January 2021

Detecting and Outlining Potential Wildfire Areas via Satellite Imagery

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ABSTRACT

Services that track wildfire spread and trajectory can provide such information and issue related alerts. The information obtained from current services is often stale and ineffective in helping people determine whether they are likely to be harmed by the fire. Moreover, such information is not in a form that lay persons can easily grasp, thus making it difficult for them to derive actionable insight from the received information. This disclosure describes techniques to leverage satellite imagery to automatically detect and outline the boundaries of large fires. The outlined boundaries are updated regularly and surfaced as appropriate within various pertinent applications and platforms such as in digital maps, virtual assistant interfaces, search results, social media, etc.

KEYWORDS

- Wildfire
- Satellite imagery
- Geostationary satellite
- Hot pixel
- Polygon outline
- Digital map
- Geographic Information System (GIS)
- Crisis response
- SOS alert

BACKGROUND

People likely to be affected by large fires, such as wildfires, bushfires, etc., often consult online sources for fire-related information, such as currently affected locations, recent updates on spread, predicted path, etc. People can look up such information in various pertinent applications, such as web search, digital maps, virtual assistant, etc. as well as receive information via mobile phone notifications. Apart from seeking the information themselves, people desire and expect to be alerted if they are likely to be affected personally or face danger because of the fire. For instance, such alerts can include public safety notifications broadcast by relevant local authorities.

Services that track wildfire spread and trajectory can provide such information and issue related alerts. However, fire maps and related information available via such services are typically updated relatively slowly. Given that wildfires can spread at the rate of 1km/10 minutes, the information obtained from existing services can be stale and not effective in helping people determine whether they are likely to be affected by the fire. Moreover, the information is typically not in a form that laypersons can easily grasp, thus making it difficult for them to derive actionable insight from the received information.

Wildfires can be monitored using satellites via algorithms developed specifically for the purposes of identifying fires. Such techniques typically rely on geostationary satellites because of their fixed position in relation to the earth, and provide frequent and predictable images of the same area. There are also some fire detection algorithms that can utilize data from polar orbiting satellites. Specifically, such techniques use images from the infrared bands in satellite multispectral cameras to identify heat-emitting pixels through smoke and other natural obstacles. The multispectral data and previously calculated static and dynamic geo-data is processed to identify hot pixels in a range of terrains and in day and night times. Each algorithm has its own unique performance characteristics, and the satellite instruments themselves have different temporal and spatial resolutions. An agency such as the National Oceanic and Atmospheric Administration (NOAA) in the United States aggregates data from a few of the different satellites into a product called Hazard Mapping System, where analysts additionally manually validate the satellite detections.

DESCRIPTION

This disclosure describes techniques to leverage satellite imagery (obtained in compliance with applicable regulations) to detect and outline the boundaries of large fires, such as wildfires. The outlined boundaries are updated regularly based on updates to the satellite imagery and information from other relevant sources, such as weather trackers, emergency management bureaus, public safety services, etc. The boundaries as determined by the techniques can be surfaced as appropriate within various pertinent applications, including but not limited to: web search, digital maps, navigation apps, mobile phone notifications, text message alerts, etc.

The information regarding fires can be used for various purposes such as triggering in online search and/or digital map interfaces, e.g., providing information about ongoing fires in these services. The information can also be used to proactively send notifications based on the boundaries. For example, a polygon that defines the boundaries can be identified and alerts can be sent to mobile devices, e.g., to the device operating system or other application that is configured to provide users safety information, which can alert the user. Additionally, the information can be used for cross-referencing with other available information, such as fire reports received from users via digital maps or other applications.

The described techniques involve acquiring publicly available imagery from geostationary satellites and the output of various associated wildfire-detection algorithms, and combining the results by probabilistically merging them to derive the outline of the geographical region likely affected by a wildfire in near real-time (e.g., within 30 minutes of processing time). Such a region can be determined by computing a probability map over the time of the wildfire and its general vicinity. The probabilities can be generated from the raw data, such as pixels in the satellite images, and combined with separate probabilities associated with neighboring regions indicating their likelihood of spreading the fire.

The algorithmic processing is combined with additional information sources that indicate that any given region on the earth's surface is likely to be experiencing a hot event, such as a wildfire, at the time. The geographical areas with the probability of being impacted by a wildfire higher than a threshold value are indexed and turned into a map polygon that denotes the approximate region likely impacted by the wildfire.

The above computations can be performed at regular intervals, such as a few times per hour, e.g., roughly matching the frequency with which the underlying raw satellite data and associated algorithmic output is updated. Such periodic updates can ensure that the generated outlines of affected geographical areas remain up-to-date.

Due to inherent imprecision of the data and the computation, the outlines are generated in the form of smooth boundaries of a polygon. When users view the polygon outline or a non-zoomable thumbnail of likely geographical areas affected by a wildfire in any pertinent application, they can click through to an associated interactive map that depicts relevant wildfire-related data, such as outline, spread speed, road closures, predicted traffic patterns, evaluation advisories, etc.

