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Analysis of PyroTamer's Effect on Current Wildfire Situations

Jaein Kim[1], Jermaine Lei[2], Matthew Lee[3] and Daniel Cha[4]

[1]Saint Paul Preparatory Seoul, Republic of Korea
[2]San Mateo High School, USA
[3]Gunn High School, USA
[4]University of California, Santa Barbara, USA

ABSTRACT

Wildfires have been devastating Earth's lands since its birth, but only recently have the fires become more rampant and increasing in numbers due to poor human decisions and excruciatingly worsening climate crisis. Our protectors, the firefighters, are constantly on an uphill battle to fight the numerous wildfires surrounding them during fire season, let alone risking their precious lives. To make matters worse, critical amounts of time is wasted as firefighters are still using old technology from decades ago like hand radios as they have been proved for a long time to be reliable. Although the reliability of hand radios are strong, they have extremely limited range and make communication onerous as verbal communication is not that efficient and prone to errors. PyroTamer is developing an application that focuses on reliability and efficiency to ensure firefighters are able to effectively communicate quickly in order to put out the fires faster.

Current Fire Situation

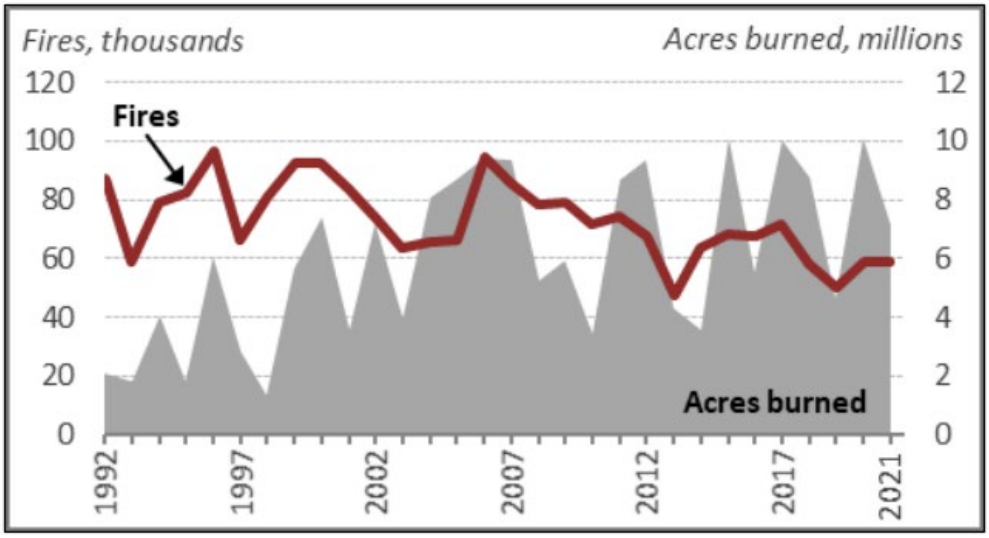

Figure 1. Annual Wildfires and Acres Burned, 1992-2021.

According to the Congressional research service program there have been 70,072 fires burnt on average since the 2000s in the US. From research based on the NICC (National Interagency Coordination Center), the acres burned per year continue to gradually increase. Although fires created from lightning strikes result in more acres burned, most fires are started by humans. These wildfires cause extensive damage to ecological resources and property. Although

only a small portion of fires become extremely large destructive fires, in 2021, the number of fires went from 1% to 2%, a substantial increase in destructive fires with a record breaking fire in California burning over 1 million acres called the august complex fire.

The impact of the increasingly destructive fires is becoming clearly apparent to communities as fires like the august complex fire build up so much wildfire smoke and fog that it turned the skies orange for nearby cities. Wildfire smoke can be extremely toxic to animals and is dangerous to people with current or previous lung diseases or issues.

