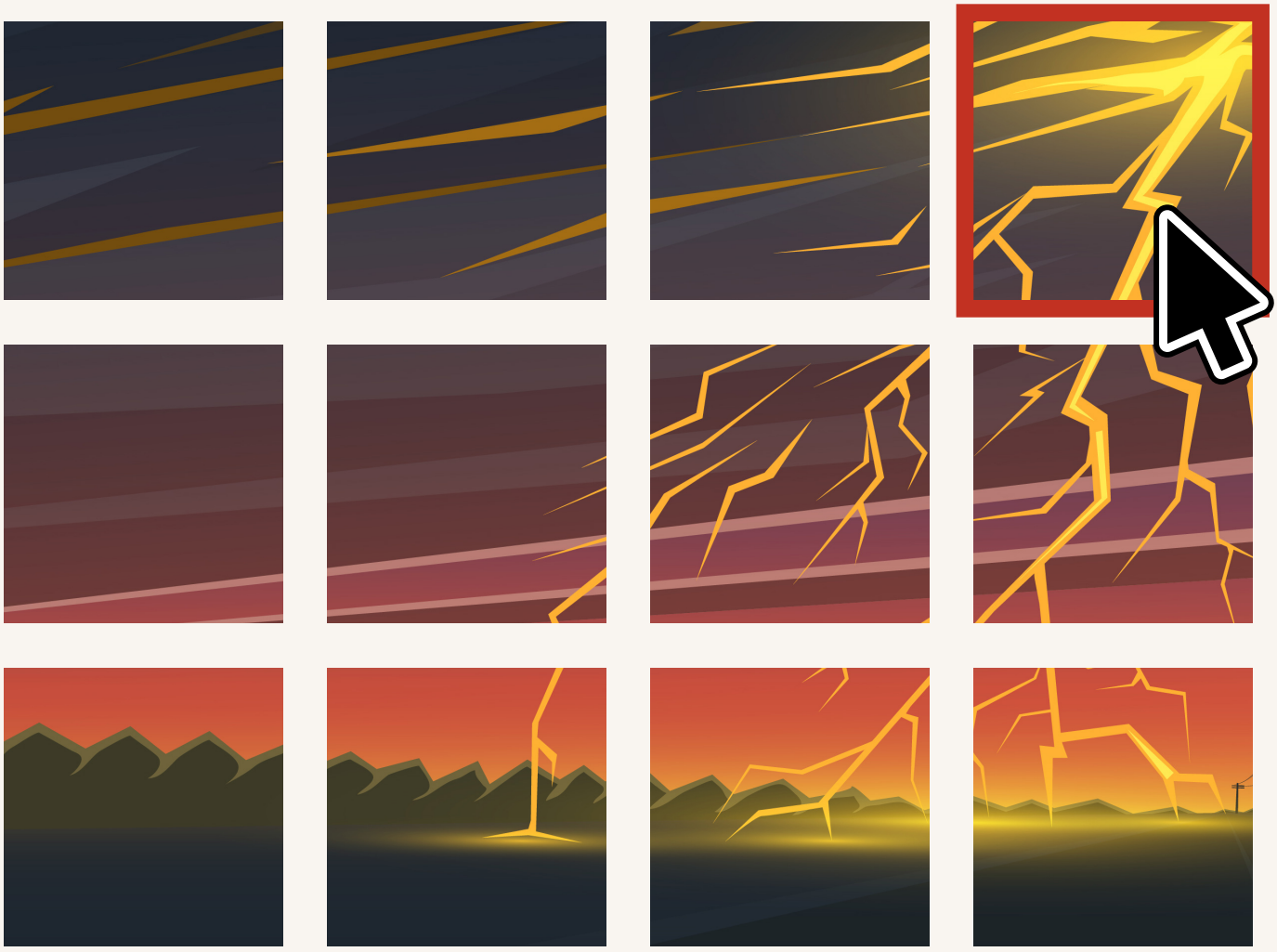

INTO THE STORM

USING ARTIFICIAL INTELLIGENCE TO IMPROVE CALIFORNIA'S DISASTER RESILIENCE

JULY 2020

PARTNERSHIP FOR PUBLIC SERVICE

Microsoft

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Introduction

DISASTER RESILIENCE is an area ripe for the use of artificial intelligence technologies. While some governments, companies and universities have already used AI in this field, most are still in the early stages of use. However, AI technologies could contribute to disaster preparation and response better than any other technology or innovation in operation now. It could help identify risks, predict disasters earlier, and assess damage during and after an event. With people's lives and livelihoods at stake, emergency responders need the most effective tools available for managing natural hazards and threats.

California is one of several states that are vulnerable to various disasters. Wildfires in 2018 caused $24 billion in economic damages,[1] and took a great human toll as well. The 2018 Camp Fire, the deadliest wildfire in the state's history, killed 85 people and displaced about 52,000 others. California also is susceptible to floods, tsunamis, landslides, avalanches, droughts, earthquakes, hurricanes and volcanic eruptions, and has had more federal disasters declared since 1953—the year record-keeping began—than any state other than Texas.[2]

As a result, AI could have a more substantial effect on improving disaster resilience in California than almost any other state in the nation, helping to lessen the toll of disasters in the state. Strong disaster resilience relies on the effective collection, analysis and dissemination of information about potential hazards,[3] and AI tools excel at those tasks.

