Prospectus

How can the Detection of Abnormal Behaviors be improved in Smart Homes?
(Technical Topic)

What is the State of the Fight against Fracking in America and its Environmental Effects in the Northeast and Gulf Coast?
(STS Topic)

By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

As an engineering student, I have always been passionate about how what I learn in class can be applied to technologies that help society. I believe the true merit of an engineer is derived from the extent their inventions can benefit the lives of those in society and not how technically skilled they may be. Holding myself to this definition, I decided to apply this to the technical topic and research topic I would explore in my last year of study.

One field of computer science that is interesting to me is the field of machine learning and its applications, specifically within home security. Machine learning is defined as a subset of the artificial intelligence field where systems are able to improve their functional results by "learning" from multiple experiences without the need of explicit programming. My interest was piqued and I spoke to professor Yuan Tian, a professor I had previously conducted machine learning research with, and inquired if she had any projects. She told me about a project she was currently working on that entailed integrating machine learning into threat detection in smart homes and I was immediately interested. Thanks to her, I am currently researching how her smart home detection systems can be optimized for high accuracy and low false positive rate for my technical topic.

For my research topic, I will explore a very different topic, the current state of fracking in the United States (US) and its social and environmental effects. The energy drilling practice has grown rapidly in popularity in the past decade and has established itself as one of the main pillars supporting US energy independence. However, many people claim that the practice is harmful to the environment and humans due to how the wastewater from the process is treated and the unexpected seismic activity that follows. With the notion of improving the quality of others' lives in my head, I am researching how smart home detection systems can be refined to more

accurately detect abnormal behavior, while I will research the current state of energy generation by looking at fracking in the US.

Technical Topic

For our technical research, we are looking at methods for sensors set up in smart homes to better train them to provide results with high accuracy. To give some background on this topic, smart homes are homes that employ the Internet of Things (IoT). This refers to the connectivity between everyday objects through the use of sensors and processors utilizing Internet connections to send and receive data. In our project, we plan on using IoT present in smart home security sensors to better train a machine learning model to learn to recognize threats accurately. These threats can include bathroom falls, kitchen fires, home burglaries and other dangerous events.

A brief note about terminology

We use "perfectly-trained model" to refer to a model whose results are 100% accurate every time it is run. While a "well-trained model" refers to a model whose results are mostly accurate, but produces inaccurate results here and there. As we go deeper into the research, we will establish thresholds that will determine whether a model is "well-trained" or not. The "One-class SVM" approach is a model that learns by analyzing data that contains one class. It uses these derived patterns from the data to recognize anomalies and is commonly used for classification purposes. The "Autoencoder" approach is a model that encodes the data it is fed into a representation and then decodes it to a representation that is close to the original data it was fed. Based on the results from this encoding process and the differing statistical "noises" generated, the model is able to detect anomalies.

Most current home security technologies are an amalgamation of different sensors that hook up and communicate with a main central command panel. These sensors most commonly include motion sensors, temperature sensors and cameras to protect against burglars and fires. These devices provide alerts to the users and homeowners, who can make decisions and respond to the threat indicated after determining if it is an imminent threat or not. The issue with current systems is that they take a long time for users to reach the control panel to make the decision that establishes a threat, than it would with an autonomous model. This time could be the factor that decides whether the user escapes harm's way or not. Current smart home sensor systems are also less accurate than perfectly-trained models as they cannot properly distinguish harmful threats from harmless ones yet.

This research provides a good solution as it will eventually link all parts of the home security system into a seamless process that can accurately predict threats. It is much quicker and safer for a well-trained model to recognize there is an external threat in the area by analyzing sensor readings it is sent. In turn, promptly contacting the police or other helpful services once a threat has been established is a big benefit of the system. This is more beneficial than typical home security systems that have no set methodology of discerning between a homeowner coming home late at night or an actual burglar. With these systems, the alarm is just triggered at any sign of an intruder.