According to the FPRF (Fire Protection Research Foundation), the cost of fires including both expenditure and loss is steadily increasing through the decades, with a sharp increase in the past decade

Current Technology

As of now, most firefighters utilize the Dingell Act Resource Tracking (DART). The intent of DART is to remotely track the location of active resources and display the location of each fire resource on real-time maps. The tracking will start when a resource is assigned to a federal wildfire. When tracking the resources, privacy and security laws are followed.

There are many parts to firefighter tracking systems. Some are traditional, including firefighter accountability tags and passport systems while others include GPS technology tied into firefighter radio systems. In recent years, new technologies have emerged overcoming the problems associated with GPS systems, namely that satellite transmissions fail in certain types of buildings and cannot pinpoint a firefighter's exact location in multi-story buildings. The new RFID firefighter Tracking Systems employ lightweight ID tags attached to the firefighter's gear, portable readers, and Incident Command computer software. This type of accountability system can tell fireground commanders exactly where each of their firefighters are in real-time. Firefighters working on the scene have tracking equipment that uses radio frequency identification gives Incident Commanders valuable information about their crews' progress during an emergency and helps to orchestrate mutual aid and multi-agency response.

In addition to trackers and GPS systems, firefighters have increasingly started to incorporate drones. Commanders can quickly and easily use drones to gather critical information about a situation reducing the risks firefighters may have to go through. In the case of a rescue operation, drones can be used to search over a large area in order to deliver food, water, or even first aid kits.

Figure 3. A recon drone used to detect signs of life and other information from high above the fires

Hand-held thermal imaging cameras have been a regular part of firefighter tools and equipment for decades, but they become an inconvenience by using up one of the firefighter's hands. Companies have started to incorporate thermal imaging cameras into helmets in order to free up both hands during an operation. This technology gives firefighters constant visibility through the thick smoke and a wireframe overlay of the surroundings, giving firefighters information about what's around them.

Tracking fire data can be extremely helpful in predicting fire dynamics, improving response times, and more. By using cloud-based computing, fire departments can make sense of the increasing amount of data flowing in from sensors, drones, and mobile devices. Some of these cloud-based softwares can analyze data in order to show big-picture trends, issues, or potential risks. Cloud-based software such as PowerDMS stores all department data and important information in one secure location which reduces the risk of losing important documents and lets users access the documents easily and quickly.

Government plans, Policies, and Current Programs

Under the U.S department of agriculture(USDA) there is a forest service department that takes care of the wildfires that happen in America. Recently, USDA has taken action in which it will increase the pay of wildland firefighters and they have launched a 10 year strategy that will reduce the risk of a catastrophic fire.

Figure 4. A Rough outline of the multi-million dollar plan for the firefighters to follow.

This strategy will prioritize lands that are at most risk for a wildfire and this is the new plan that they are trying to implement in order to help the community better from wildfires. This plan, costing them 131 million dollars, will begin with the initial investment in the 10 landscapes in Washington, Oregon, California, Idaho, Montana, Colorado, New Mexico and Arizona which is about 200k acres of land and the strategy calls for treating up to 20-30 million acres of land.