For example, researchers from Harvard University and the Massachusetts Institute of Technology using AI to analyze past earthquakes in Oklahoma found more information than employees using traditional earthquake detection tools at the Oklahoma Geological Survey, the state agency responsible for collecting the information, according to a 2018 study.[4] Changes in a seismological dataset indicate earthquakes had occurred, and the AI analysis found 17 times more changes than did the state agency, which did not have the ability to use state-of-the art AI technology. Government employees, such as those working for the Oklahoma state agency, could accomplish their mission more effectively with AI tools that help them analyze data and information.

Recognizing the positive impact AI could have on disaster resilience in at-risk states such as California, the Partnership for Public Service worked with Microsoft to examine ways artificial intelligence could help the federal, state and local governments in California improve disaster resilience.

This paper examines the use of AI tools to help regions predict future disasters, assess disaster impact, identify disasters earlier or in real-time, and evaluate damage after a disaster occurs. It examines the need for governments to consider issues such as data quality and usability, collaboration between governments and how to make AI tools user-friendly. And in a case study, it examines how the city and county of Los Angeles and neighboring counties use an AI software called WIFIRE to predict the path and extent of wildfires..

What we mean by disaster resilience and artificial intelligence

Disaster resilience

"The ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events." The resilience process includes preparedness, response, recovery, mitigation and adaptation.[5]

Artificial intelligence

Computers and software performing tasks we typically associate with people, such as recognizing speech or images, predicting events based on past information, or making decisions. AI tools use data to learn a task, and they continue to improve at functions such as transferring information from paper into computers, answering questions by quickly finding relevant information in databases or documents, detecting patterns in data, making decisions about simple queries, and predicting someone's behavior based on past conduct.

1 National Oceanic and Atmospheric Administration, "2018's Billion Dollar Disasters in Context," Feb. 7, 2019. Retrieved from https://bit.ly/2QKBELL

2 Federal Emergency Management Agency, "Disaster Declarations by State/Tribal Government," 2020. Retrieved from https://bit.ly/2IUXO9Y

3 National Academies of Sciences, Engineering, and Medicine, "Disaster Resilience: A National Imperative," 2012, 2. Retrieved from https://bit.ly/2WKJyJ0

4 Thibaut Perol, Michaël Gharbi and Marine Denolle, "Convolutional neural network for earthquake detection and location," Science Advances 4(2), February 2018. Retrieved from https://bit.ly/2WKYMO6

5 National Academies of Sciences, Engineering, and Medicine, "Disaster Resilience: A National Imperative," 2012, 1, 7. Retrieved from https://bit.ly/2WKJyJ0

Using Artificial Intelligence to Improve Disaster Resilience

Artificial intelligence is used in many government agencies to automate routine tasks and help analyze an overwhelming amount of information. AI is also increasingly used for disaster resilience, as researchers worldwide study the potential of AI algorithms and tools to help governments and emergency responders mitigate and manage a range of natural hazards.

On the pages that follow, we describe how artificial intelligence could help California governments and emergency responders prepare for, respond to and recover from natural disasters. We highlight the range of potential applications and ways AI tools could assist in all phases of disaster resilience planning and action, including predicting future disasters and identifying their potential impact, calling attention to disasters in real time, and assessing damage after disasters strike.

Predicting the likelihood of future disasters

Scientists and researchers in California are using data collected with artificial intelligence technologies to predict natural disasters. The state and local governments there could also benefit from research conducted outside of California, since such disasters are similar enough for lessons learned in one community to help another one, said Bistra Dilkina, AI researcher and associate professor of computer science at the University of Southern California.

Knowing what disasters may strike and what their potential impact may be could improve resilience by enabling California governments and emergency responders to prepare more useful mitigation plans and decide how to spend limited resources more effectively. The information AI provides also could reveal a community's susceptibility to disasters it might not have previously known, such as being in the path of potential floods.

Predicting disasters could involve creating computer simulations about future trends by wading through millions of rows of data, each on a different characteristic—for example, information on hurricanes from the last hundred years. Simulations then produce additional data that must be analyzed. A computer simulation of extreme weather patterns, for example, "can easily produce 100 terabytes of data spanning 100 years of simulated time in the future," said Prabhat, data and analytics services group leader at the Lawrence Berkeley National Laboratory. For comparison, the average personal computer can store up to half a terabyte of data.

AI tools could find patterns to identify hazardous events, while also helping to analyze how those patterns and trends, such as the length or intensity of droughts or floods, could change in the future.

"AI can help thin the data flow," and can do it "much more effectively than having many people processing the data manually," said Stephen Volz, assistant administrator for satellite and information services at the National Oceanic and Atmospheric Administration. Prabhat agreed. "Automatically extracting data, ingesting datasets, finding patterns in datasets and flagging for human experts and decision-makers what might happen next, those are all things that AI systems can almost certainly do," he said.

