IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Fighting fire with AI: Using deep learning to help predict wildfires in the US

Lakshmisri Surya

Sr. Data Scientist & Department of Information Technology

USA

Abstract

Fire is a great servant but a bad master. Mastering fire was very crucial for the evolution of the human species. However, fire has been responsible for losing significant human life and property over the millennia. Wildfires have devastated humanity since the beginning of time. As technology has advanced, we have found different methods to address wildfires. These methods have had various levels of success against wildfires. Artificial intelligence is the newest tool humanity has developed to address its problems. Implementing artificial intelligence with deep learning will allow for a more efficient method of fighting wildfires. This will reduce the time taken to get wildfires under control and ensure the least number of human casualties in the process. This report highlights the advancements made in artificial intelligence and deep learning with regards to fighting and containing wildfires.

Key Words

Artificial Intelligence, Deep Learning, Wildfire prediction.

Introduction

For firefighters to do their work, getting the right instruments is essential. This includes the physical equipment every day, their team communication skills, their initial fire training, and their continuing CEE fire training (continuing education). But now, the way firefighters respond to emergencies is evolving and improving with artificial intelligence (AI) and several other advanced technologies (Wu et al., 2017). Medical AI helps EMS practitioners diagnose cardiac arrests faster, and autonomous vehicles can more efficiently and safely move emergency responders and equipment with less collision. This is an opportunity for the firefighters to see the usefulness of cutting-edge technology and sometimes convey some actual relevance to ensure that the technologist's world is not too detached from the reality. The system will also help firefighters as they prepare for fires just before they occur by performing tests of future fires, giving room for firefighters to identify any kind of vulnerabilities before they burn up and become a catastrophe.

Firefighting is one of the most challenging professions. This is because running headfirst without any care in the world in a raging is one of the most disorienting feelings in the world. This is because it goes against our primal instincts against fire, which is always flight (EA & Harris, 2017). Raging fires are an outrageous attack on a firefighter's senses. This begins with the sight as fires are either bright with flames or dark with heavy smoke clouds. Hearing the roaring flames significantly pushes us to run away, but a firefighter has to run towards the danger in order to save lives. Fires also make it incredibly difficult to breathe (Tang et al., 2018). These challenges on fire fighters' senses have a compounding effect on their careers. The firefighter has increased vulnerability to heart attacks, which is the most common health danger for this profession.

Identifying the location of the fires enables a far more accurate way to forecast fire patterns in the wild. Such a data-driven strategy is what drives the firefighting application of artificial intelligence. Therefore, it is essential to have a system that allows for safe fighting of fires to reduce the risk of exposure to our first responders. NASA saw there was the need to address a need to develop a much more efficient method of fighting wildfires in order to address the issue with exposure to dangerous conditions (Howard, 2019). Firefighters could use this system to collect data such as temperature, wind direction, gas composition, and other hazardous environmental factors for analysis (Sung et al., 2019). The research can be done on-site to highlight various aspects that the firefighters might now identify independently. This will lead to a safer way of fighting fires.

Literature Review

How AI Help in Predicting Fire

Wildfire is a very catastrophic phenomenon that occurs more frequently in the United States. Knowing about the sources of fuel in the path of a wildfire is crucial in predicting the way it is going to move. An area covered by dry bush will easily ignite into flames when it is lit, and at the same time, a well-watered grass in its course may halt the tracks of the fire. Therefore, AI software helps examine the high-resolution images from the satellite to predict the level of combustion of vegetation under fire and then collaborates the information to assist in predicting fires. Since factors like precipitation and wind can also have an adverse effect on the fire, the targeted weather information is then directed to the system to assist in prediction (Meng et al., 2018). This means that AI can serve a warning system, which identifies plumes of smoke from cameras located on high mountainsides. The images are clear and are not affected by clouds or fog. In the US, a system called WIFIRE is used as an artificial intelligence system in predicting fires.

The center for fire agencies within the US is implementing a recurrent neural network to help them predict wildfire. This is a type of AI model designed to investigate patterns from a large amount of data and pinpoint the patterns that help predict fire. The database trains the system for National Fuel Moisture information. The following step involves the application of additional satellites for observations to estimate the levels of fuel moisture (Madridano et al., 2017). The WIFIRE system comprises a fixed wireless network and a fiber optic network that is of a high speed which connects with the center of supercomputers and hundreds of weather stations that are remotely located all over the nation. WIFIRE system is fed with high-resolution data for the weather, which helps the program of system model to predict how a fire will move in reality (Goyal et al., 2018). This system also gives room for responders to be adequately prepared in case of a fire emergency just before they occur by taking out simulations of various possibilities of its occurrence, hence helping the firefighters to identify any vulnerability that is potential just before they become a disaster.