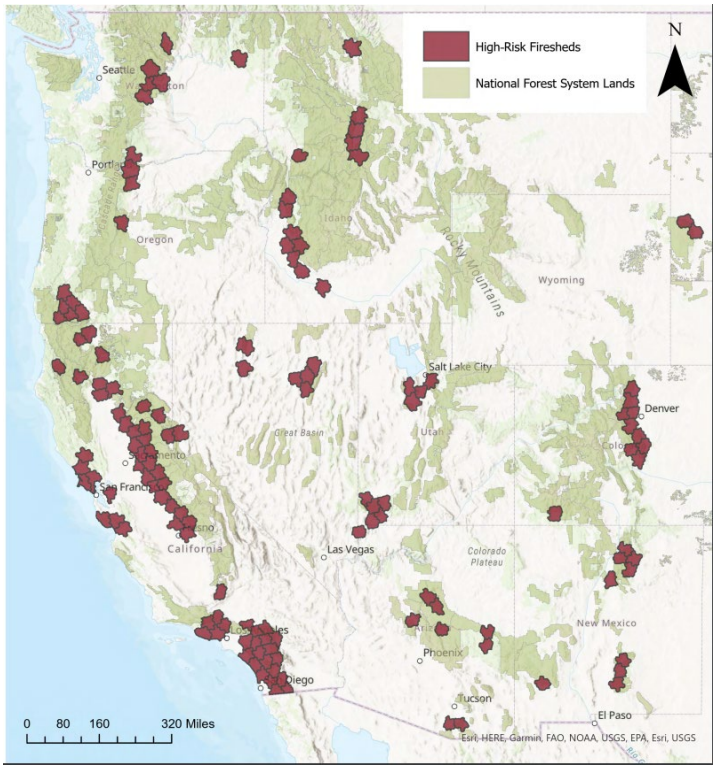

Figure 5. High-risk Areas for Wildfires.

PyroTamer's Effectiveness

The problem with firefighters' current solutions is that they still lack many functions that firefighters need in order to speed up assessment and planning time: the expensive cost, unstable network connection, and indirect information display.

To cope with the insufficiency with the current solutions, PyroTamer is designed to not only save more lives but also protect firefighters' own safety. PyroTamer's exclusive resource management features are developed to prioritize urgency and efficiency to help firefighters organize and track resources and accelerate their organization process to save more lives.

The app serves the firefighters by strengthening their communication and improving resource allocation when fighting fires. By communicating with a lifetime firefighter in California, Mr. Rugo, we developed and proposed several key features that are exclusively crucial in aiding the firefighters.

PyroTamer's Functions

I. Simple User Interface (UI) Design

First of all, we analyzed the communication factor. Firefighters have difficulty communicating when fighting fires due to the range of the radios and potential errors when using the device, such as frequency differences. Even when the firefighters are able to connect with each other, audio-only devices are prone to miscommunication as there are not any visuals to guide the comprehension of the firefighters. In order to enhance firefighting communication, our team believes that mobile apps with a simple UI design that utilizes mesh networks reduce communication errors and improve the range in which firefighters can converse. A practical and visually simple design is a keystone concept to our product.

II. Resource Plotting

Adding to the aforementioned communication difficulties is the situational awareness factor. Without knowing the available resources and where they are located, firefighters are unable to know the quantity and locations of the resources required for any area. Due to the lack of awareness, firefighters are forced to be in a passive state, causing them to react to the increasingly ferocious fires instead of proactively ceasing the coming flames before they arrive virtually. Due to the delayed reactions of firefighters, fires increase in severity, and they become uncontrollable, ravaging millions of acres of land before finally dying out months later, stretching the resources of our firefighters thinly and exhausting the energy of all our first respondents. Our app allows firefighters to easily mark down resource locations with the click of a few buttons.

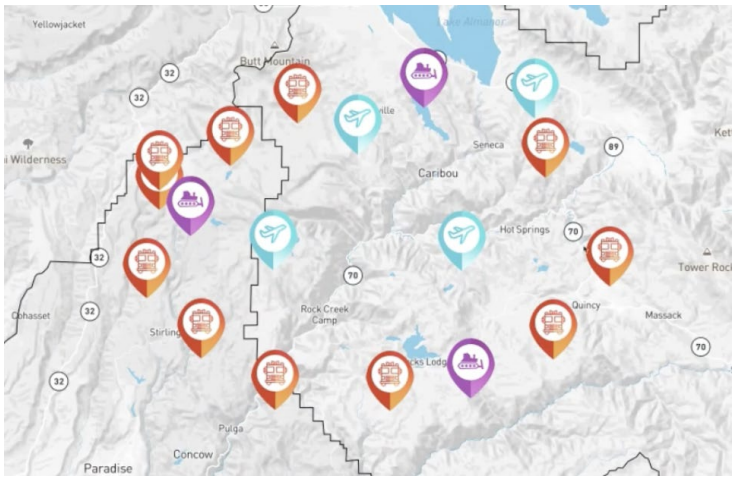

Figure 6. PyroTamer icons depicting different firefighting resources, such as Fire Trucks, Dozers, and Airplanes.