Prabhat and his team are using AI to research how precipitation is expected to change in California in the coming years and decades due to changing climate and weather patterns. "Atmospheric rivers," which are narrow corridors of air that transport water vapor between the Earth's regions, play a big role in California's precipitation levels, according to Prabhat. "What we would like to know is, say, 100 years from now, are atmospheric rivers going to continue to make landfall in California?" he asked. "When they make landfall, will they have more precipitation associated with them or less precipitation?"

Preliminary results indicate that these atmospheric rivers might increasingly miss California, decreasing rain and precipitation in the coming decades, Prabhat said. If that is the case, it will have implications for California governments and their water resource planning. To contend with more or longer droughts, governments might have to find new sources of water besides rainwater and snowmelt and implement more sustainable water practices.

Identifying risks to predict the impact of disasters

Artificial intelligence tools could assess the impact of natural disasters, using data on people and details about communities, such as the age or height of structures, the number of hospital beds or the location of fire stations. AI could then compare and contrast that information with disaster simulations based on past data. The data could help identify, for example, which parts of a city are vulnerable to landslides after torrential rainfalls, based on soil type, or where and how quickly a neighborhood could be evacuated from the path of a tsunami, based on population, evacuation routes and land elevation.

For California officials and responders to prepare sufficiently for disasters, it is crucial for them to know if a disaster is likely to strike, and what the potential impact could be. "AI is really a way for us to increase our ability to review threats and plan for them," said Aaron Gross, chief resilience officer of the city of Los Angeles. Dan Ghiorso, former chief of the Woodside Fire Protection District in northern California, said AI's predictions could help governments "do some sort of mitigation, such as hardening homes and hardening buildings to make them more earthquake resilient."

For example, Los Angeles partnered with the University of Southern California to prepare its water pipe system for earthquakes. The city has two goals, said Bistra Dilkina, associate professor of computer science at the University of Southern California and co-director of the USC Center on AI in Society, who develops AI algorithms and is working with the city on the water pipe project. One is to ensure water is available after an earthquake for evacuation centers, hospitals and other sites providing emergency services. The other is to ensure water is available within one mile of every location in the city, so firefighters can respond where needed.

Dilkina's AI algorithm maps the city's infrastructure and finds a network of pipes that meets those two goals "with the smallest footprint and smallest cost," she said. The study results, expected in late 2020, could help city officials identify pipes to replace with earthquake-resistant water pipes, rather than replacing all pipes—a costly undertaking—or improving the infrastructure in a more ad hoc way.

AI could help predict the impact disasters have on people's behavior as well, such as what people will do during an evacuation, a focus of NASA-funded research at Chapman University in Orange County, California. Researchers there scrutinized location information from Facebook users who allowed the company's apps to track their location around the time of two fires in northern California in 2018 that were among the most destructive in the state's history.

Analyzing information like this could help emergency responders understand how people behave during disasters, which could inform future emergency response efforts, according to researchers.[6] It could also inform officials, who must decide how many shelters to set up or how many evacuation routes need to be created. And it could reveal factors that speed or slow evacuations, which could save lives during fires.

Researchers found that evacuation patterns showed people did not simply go from their homes to evacuation shelters during the highly damaging northern California fires. This suggests that people had more options for where to go during the fire, such as staying with friends or family at more distant locations.[7]

The pattern of people returning home was clearer. During one of the fires, in and around Mendocino County, the data indicated that most

6 Stephanie House, "Fighting Fires With Facebook," Chapman University, May 31, 2019. Retrieved from https://chapma.nu/3aiyjvb

7 Ibid.

homes remained habitable. During the other fire, which raged about 90 miles north of Sacramento and was named the Camp Fire, data showed most people did not return, because many of the affected areas and homes were destroyed.[8]

The use of AI also could help predict disaster impact and identify cause-and-effect relationships that are not immediately evident, such as social or economic impact, said Bijan Karimi, assistant deputy director of the San Francisco Department of Emergency Management. Traditional disaster forecasting focuses on immediate effects, such as the number of lives lost, or property destroyed. But knowing and planning for secondary and third-order effects is just as important, he added.

For example, after a volcanic eruption blankets a certain area with ash and smoke, AI technology might help emergency responders project how many people will seek medical attention because of lung damage and, down the line, how many new lung specialists area hospitals might need to hire to deal with an influx of new patients. Analyzing the downstream impact could help governments and emergency responders prepare more comprehensive disaster plans and take wide-ranging steps to slow the ripple effects after disasters.

Detecting disasters earlier

If officials get information about an imminent earthquake, tsunami or other disaster minutes or, better yet, hours earlier than with traditional detection methods, they have more time to help people seek shelter or evacuate, potentially saving lives. Such early warning also would help emergency responders disseminate information in advance to more people and speed recovery efforts afterward with assistance from emergency responders who are not in the disaster's path.

AI can continuously monitor large quantities of information and data streams, such as by-the-minute atmospheric pressure readings from weather stations or publicly available social media feeds. Unlike a human, AI does not tire after hours or days of a repetitive task and can sift through information with the same effectiveness and efficiency for weeks or months. This functionality is what allows an AI tool to give early warning about disasters.

Additionally, scientists can teach AI to discern even small data changes, such as a rise in air temperature around an airport. The technology can then identify whether the temperature change was caused by an oncoming hazardous event or if it was simply from aircraft engine exhaust accumulating after a sudden increase in the number of planes taking off. Alternatively, AI can differentiate when hundreds of mentions of "shake" on social media pertain to a dance-off and not an earthquake.