WIFIRE uses high-quality satellite imagery as the core data entry method for artificial intelligence. The satellite images are analyzed to determine the combustibility of the vegetation near a fire in order to predict the fire movements (Shamsoshoara et al., 2019). WIFIRE's artificial intelligence considers that wind and precipitation have a profound effect on the fire patterns and therefore uses real-time weather information along the satellite imagery to provide accurate fire patterns that are then relayed to the fire department responding to the wildfires so that they can revise their tactics accordingly.

Additionally, AI is currently helping to predict where the fires might spread and how big they might get; all these are efforts to aid in the fight against the impact of wildfires. There are also AI-powered drones, which are significantly helping in the fight against fire (Bhattarai & Martinez-Ramon, 2018). A good example is a system referred to as IGNIS, which is amplified by drones and carries a bulk of chemical spheres injected using glycol and explodes just after hitting the ground and igniting a tiny fire. The main idea behind this is that starting fires helps in putting others out. Another tactic is called back burning. There is creating a line of containment or using containment lines already existing and come up with a controlled fire where the fire is sent back to its primary source (Liu et al., 2016). The theory behind this tactic is that when fuel burns, then it cannot burn once more. Therefore, if a fire is moving on grass towards a point and then you start the fire from that point towards the fire, once they meet, there is no fuel left to burn; thus, the fire goes out. IGNIS is implemented with different commercialized drone platforms and uses an Android app that controls and monitors ignitions and flights (Innocente & Grasso, 2019). It can also undertake mapping and robotic missions, recordings, and visual pictures, scouting, and manual ignitions.

However, there are still problems associated with predictions using AI, which in essence, there is a challenge of equity and probability. It is because, no matter how researchers and designers are working in studying ways of predicting fires using AI, technology is still a shiny object, and fires are more complex than they may seem (Edlinger et al., 2019). Currently, what has been achieved does not guarantee the possibility of all the variables and understanding the relationship between them. Also, the behavior of fire in both the wildland and urban environments is determined ultimately by the principles of chemistry and physics.

The other challenge lies in the various variables that affect fire behavior in both settings, such as human behavior, which is the most challenging variable, topography, ignition source, fuels, humidity, temperature, and weather. Whether the fire is wild or urban, it holds only a ten percent rate in its probability (Velencoso et al., 2018). The control that firefighters have is only so much over the variables, which means that the risk can change significantly daily. Therefore, it remains a favorable decision to use predictive analytics to increase the effectiveness in preparedness, prevention, and mitigation of fire (EA & Harris, 2017). The only hope that is also remaining is to leverage the AI models to enhance the deployment of resources during the recovery, response, and prevention phases of an incident of fire. As long as firefighters evolve, AI technology will always play one of the most significant roles, and at the same time, humans will remain at the core (Ahmed, 2018). Fire is an opponent that does change as fast as weather, which means that humans will play a significant role in mitigating the fires.

AI and Deep learning in fighting wildfires

Artificial Intelligence (AI) is the cutting edge of computer technology. AI aims to build smart machines capable of performing high-level tasks that require logic without the input of humans' operation. As AI evolves, it has seen application in various industries such as health and safety (Goyal et al. 2018). It allows for the analysis of scenarios to determine trends that may not be obvious to humans. This is the driving force behind the introduction of AI in firefighting. Wildfires are highly unpredictable, making it difficult to critically analyze them to find the best approach to fighting fires. This has led to lifelong challenges for firefighters. AI will address the challenges with firefighting and allow for a safer way of managing these disasters (Wu et al., 2017). Additionally, deep learning will allow for an active approach to wildfires by finding the causes and eliminating them before a fire can arise. This will be resulting in a safer environment and reduce risk exposure to all stakeholders.