III. Data/Marker Editing

Data/marker editing allows firefighters to mark crucial resources like fire trucks, dozers, and airplanes anywhere on the map with ease and precision. By clicking on any of these resources that are sorted with icons, firefighters can see the names and resource types in the pop-up format. These data points can also easily be altered or deleted for many possible fire-fighting scenarios. When a firefighter's shift ends, or if they need to move to a new location, there is a section to remove or change the location quickly. An additional add-on is the geolocation feature, which incorporates personal location tracking to make position recording of engines and other resources much more accurate. This primary feature minimizes human errors when analyzing and allocating existing resources.

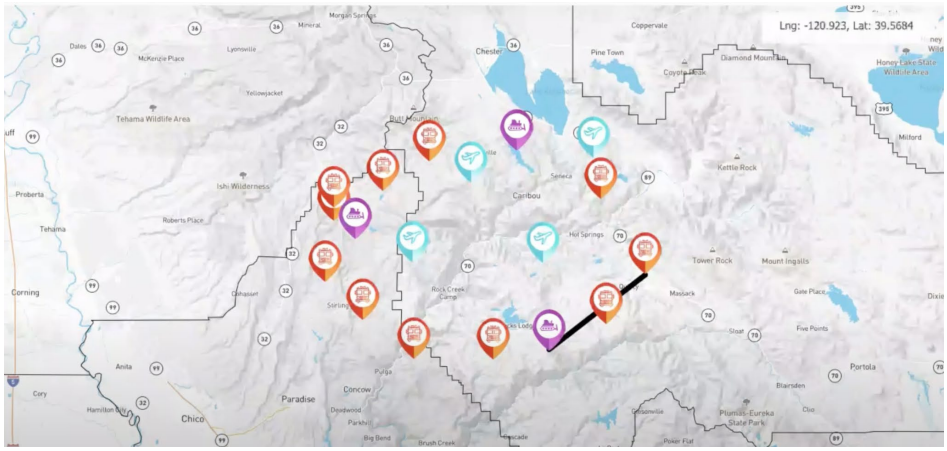

Figure 7. Example of a line marker that shows a potential fireline after a dozer has gone through.

IV. Line Plotting

Line plotting enables firefighters to draw out the different lines to represent the dozer lines and hand lines to stop fires. These lines also help inform other firefighters of the contained areas, so they will be on the same page fighting the same fire with more latest updates from one another. Like the point deleting capabilities, firefighters can delete the firelines if they make errors when plotting the line. Drawing lines on the map in real-time is of paramount importance for a quick assessment and strategy development. It facilitates the team's understanding of the containment zones and, subsequently, a retrospective review of firefighting strategy regarding the zone construction.

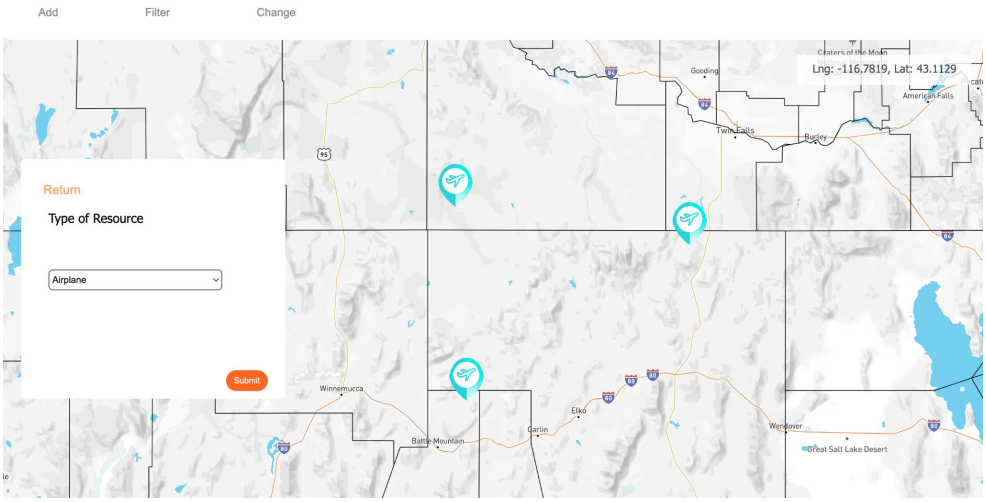

Figure 7. Example of resource filtering for airplanes only.