On the earthquake front, in January 2019, Los Angeles launched a mobile phone app, ShakeAlertLA, as an earthquake early warning alert before people feel shaking. ShakeAlertLA, already downloaded by 870,000 people, uses the U.S. Geological Survey's ShakeAlert system, a West Coast sensor network that calculates the intensity and epicenter of an earthquake.

The app "gives you an alert within seconds of an earthquake starting, lets you know you are going to feel shaking and tells you the severity of shaking based on your location," said Jeanne Holm, Los Angeles' chief data officer. The app's algorithm predicts the time and severity of the shaking at any given location by analyzing the initial seismic data. The ShakeAlert system detects the first rapidly moving seismic waves caused by an earthquake—called primary or P-waves—and immediately notifies users to expect an earthquake. This warning is important because it can reach people before the most damaging waves strike—the slower moving seismic waves called secondary or S-waves.[9]

Tsunami detection and the ability to give an early warning is another potential use of AI. NOAA uses a deep-sea buoy network, called DART, to monitor impending tsunamis off California's coast and elsewhere. The DART system consists of a surface buoy and a seabed bottom pressure recorder that monitors and records temperature and pressure on the seabed. Increased pressure could indicate a tsunami passing, which earthquakes can cause. If the recorder's software indicates a possible tsunami, it starts collecting data more frequently to monitor the changes in pressure. Real-time data is transmitted to the surface buoy, which then relays the message to tsunami warning centers through satellites. Based on this information, the warning centers produce forecasts and may issue warnings and alerts.

Individuals can analyze the data from those buoys and confirm the warning signs, but AI would likely identify dangers faster. "We have the data specialists and scientists who are working on monitoring, but AI could point them to the more interesting bits of data" that might indicate an impending disaster, said Eric Kihn, director at NOAA's Center for Coasts, Oceans and Geophysics.

AI also could help NOAA discern temporary changes in the data that could simply be harmless anomalies. The technology could help "make sure that you are not tackling something hastily in real time" and issuing a warning when there is no danger of a tsunami hitting the shore, Kihn added.

In a world where the chatter on social media is overwhelming, AI technology could help emergency

8 Kasha Patel, "Understanding Evacuation Patterns with Social Media," NASA, Aug. 5, 2018. Retrieved from https://go.nasa.gov/3dVQk4j

9 City of Los Angeles, "Download the ShakeAlertLA Early Earthquake Warning App," 2020. Retrieved from https://bit.ly/33KkCTq

responders cut through the noise to recognize signs of a possible disaster sooner than they can now. Many people post to Facebook, Twitter and other platforms when they are witnessing a natural disaster, and AI could help pick up on that much more quickly and efficiently. AI also could categorize and distinguish those 911 or 311 calls that likely involve natural disasters from calls that are about the danger of other issues, such as a robbery in progress.

"The amount of information coming our way is overwhelming," said Karimi of the San Francisco Department of Emergency Management. "In the intelligence cycle, you gather, you analyze and you disseminate. My team is spending so much time on gathering that they do not have the time to do the analysis. I might not have the right information for the right people at the right time, because I don't even know what the right information is," he added.

Stephanie Tennyson, chief communications director at IEM, an emergency management company, agreed. "It's just more information than humans could possibly go through. Analyzing the information is certainly a very successful use of computer algorithms and artificial intelligence," she said. If AI points emergency responders to the right information faster, it could improve response times, which could mean lives or property saved. It also could allow emergency responders to redirect their time from trying to identify that a disaster is happening to preparing for when a disaster strikes.

Assessing damage after disasters strike

Rapid recovery after a disaster is important for both the economic and psychological health of communities, and AI could help California governments and emergency responders assess damage as quickly as possible. "AI could help us come up with a more accurate damage estimate—both where the damage is and how significant it is," said Karimi.

Knowing the specifics of how a disaster has affected a community or neighborhood could eliminate the need to spend hours surveying disaster damage, valuable time that could be spent getting aid to the hardest-hit areas or setting up shelters. Officials and responders typically eyeball damage, sometimes by flying in helicopters or sending drones over an area to evaluate the destruction. This activity mostly provides a high-level assessment. It also is very time-consuming, as responders must spend time assessing and making judgments about each individual structure.

"It is a very manual task and not very granular. It assesses whether a building is or is not destroyed," but often does not assess the scale of damage more granularly, said Ritwik Gupta of the Carnegie Mellon University's Software Engineering Institute and the federal Defense Innovation Unit, a Defense Department organization aimed at helping the military use emerging commercial technologies more rapidly. But emergency responders need to know the extent of the damage to infrastructure to gather appropriate recovery resources from existing supplies or to request additional help from the federal government or the state. For example, a ruined low-rise structure should not get immediate attention if a nearby high-rise is badly damaged and in danger of collapsing, possibly cutting off an evacuation route or falling onto an undamaged building with people inside.