The proposed research is focused on improving the systems that professor Tian successfully constructed. Currently, the shortcomings of these models are that the One-class SVM approach has high accuracy with a high false positive rate while the Autoencoder approach has low accuracy with a low false positive rate (Yu, 2019). My team member, Siyuan Shen, and I have been brainstorming and testing simulated data which we believe can increase the models'

accuracy while decreasing the false positive rate. Having a high false positive rate in this situation means the smart home system is likely to alert emergency services when there is no real threat present. This poses a big risk as homeowners of different race/ethnicity may be treated very differently by police than a "White" homeowner. Quote from a paper by Buerger and Farrell (2002) describes this relationship, "Black doctors, dressed in formal clothes and driving upscale cars, stopped and interrogated within sight of their homes because they "did not fit" the otherwise White neighborhood, and many more." (p. 275-276). An instance of this could be if police encounter a non-"White" homeowner under suspicious circumstances where it may seem that a crime has been committed. Given the strained relationship between non-"White" homeowners and police, this encounter could easily have a controversial outcome. Therefore, it is important for us to attempt to achieve a false positive rate of zero or at least come close to achieving it. Having a high false positive rate risks causing an unwanted threat to come to a user's home, a fear shared by many non-"White" people.

As prefaced by the previously stated risk, this research affects human and social elements. If perfected through relentless testing and modification, this system would keep humans safe from burglaries, fire and other external threats that may arise. If the optimal system is modified for large spaces, it could be installed in other places such as shopping centers, malls, warehouses and other buildings to keep them from harm while bettering the safety of society.

This technology can also be extended to other alternative users. Aside from providing security to users with perfect health, this system also aids with users who may be disabled with memory loss issues such as dementia. The system will be able to recognize and learn that their repetitive behavior resulting from their memory loss is their normal behavior (Yu, 2019).

The goal of this system is for it to learn the customs and habits of the user it monitors and for it to become best accustomed to recognizing their normal/abnormal patterns so it can provide the utmost safety to its user. We require this level of security in our life because we want to keep ourselves and others same from harm. We're afraid of what could happen to our loved ones if a fire breaks out in their house while they are sleeping or if a thief breaks in and demands money from them. We cannot live our lives free of fear because crime has a presence everywhere we go. In order to break this norm and prevent being the next victim, precautionary steps such as refining this smart home technology must be taken. This includes having this technology cater to all types of users across race, ethnicity, mental/health state and other categories.

Fracking's Rise and its Repercussions

While I enjoyed researching smart homes and how machine learning algorithms can be used to detect abnormal behavior, I decided to research an individual topic that I'm passionate about, hydraulic fracturing. Hydraulic fracturing, more commonly known as "fracking", is a drilling process where oil and gas companies shoot a mixture of water and chemicals at high pressure to fracture loose levels of shale rock. By fracturing the shale, a geological layer in the Earth's crust, companies are able to efficiently extract the crude oil deposits that exist above the shale, while generating byproducts such as highly toxic wastewater and cracks in the rock layers.

The popularity of this practice has exploded in recent years, especially in the Marcellus shale region (Natural Gas Pipeline Certification: Policy Considerations for a Changing Industry, 2017). According to Murtazashvili and Piano (2019), this was mainly due to the optimal fracking water mixture discovered by George Mitchell and the US energy companies realizing they would now be able to access difficult-to-reach crude oil resources that they were not able to

before. George Mitchell is widely considered the "father of fracking" and experimented with different hydraulic fracturing techniques until he found the right one that allowed him to economically drill for shale gas. This led to a craze in land leasing by oil companies from brokers in order to acquire as much land as possible in Texas and the Marcellus shale in the Northeast US. Due to the US's private property rights and the eagerness of oil companies to acquire "frackable" land, a land market formed encouraging landowners to make money by allowing companies to drill their property. This allowed the United States to greatly increase shale production compared to other countries (Murtazashvili & Piano, 2019). Furthermore, Majumdar states that the United States federal government also encouraged fracking's rise in popularity through the Halliburton Loophole, 2005 Energy Act. The Halliburton loophole exempted the oil and gas industry and its injection of fracking fluids into the ground from the Safe Drinking Water Act. This enabled the federal government to overstep state governments and force them to deal with their legislation, usually loose restrictions put in place to remove fracking from federal oversight. Oil and gas-rich states that fracking has gained strong momentum in, such as Texas and Wyoming, welcomed the regulation. While states that have discouraged the practice, such as New York and Florida, protested against it (Majumdar, 2019).