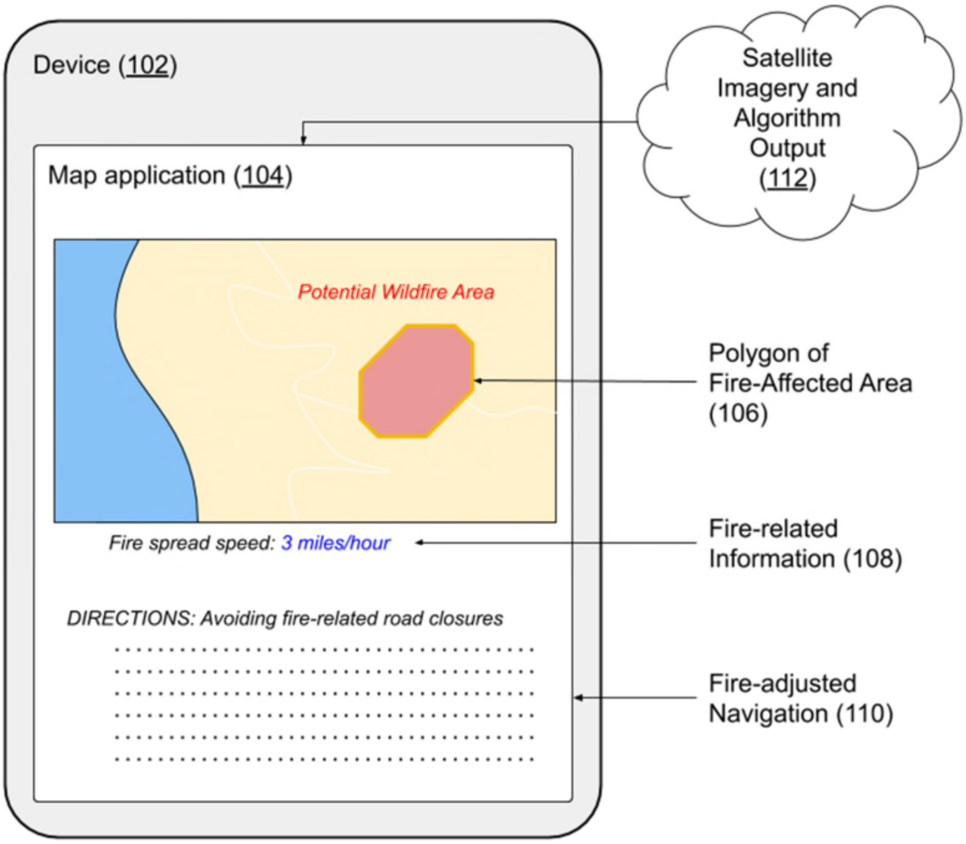

Fig. 1: Displaying potential areas affected by wildfires within a digital map application

Fig. 1 shows an operational implementation of the techniques described in this disclosure. A user seeks navigation (or otherwise views) a digital map application (104) on a device (102). The user's routing options involve a region with an ongoing wildfire. Satellite imagery and associated output of algorithms processing the pixels (112) is obtained to determine and outline a polygon (106) marking the area with the map potentially affected by the wildfire. The digital map application provides additional fire-related information (108) that can be useful and relevant for the user. The directions provided to the user (110) are based on routing techniques that take into account the impact of the fire, such as road closures.

While Fig. 1 shows a digital map application, similar user interfaces can be included in other applications such as web search, virtual assistant results, notifications or alerts, social media feeds, etc. where such information can be useful to the user. Further, alerts regarding a wildfire can be provided proactively, e.g., via a safety feature of a mobile device, and may be provided via any suitable mechanism such as a displayed user interface, an audible alert, haptic-feedback, or other available mechanism. While Fig. 1 shows the use of the determined polygon in routing/navigation, the information can be provided to the use in any suitable context, e.g., a user browsing a digital map can be provided a map view that includes the polygon, thus alerting the user to an ongoing wildfire. User permission is obtained to access the user's location, e.g., to provide visualization of nearby areas, or to provide route guidance. Thus, the digital map can be usable by users that are outside the area to understand the extent of the fires, e.g., when they view the digital map based on a received alert.

The satellite imagery can be processed using algorithms that have been validated and are continually reviewed, with a strong historical performance record and known development history. The algorithms typically function by thresholding a specific infrared band based on a threshold determined by analyzing one of the other bands as well as a pre-calculated ecosystem model. The algorithms output a code indicating whether a given pixel in the satellite image is likely to map to a fire along with estimates of the size and temperature of the fire. Moreover, any pixels with likely fire are filtered temporally by comparing them to the previous time a fire was detected in any nearby pixels. If any nearby pixel indicated a fire within the past 12 hours, the given pixel is flagged as "temporally filtered."