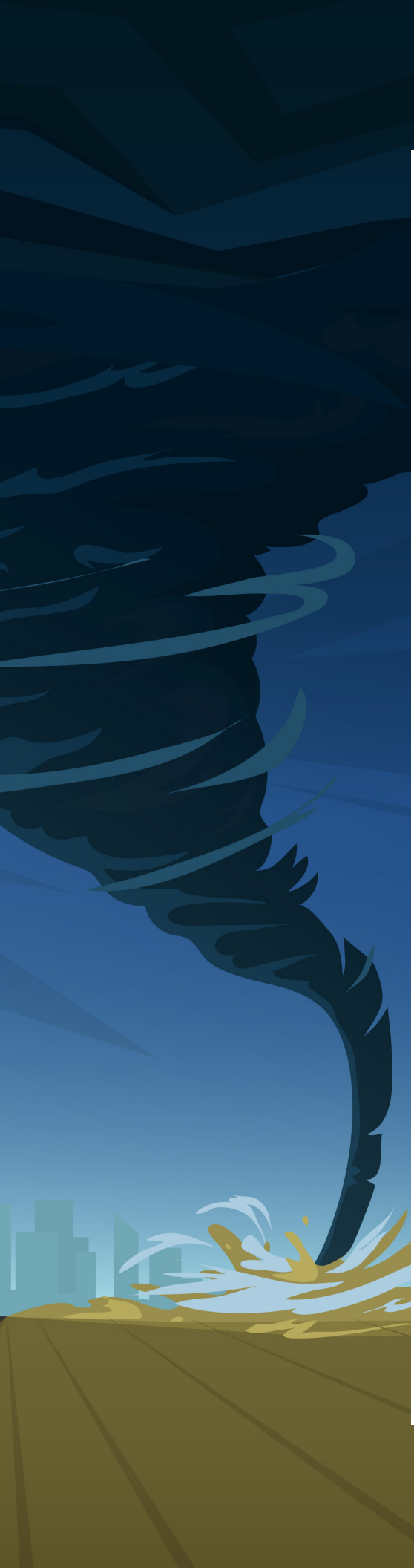
Researchers at the Carnegie Mellon University's Software Engineering Institute, together with the Defense Innovation Unit, have been working on creating datasets that AI tools could sift through to learn to promptly and accurately assess damage, Gupta said. Researchers compiled satellite images of areas all over the world hit by natural disasters and categorized images of more than 850,000 structures across 17,500 square miles based on damage to the structures. Satellite images consisted of pictures taken following six types of disasters: earthquakes, floods, tornados, tsunamis, volcanic eruptions and wildfires.[10]

Instead of people having to manually survey damage, structure by structure, governments and responders could turn to a satellite flying overhead hours, if not minutes, after a disaster strikes, capable of photographing large swaths of the disaster area. AI can then "automatically do damage assessment on images from space, so no people are involved in the assessment," Gupta said, and that would free responders to focus on helping people on the ground.

In September 2019, the Defense Innovation Unit issued a challenge to the public to help it with AI solutions. Through the "xView 2" prize challenge, the organization made its disaster image dataset public, so individuals could use it to create AI algorithms that could, after learning from the initial data, investigate any subsequent satellite data to assess building damage.

More than 2,000 participants responded to the challenge and developed AI algorithms, Gupta said. The teams or individuals with the algorithms that identify damaged buildings in the innovation unit's dataset most accurately will win up to $150,000 in 2020.

10 Ritwik Gupta et al., "xBD: A Dataset for Assessing Building Damage from Satellite Imagery," November 2019, 4–5. Retrieved from https://arxiv.org/abs/1911.09296



Considerations when adopting AI tools for disaster resilience

Artificial intelligence is likely to improve disaster resilience and help governments and emergency responders save lives and property. However, governments must think carefully about how best to implement AI for preparedness, response and recovery. The experts with whom we spoke raised several issues for consideration.

Data access, quality and usability

Accessible, quality data is the foundation of any AI tool, but the potential risk to lives and property during disasters makes these features especially crucial when using AI for disaster resilience. Collecting data is not always straightforward, however. It can be difficult to access data from the many government agencies where it is kept, due to privacy, security and record-keeping rules.

Additionally, while data on certain natural disasters, such as hurricanes or tropical cyclones, is often abundant—the National Oceanic and Atmospheric Administration, for example, could "easily overwhelm anybody with satellite data" for analyzing disasters, said Stephen Volz, assistant administrator for satellite and information services—the relative rarity of other disaster events, such as tornadoes, sometimes makes it difficult to collect ample data to train AI tools.

"Although disasters make the news, they do not tend to happen over and over again," said Amy McGovern, professor at the University of Oklahoma, describing her research on tornadoes. "So, when you are predicting something that happens only a handful of times a year, you have to collect years of radar data to get a quantity sufficient enough to train an AI tool."

Yet, ensuring the availability of quality data is a necessary first step for governments seeking to use AI for disaster resilience. One method for getting access is through the United Nations International Charter for Space and Major Disasters. If an agency involved in disaster management requests data, the charter "allows immediate access to private satellite data and restricted satellite data in response to disasters," Volz said. "All the countries who are signatories to the Disaster Charter and who may have restricted data policies open up their data post-earthquake or tsunami, for example."