V. Filtering Capabilities

Firefighters sometimes get overwhelmed by the number and different resources on the map. The filtering function of the app allows firefighters to quickly filter out the resources and get notified of their positions through PyroTamer's resource tracking app feature and data. Furthermore, key features such as the ability to track and share locations of resources on the map are crucial in helping firefighters cut down the time spent navigating the other applications. The ability to draw certain completed and in-progress activities such as hose lays, hand lines, and dozer lines in the app also allows firefighters to quickly and efficiently communicate with each other for better resource management and accurate map status.

VI. Weather Elements

To raise situational awareness, PyroTamer believes technology can help firefighters capture the current fire situation and resource allocations visually on the map to alter the firefighter's state from passive response to instant response. Our team realized that the app should integrate some sort of weather data like wind maps, temperature, humidity, and weather conditions visually for fire spreading prediction. By integrating the environmental conditions, firefighters have a more comprehensive view of the surrounding threat allowing them to make more proactive decisions. PyroTamer acknowledges that firefighters are currently taking certain proactive measures against fires, drawing firelines before the fire travels to that area, and our goal is to quicken the time between decisions and actions. Real-time wind map overlays pull wind speed data and draw wind maps so firefighters can predict or assume fire movement. This weather data enhances firefighters in predictive capability, allowing firefighters to take a quicker proactive approach towards fighting the fires.

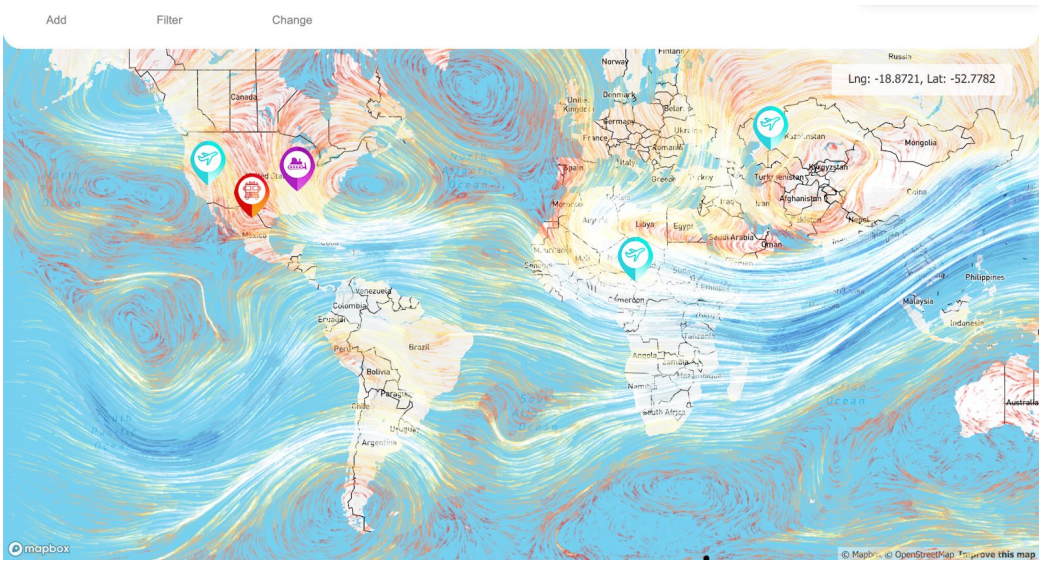

Figure 8. Real-time wind map overlay showing color-based wind speeds.

