting actual fires. They can even be trained for a specific forest.

To train the machine learning models, researchers create artificial environments in which they burn materials from target forests. The smoke generated from these controlled burns is then fed to machine learning models to teach them what a fire actually “smells” like. This process is repeated hundreds of times to improve the accuracy of the models. The more diverse the training data, the better the AI becomes at distinguishing between real fires and false positives.

Predictive Capabilities of Satellites

Another approach to wildfire detection is the use of satellites. Satellites have a great overview from above and can use cameras and infrared sensors to detect hot spots and wildfires from space. With the help of AI and image recognition techniques, this process can be automated, and authorities alerted when a fire is detected.

However, one of the key drawbacks with regard to wildfire detection is the resolution and the frequency of updates. Satellites used for detecting wildfires can be either geostationary (about 32,000 kilometers from Earth) or low-orbiting (about 600 kilometers from Earth). One pixel of a geostationary satellite image could cover as much as 500 square meters, meaning a fire would have to be very big to show up at all. And once fires are very big, they become incredibly difficult to extinguish. Low orbiting satellites, on the other hand, are closer to earth and can provide higher resolution (e.g., 100 square meters), but as the Earth rotates below, these low orbiting satellites can provide updates only every six hours for a given spot on earth. This can be mitigated by launching hundreds of satellites to get to frequent revisit times, but that would be quite costly given the relatively short lifespan of low orbiting satellites.

What satellites excel at, however, is being able to predict the development and spread of wildfires by considering various factors such as terrain, wind direction, and speed. AI and machine learning can be an immense help in predicting the development of wildfires by taking into account huge amounts of data to quickly build accurate models. This information can be passed along to firefighting and evacuation teams on the ground to help them coordinate efforts.

Each technical approach for containing the increasing threat of wildfires presents its own advantages and disadvantages. However, by combining and integrating the information from various detection methods, the advantages of one approach can cancel out the disadvantages of another. AI is a common theme across all solutions and will be able to help coordinate response efforts in real time. Data from gas sensors, cameras, and satellite imagery could be analyzed together to provide a comprehensive view of the wildfire. We would know where the fire started, its estimated size, and its likely path and spread.

By utilizing AI to enhance wildfire detection, we can significantly lower wildfire risks by enabling us to detect and extinguish them in their early stages, before they have a chance to spread out of control. Extinguishing a small fire requires dramatically fewer resources than trying to contain a megafire.

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