Becoming more proactive

Widespread use of AI for disaster resilience involves shifting emergency responders' focus to preparing for potential disasters, rather than reacting to them. "We tend to be reactive instead of proactive, for the most part. That needs to change," said Ghiorso. "Being prepared for something is a lot better than being reactive to it," he added.

AI tool creators and users need to educate emergency responders about the potential benefits of the tools and explain what those tools can help them accomplish, Ghiorso said. This could get more people to use AI to predict disasters and their potential impact.

Another benefit of investing in preparation is funds might be saved in the long run. "Money invested in mitigation often decreases the impact of future disasters," said Bijan Karimi, assistant deputy director of the San Francisco Department of Emergency Management. According to the U.S. Federal Emergency Management Agency, $1 spent on mitigation saves $4 in recovery costs, on average.[11]

Collaboration among governments

Wide adoption of AI and coordination among governments could help them all improve their disaster resilience, as disasters do not stop at state or county borders. "If we were to have the big earthquake today, and I have an AI platform [in my jurisdiction] that worked great for me, I'm still a very small picture of that disaster," Ghiorso said. "If no one else is going to buy in on this AI platform," that could hamper recovery efforts.

David Hahn, chief of naval research at the Department of the Navy, echoed this sentiment. "Disaster resilience is a team sport," where collaboration among agencies and levels of government is essential.

The need for human expertise

While AI can collect and analyze information effectively, governments and emergency responders still must interpret and act on an AI tool's recommendation, so human expertise is a crucial component of AI-enabled disaster resilience tools. "AI is not a replacement for human expertise. It is a complement to it," said Mike Pavolonis, physical research scientist at NOAA.

Subject matter experts are vital for ensuring AI tools are designed correctly for their tasks. Experts in tsunamis, for example, could identify relevant data on past tsunamis and use their expertise to check and correct, if necessary, an AI tool's prediction on a coastal community's vulnerability.

When NASA researchers designed an AI algorithm to predict hurricane intensity, for instance, their team included both data scientists trained in AI techniques and hurricane experts. "You really need subject matter experts to work hand in hand" with AI experts, said Rahul Ramachandran, a senior research scientist at NASA.

User-friendliness

Emergency responders work in high-pressure environments and must often make quick decisions to save lives and property, so any AI tool for disaster resilience should be designed for the unique nature of the job and the environment in which it operates.

AI tools should help emergency responders do their jobs more effectively, rather than simply be another device or system they must monitor, said Stephanie Tennyson, chief communications director at IEM. Those creating AI tools for emergency responders must "make it most relevant for them, rather than just one more thing that they have to factor into their response. Because if not, they are not going to bring the tool out in the middle of a disaster response," she said.

Emergency responders do not have time to navigate complicated platforms amid a disaster, agreed Brian Fennessy, chief of the Orange County, California, Fire Authority. "We need AI tools that help us process, focus and highlight the key things we need out of all of the data we cannot see. As a result, the AI tool has got to be really simple to access, and it has got to help focus commanders on key information in the heat of the battle," he said.

For example, the AI tool could be more usable as an added function to another tool responders already use, Fennessy said. Local firefighters often use publicly available messaging applications to communicate during a response. "If I was on a fire, my phone would buzz, and in a message I am receiving a map. I am getting a video created by an AI tool that tracks a wildfire's path. Then I catch that information because it is useful and simple to access," he said.

11 Federal Emergency Management Agency, "Protecting Yourself Through Mitigation," July 5, 2019. Retrieved from https://bit.ly/3bx5V8Q

Case Study

Predicting the Paths of Wildfire with WIFIRE

WILDFIRES ARE THE MOST common natural disaster in California, according to the Federal Emergency Management Agency's disaster declaration database.[12] Fires are a natural part of the ecosystem, clearing out dead plants and overgrown areas and creating fertile soil for new plant growth. However, they are becoming even more prevalent and severe and thus threaten more people and property than before. California's fire season used to run from October through December, but in recent years, it has stretched by 75 days, on average, according to the California Department of Forestry and Fire Protection.[13]

The state is addressing the growing threat of fires with the help of artificial intelligence tools, the computing power of which can quickly and systematically analyze large quantities of information from past wildfire data, real-time weather data and other sources. AI also continuously assesses new information, such as a change in wind direction, to recalculate a fire's path or size.

Historically, fire departments in the state relied on firefighters' experience, expertise and knowledge of their neighborhoods, and the local climate, to predict how a fire might spread. That started to change in the city of Los Angeles after the chief of the city fire department heard about WIFIRE.

In 2015, Chief Ralph Terrazas read an article in an in-flight magazine about University of California, San Diego, Professor Ilkay Altintas and WIFIRE, an AI-powered online software for predicting the spread of wildfires. University researchers also had a supercomputer, enabling Altintas to run complex analyses on real-time wildfire data, which the city's fire department did not have the staff or computer capacity to do.

Within days of reading the article, Terrazas reached out to Altintas, recognizing their overlapping goal of better wildfire response, and went to meet with her. During a tour of the university's supercomputer room, the contrast hit home: Altintas' AI gave the researchers a big advantage over the Los Angeles City Fire Department's method of relying on its firefighters' experience and expertise to predict wildfire paths.