Wireless Sensor Network (WSN) as an AI Model of Fire Prediction

For a long time, WSN has gained more attention as it has become instrumental in warning the relevant authorities about disasters and predicting disastrous situations like fire. WSN is crucial since fire detection should be accurate and fast as it may cause destruction and damage on a large scale (Chau, 2019). In preventing wildfires before they can become out of control, WSN cooperates in the WFHP systems, which are employed in predicting the area's most likely for fire incidents during fire seasons. Another system referred to as the Fire Weather Index (FWI) system is implemented in predicting wildfire danger. This system comes up with national maps of the ratings of fire risks, which are implemented in forecasting the trends (Sung et al., 2019). Its computations are focused on daily observations from the weather network of fire, which is made up of several weather stations or metrology stations sparsely distributed worldwide and satellite communication (McKeown et al., 2019). The findings from the observations are then reported on a central processing and repository center (CPRC). Here, they are integrated daily to come up with maps for the danger of fire. Although, due to observation stations and satellite communication, the FWI system comes along with some limitations. They include; the deployment of emergency of the course within the new regions is too slow (Yun et al., 2018). There is a lack of questioning a particular domain of a location with ratings of fire hazard and limited points of measurements due to a metrology station's maintenance costs.

Therefore, a WSN based on wildfire hazard prediction (WSN-WFHP) models has been recently developed in addressing all these drawbacks. The system comes with several advantages: a simple complimentary and rapidly deployable within the current FWI system, low costing sensors for weather observations, energy efficiency, and timely hazard prediction. These weather sensors are implemented as recent sources, which are far much similar to the FWI system metrology stations (Shamsoshoara et al., 2019). Additionally, the nodes for weather sensing run wireless communication protocols and compute the fire stack's prediction of partial hazards to ensure integrity, organization, and connectivity. This system's first tire is made up of the links between cluster head nodes and weather sensor nodes (Tang et al., 2018). The second tire comprises the links between central coordinator node links or sink and cluster head links. The relations of communication, in this case, are industrial, scientific, and medical (ISM) low powered band which offers wireless communication as compared to FWI system that uses satellite links. Thus, when a steady wireless network state has been successfully achieved, the weather sensors' nodes collect weather data from an input file specified (Yun et al., 2018). Then sends the indices for partial fire hazard to their respective cluster heads varied when required and in every thirty seconds. When the cluster head nodes have received the index, they compute the semi-fire hazard indices and then transfer them to the sink to be processed further (Madridano et al., 2017). This system provides temporal resolution and a high spatial wildfire system for the easily deployable, energy-efficient, and cost-effective prediction to provide means of interaction and emergencies. The model sanity of WSN-WFHP as an AI model has been successfully verified through real datasets of wildfire.

How this Research on Fighting Fire with AI Will Help the United States

One of the most challenging aspects of wildfires is their unpredictable nature. This has never dampened the resolve of firefighters in the United States of America. The firefighters understand that no two fires are ever the same, and the best way to approach the wildfires is to respond to them based on the information at hand. Communication is vital for the safety of the personnel and allows for the saving of lives and property. This data-driven approach is what drives the implementation of artificial intelligence in firefighting (Howard, 2019). In the United States, computer programs that AI powers are deployed in space and on the ground to perform various tasks. Starting from mapping the risks associated with wildfire more accurately to a point at which they sound the alarm whenever there is a fire breaking out in some hours earlier before it can be a catastrophe.

Additionally, this technology, however, that AI is at its developing phase will significantly reduce wildfire threats that have become more destructive and grown larger recently within the dry western parts of the United States. However, nothing will ever complement or replace the human brain during decision making, but at the same time, AI can significantly help humans in making excellent decisions. Additionally, the AI algorithms can be run in a satellite and help in processing images within a very few times, which will help predict fire occurrence just before it becomes massive. Additionally, since AI technology is advancing, and new algorithms and models are designed daily. It means that soon, an AI-based system will be providing regular contact with the earth in combination with the ability to send real-time alerts to responders of emergencies on the ground.

Conclusion

The field of artificial intelligence has grown in leaps and bounds over the last decade. The progress made has made human life more manageable. Artificial intelligence can identify trends and patterns that may not be evident to humans. This allows the system to fight fires more efficiently and safely when compared to traditional methods. Firefighters put their lives on the line to save the lives and property of others. Therefore, it is essential to ensure that their lives are protected in the best possible way. Artificial intelligence identifies the best way to approach wildfires in order to minimize casualties and ensure that the least amount of time is taken to keep the fire under control.

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