While infrared light can penetrate smoke caused by a fire, it is scattered by water vapor in clouds. Therefore, the algorithms cannot typically detect fires that are covered by clouds. As a result, there may be cloud-obscured areas likely affected by the fire that are undetectable for long periods, especially in the case of a long-lasting fire covering a large geographical area.

Moreover, the output of the algorithms can degrade in the presence of excessive sun glint off of the earth's surface. While switching to images from a different geostationary satellite can ameliorate the impact of sun glint, the effect of cloud cover cannot be avoided. Extended cloud cover can thus result in completely missing a fire pixel in the satellite images because it is already fully burnt by the time clouds dissipate. In such cases, outlining the overall area affected by the fire can include marking areas with long-term cloud cover as being potentially affected.

Areas with long-term cloud cover can be handled in one or more ways such as: (i) displaying only the detected active areas after clouds dissipate; (ii) employing additional algorithms to detect burned areas and determine previously affected areas; and (iii) displaying a fire perimeter ignoring the few pixels blocked by clouds given that very hot fires are likely to produce smoldering pixels that are detected by the algorithms in spite of cloud coverage.

The described techniques are based on using algorithm processing output data indicating the probability of the existence of a fire at the geographical location corresponding to a given pixel in the satellite imagery. Based on various threshold values, the probability values can be classified into relevant bins, such as high, medium, and low. To improve the probability estimate by obtaining a better estimate of the sub-pixel fire location, the area potentially affected by the fire can be divided by the geographical area covered by the pixel. Further, the probability estimates can be annotated with additional information, such as saturation, cloud cover, failure reasons (e.g., sun glint), previously processed fire, etc. Such information can impact the accuracy of the probability estimate, thus helping determine whether the fire perimeter can be outlined with sufficient confidence. If the data precludes generating reasonably confident outlines of potentially fire-affected areas, the user is shown a message to that effect, rather than displaying a bounded region.

The described techniques are aimed at generating reasonably accurate and timely probabilistic boundaries around fire zones. Since fire zones are probabilities, the boundaries produced by the techniques are not necessarily the tightest possible bounds around the affected areas. Depending on the resolution of the available data, the techniques can reliably handle wildfires of large sizes, e.g., greater than 25 thousand acres or 100 square kilometers. However, with availability of data of greater resolution, the techniques can handle smaller wildfires as well. Moreover, the techniques aim to provide end users with up-to-date safety-related information during an ongoing wildfire. As such, the probabilistic outlines of fire-affected areas generated by the techniques are limited to such purposes, and do not necessarily provide sufficient spatial accuracy or timeliness that may be suitable for the purposes of first responders and firefighters.

The techniques are implemented to favor temporal resolution over spatial resolution in order to provide users with reasonably up-to-date information regarding wildfires. Since wildfires typically move rather rapidly, an outline with potential false positives (containing some unaffected areas) is preferred. In contrast, a high spatial resolution outline is likely to exhibit false negatives (miss some affected areas) since it is based on hours-old information.

The techniques described in this disclosure can further refine the generated outline of the fire-affected areas by cross-referencing with additional relevant information, including but not limited to: contextual understanding of the current situation on the ground, topographical characteristics of the geographical areas, vegetation, weather patterns such as wind direction and velocity, etc. Such information can be used further to predict the likely spread of the fire in the near future. Moreover, the techniques can also incorporate imagery from additional sources, such as drones, balloons, etc.

In addition to being surfaced within various relevant online applications, the geographic outlines of fire-affected areas generated by the above techniques can be embedded within any software designed specifically for geographical information, such as digital maps, 3D geospatial engines, etc. Such embedding can be achieved via any suitable mechanism, such as file import, Application Programming Interface (API), etc. The threshold values of various parameters used to determine the outline generation can be set by the developers and/or specified by the users and/or determined dynamically at runtime.

Implementation of the techniques to identify and display regions affected by wildfires can enhance the quality, utility, and timeliness of online public safety information that is delivered to end users of numerous general-purpose applications and platforms. The techniques can be a useful tool to support crisis response efforts of various commercial and non-commercial entities, such as governments, non-profits, emergency services, first responders, social media providers, crisis response organizations, insurance providers, etc.

CONCLUSION

This disclosure describes techniques to leverage satellite imagery to detect and outline the boundaries of large fires. Publicly available imagery from geostationary satellites is obtained and analyzed using various wildfire-detection algorithms. The results are combined by probabilistically merging them to derive the outline of the geographical region likely affected by a wildfire in near real-time. The outlined boundaries are updated regularly and surfaced as appropriate within various pertinent applications and platforms such as web search, digital maps, navigation apps, mobile phone notifications, text message alerts, etc. The techniques can enhance the quality, utility, and timeliness of online public safety information related to wildfires delivered to end users of numerous general-purpose applications and platforms.

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