"I remember walking through all those computer servers thinking, 'this has got to be better than what I came up with, because my tool is predicated on the knowledge of the user, and that knowledge consisted of knowing topography, fire fuel and the wind direction, and then putting that information down on a map,'" Terrazas said.

The LA City Fire Department started using the AI tool shortly thereafter. Today, three county fire departments also use it—Los Angeles, Orange and Ventura—as does the California Public Utilities Commission.

WIFIRE's deployment five years ago came at a felicitous time for the city's fire department. About one-third of the staff had retired

12 Federal Emergency Management Agency, "Disaster Declarations by State/Tribal Government," 2020. Retrieved from https://bit.ly/2IUXO9Y

13 California Department of Forestry and Fire Protection, "2019 Incident Archive," 2020. Retrieved from https://bit.ly/2UxATHX

over the preceding five years, and the approximately 1,000 new hires did not have the experience to estimate how fires spread. However, since WIFIRE is not dependent on department expertise, "it doesn't matter who is working, it just matters that the algorithm is activated," Terrazas said.

WIFIRE makes its prediction based on a host of data, including weather data from remote weather stations, such as air temperature, humidity, and wind speed and direction; still images from the region's cameras, which can help locate fires or smoke; and satellite images, including images of the topography and infrastructure, or ones that identify the type of soil or vegetation.[14] The software also incorporates predictive data and scientific models on how wildfires spread.[15]

The online software creates an initial map of the wildfire and its predicted path minutes after the firefighters tell the tool where the fire has started. It then refines its prediction as new information becomes available and "continues modeling based on fuel, weather, temperature, all those factors that go into how fires spread," said Brian Fennessy, fire chief of the Orange County Fire Authority.

Thanks to WIFIRE, "we have been able to more accurately send sufficient firefighters, fire engines and helicopters to the fires within minutes as compared to hours," Terrazas said.

In late 2019, to further improve the response to wildfires, Fennessy and the Orange County Fire Authority, working with private companies, launched a pilot program of another AI tool called the Fire Integrated Real-Time Intelligence System, or FIRIS. Its job is to confirm WIFIRE's predictions and feed real-time information into the WIFIRE algorithm. FIRIS gets its information from infrared cameras and sensors mounted on aircraft that fly over a wildfire. The infrared cameras can see through smoke to get a more accurate picture of the size and spread of a fire than traditional video cameras.

"At that point, if it is a big fire, I take a screenshot of the WIFIRE projection and text it to the mayor, to the incident commander and my command staff," Terrazas said. "We also start alerting the media for evacuations. We update our evacuation map at www.lafd.org. That evacuation map is predicated on the WIFIRE wildfire projection."

Accurately predicting the size of the fire is critical for mustering an appropriate response. "How big is the fire? That's the first thing you are going to want to know," Fennessy said.

If AI can predict a fire's path and size, firefighters can dispatch the proper number of units to fight it without spending too many resources on one fire and pulling resources away from other duties. The LA City Fire Department gets more than a thousand emergency calls a day, on average. "That is why speed and accuracy are critically important: We can more effectively deploy our firefighters while maintaining protection for the rest of the city, and our 1,350 other calls," Terrazas said.

WIFIRE and FIRIS were both deployed during the fall 2019 Getty Fire in Los Angeles. After a motorist reported the fire to 911, the emergency operations center dispatched fire engines and helicopters to the scene. Within 20 minutes, the fire department ran the WIFIRE algorithm to predict the fire's path and help officials determine the evacuation area. The FIRIS plane also was dispatched to validate WIFIRE's prediction and ascertain that the evacuation area officials decided on was appropriate to the size and path of the fire. FIRIS then confirmed that the initial projection was accurate, and the evacuation area was large enough to keep the local community out of harm's way, Terrazas said.

"We cannot afford to be wrong. You have to anticipate the speed at which that fire would travel," Terrazas continued. "LA is a very densely populated area, and within minutes of a fire spreading we have houses that are being threatened, with thousands of people that potentially need to be evacuated."

Thanks in part to WIFIRE's initial projection, firefighters got it right about the size and spread of the Getty Fire and were able to contain it in a few days, and to a few hundred acres. No lives were lost, and only 10 houses were destroyed, despite the fire burning near populated neighborhoods.

14 Ilkay Altintas et al., "Towards an Integrated Cyberinfrastructure for Scalable Data-driven Monitoring, Dynamic Prediction and Resilience of Wildfires," Procedia Computer Science 51, 2015, 1635–1637. Retrieved from https://bit.ly/2MOCGnP

15 Ibid.

Conclusion

ALTHOUGH AI IS IMPROVING disaster resilience and how governments and emergency responders prepare for, respond to and recover from natural disasters all over the country, few places are likely to feel AI's impact more than California, which is prone to more natural hazards than almost any other state in the nation.

Several California cities and counties have already tested and used AI tools to improve disaster management. Many others are bound to follow after exploring AI's potential benefits. And scientists in the federal government, such as at NASA and the departments of Commerce, Defense and Energy, as well as in the private sector and academia, are researching new ways for AI technologies to help with disaster resilience. The options for using AI tools are likely to expand as AI technologies improve.

As the federal, state and local governments in California seek additional AI tools for disaster resilience, they need to improve access to quality data and provide government data to researchers developing AI algorithms. Using AI to mitigate disasters requires government officials and responders to shift their mindset from reacting to crises to preparing for them.