VII. Off-Grid Mobile Mesh Network Support

An off-grid mobile mesh network backed up by industry leaders like Go Tenna, IBM, and Verizon, despite currently pending partnership, enables our application to work in the presence of internet connectivity issues and further investigate its viability and scalability. With the right infrastructure, PyroTamer will empower firefighters during their battle against the blaze upon successful launch. We will continuously enhance and test features in the product, PyroTamer, using feedback from firefighters and industry experts, contributing to the firefighters' relentless endeavor to protect communities from wildfires, especially in California, where everyone lives in constant fear of fire during the dry season.

Effect on Firefighters

Using the application PyroTamer armed with the aforementioned extraordinary features that have been developed, firefighters can quickly plot their location without inputting latitude and longitude coordinates on the map manually; they can simply press a button to record their position, saving their critical time to assess the severity of the fire more efficiently and effectively. It is high time for us to help our firefighters with apt technology such as the PyroTamer app so they don't need to waste any time that should not be wasted and instead focus on what they do best; extinguish the fire and save our lives.

Discussion

When going through beta testing of the application, firefighters from Palo Alto Station 5, Seocho Fire Station, and other fire stations proved that PyroTamer will aid in extinguishing fires more effectively. This result shows that PyroTamer, when fully developed and launched, will have a positive impact on the firefighting industry. PyroTamer's official launch will significantly help the firefighters worldwide, ultimately helping them to extinguish the hazardous global wildfires. Because Porter's efficiency was tested before it was officially launched, it was difficult to test its efficiency on a broad audience. This limitation of the size of the experimental group may have significantly affected our results, since the usefulness of the application is highly subjective to each individual firefighter.When officially launched, it will be easier to track user's review and thoughts on the application and thus follow up with more credible, official data and numerous firefighters' reactions to the application.

Methods

In order to check the effectiveness of our application, we did beta testing and had direct communication with firefighters to predict the potential and usefulness of the application. We reached out to industry specialists to discuss the capabilities of our project and received. We ran multiple iterations in order to improve our UI and functions to maximize firefighter efficiency and ease of use. We researched and discussed many types of helpful functions that would be a must have in the application and incorporated them for more testing.

Conclusion

PyroTamer will be the pinnacle of solving the problem of wildfires. With the current technology that we have today, and the active support from the government, more lives will be saved from wildfires and drastically improve firefighters' capability of fighting the fires.

Limitations

The current limitations of our application are that we require the partnership of mesh network companies in order to maintain connectivity and respond to the cloud for updated information. The application still saves all information up to the point when connection is cut off so the firefighters are still able to get as much information as they can. Our Artificial Intelligence resource allocation function is still in its developmental process and testing will begin after the first function prototype is built. Also, due to the pandemic situation, there was an unfortunate limitation in beta testing our application to test its effectiveness; however, we were grateful for being able to take beta tests online with fire stations like the Palo Alto Station 5 and will continue to take beta tests online with fire stations worldwide and tests our product's efficiency before launching the application.

Acknowledgements

We would like to thank Firefighter Tim Rugo who actively communicated with us to help analyze the current dire situations the firefighters are facing. His feedback to our constantly updated demo websites and application drafts were extremely helpful to us in developing the app that can significantly improve the firefighters' work efficiency and the severe fires worldwide. We would like to express gratitude to Phnam Bagley, a Partner at Nonfiction Design Studio and Executive Board Member at Fast Company, for conscientiously reviewing our software solution and advising us. We also show appreciation to William Liao, a Director of Operations at Crisis Technologies Innovation Lab, for helping us discover various forms of technology and incorporate the most optimized technology to our application. We extend our thanks to judges of the Conrad Challenge and Diamond Challenge, Chief Officers at IBM, San Mateo Congresswoman Jackie Spier and global fire departments at Palo Alto, Woodside in California and Seocho, South Korea for providing constructive comments in relation to technological, environmental, and financial aspects. PyroTamer would not have approached the current stage without the help of these supportive advisors.

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