Additionally, disaster resilience plans and activities need to cut across organizational silos and jurisdictions, as disasters do not respect city, county or state boundaries. Organizations must collaborate across agencies and governments for a more effective response, and make sure AI tools are user-friendly and intuitive, since time is of the essence when disasters strike.

The federal government, with its broad reach, could take a lead role in helping California use AI for disaster preparation and response. Already, federal government researchers are studying how AI could improve disaster resilience, and federal agencies should continue to work with California state and local governments to find further applications for AI technologies.

In the future, federal agencies should fund more AI research to build California's resilience, and agencies such as the Federal Emergency Management Agency could encourage and facilitate the use of AI tools across city and county borders. The federal government also could lead the way in making more natural disaster data public, so the private sector, nonprofits and universities could tap into federal data when creating AI algorithms.

The Partnership and Microsoft hope that the federal government will continue to collaborate with state and local governments in California to explore the use of AI to minimize disaster impact, and we hope those governments will find our report a helpful guide along the way.

Appendix I
Methodology

The Partnership for Public Service and Microsoft's goal was to highlight lessons learned from federal, state and local governments, private companies, universities, and nonprofits that had used AI tools for disaster resilience. We also sought to find applications government is not using that would be beneficial for agencies. In February and March 2020, we interviewed 23 federal, state or local government employees, or private sector or academic experts in disaster resilience, artificial intelligence or both. We also reviewed scientific studies and government emergency preparedness plans, and reports on disaster resilience and AI.

Appendix II
Acknowledgements

The individuals listed below generously offered their input on the use of artificial intelligence for disaster resilience in California. We greatly appreciate their time and counsel. The contents of this white paper do not necessarily reflect the views of those with whom we spoke, and the views of participating federal, state and local officials do not necessarily reflect positions or policies of the federal, state or local governments or their agencies.

Cameron Birge
Senior Program Manager
Microsoft Philanthropies

Bistra Dilkina
Computer Science Associate Professor and Co-Director, USC Center for AI in Society
University of Southern California

Eric Egland
AI Subject Matter Expert, Microsoft

Brian Fennessy
Fire Chief, Orange County Fire Authority

Dan Ghiorso
Former Chief, Woodside Fire Protection District

Bryce Goodman
AI Expert, Defense Innovation Unit, Department of Defense

Aaron Gross
Chief Resilience Officer
Office of Mayor Eric Garcetti, City of Los Angeles

Ritwik Gupta
Machine Learning Research Scientist and Technical Program Manager
Defense Innovation Unit, Department of Defense
Carnegie Mellon University Software Engineering Institute

David Hahn
Chief of Naval Research
Department of the Navy, Department of Defense

Jeanne Holm
Senior Technology Advisor to the Mayor and Chief Data Officer, City of Los Angeles

Bijan Karimi
Assistant Deputy Director, Division of Emergency Services
Department of Emergency Management, City of San Francisco

Eric Kihn
Director, Center for Coasts, Oceans and Geophysics, National Centers for Environmental Information
National Oceanic and Atmospheric Administration, Department of Commerce

Kristina Libby
Chief Science Officer, Hypergiant

Amy McGovern
Professor, School of Computer Science, and Adjunct Professor, School of Meteorology, University of Oklahoma

Nirav Patel
Geospatial Data Scientist and Project Manager, Space and AI/ML Portfolios
Defense Innovation Unit, Department of Defense

Michael Pavolonis
Physical Scientist, Advanced Satellite Products Branch
National Oceanic and Atmospheric Administration, Department of Commerce

Prabhat
Group Leader, Data and Analytics Services
Lawrence Berkeley National Laboratory, Department of Energy

Rahul Ramachandran
Senior Research Scientist
Marshall Space Flight Center, National Aeronautics and Space Administration

C.K. Sample III
Chief Technology Officer, Hypergiant

Stephanie Tennyson
Chief Communications Director, IEM

Ralph Terrazas
Fire Chief, Los Angeles City Fire Department

Stephen Volz
Assistant Administrator for Satellite and Information Services
National Oceanic and Atmospheric Administration, Department of Commerce

Michael Wehner
Senior Staff Scientist, Computational Research Division
Lawrence Berkeley National Laboratory

Appendix III
Project Team

Partnership for Public Service

Elizabeth Byers
Associate

Samantha Donaldson
Vice President, Communications, and Acting Vice President, Research, Analysis and Evaluation

Alexandra Kakadiaris
Intern

Peter Kamocsai
Manager and Project Lead

Katie Malague
Vice President, Government Effectiveness

Tim Markatos
Associate Design Manager

Ellen Perlman
Senior Writer and Editor

Microsoft

Jennifer Rudy
Strategic Partnerships

PARTNERSHIP
FOR **PUBLIC SERVICE**

1100 New York Avenue NW
Suite 200 East
Washington, DC 20005

(202) 775-9111
ourpublicservice.org
CFC# 12110

partnershipforpublicservice

@RPublicService

rpublicservice

One Microsoft Way
Redmond, WA 98052

(425) 882–8080
microsoft.com

microsoftingovernment

@Microsoft_Gov