As the practice grew in popularity, so did the backlash. It became common knowledge that hydraulic fracturing had a number of detrimental effects to the environment and to humans and society. The first of which was the possibility of drinking water supplies being contaminated through groundwater due to dumping wastewater into disposal wells. As explained in Myers's paper (2012) that analyzes water movement in the Marcellus shale, fluids travel much quicker through areas that have already been "fracked" than "un-fracked" areas. This is supported by an analysis on the porousness of sandstone and shale by running mock scenarios with water flows

(Myers, 2012). As groundwater supplies can be contaminated, so can surface water supplies. The paper written by Entrekin, Evans-White, Johnson and Hagenbuch (2011) analyzes possible paths wastewater could have traveled given the topography and the short distances to above ground drinking supplies. The analysis also takes into account the welling sites of these energy companies and their corresponding proximities to public drinking wells, displaying how likely contamination can take place (Entrekin et al., 2011). A possible instance of this was explained in a New York Times article that stated a fracking chemical, 2-Butoxyethanol, was found in 3 Pennsylvania households' drinking water. This is a media article, so its findings may not be as accurate as those of a scientific journal. Testimony from Susan Brantley, a geoscientist from the University of Pennsylvania, states this is the first instance of organic compounds ending up in drinking water wells due to shale gas development (St. Fleur, 2015). The most likely cause is that there was insufficient casing surrounding the drill. In turn, this caused wastewater to escape the drilling well and be released into surrounding rock layers allowing liquid to flow anywhere. Busby and Mangano state another truth to give these experiments and analyses some weight, the discovery of the rise in infant mortality from hydraulic fracturing. In an analysis, a correlation is drawn between infant mortality and fracking activity in Pennsylvania (Busby & Mangano, 2017). Therefore, displaying again that there is so much unknown about this harmful practice and its dangerous effects. The last treacherous danger of fracking is the unexpected seismic activity that results from the fractures in the rock layers. One analysis associates the rise in seismic activity in Oklahoma with the increase in hydraulic fracturing injection wells, presenting a clear, causal relationship between the two variables (Bulgarelli, 2017). Given these damaging consequences, anti-fracking sentiment began to steadily rise and grow.

However, Mazur says the harmful effects discussed above weren't discussed within society until the movie, *Gasland,* directed by environmental activist Josh Fox, was released. This movie brought to light the ways people who resided in fracking states health and lives had been affected by the practice. It sparked discussions about regulating hydraulic fracturing/energy companies and gave rise to the anti-fracking movement (Mazur, 2018). Now that it became well-known that fracking was causing problems, the populace began to take matters into their own hands. To understand from a human and societal perspective, Ladd's paper states the main points that encourage Floridians to take active action against energy companies. These points are the protection of community health and the water supply, protection of the environment and peace between all parties involved in this societal conflict for the betterment of climate change and renewable energy sources (Ladd, 2018). If energy companies displayed more regard for these items, their actions would be received much more warmly. However, that is not the case.

Given this support for the anti-fracking movement, Majumdar says one would normally believe that it would be easy to repeal these regulations that encourage reckless activities by energy companies. However, it is much more difficult for lawmakers in energy dependent states. They have to deal with conflicts between their constituents and balancing both economic and social returns (Majumdar, 2019). Meanwhile, Boudet, Zanocco, Howe and Clarke state there are those on the other sides of society that are supportive of the fracking wells and believe they do not mean any harm. Their study actually stated the indifference in opinion of those who actually live near the wells compared to those who have opinions from afar (Boudet, Zanocco, Howe, & Clarke, 2018). These difficulties and people are to blame as to why these practices have not immediately faded away from society once their effects became public knowledge.

Given this, this research is an important concern as fracking needs to be phased out of society due to its damaging consequences. And for those who do not understand these terrible consequences, they need to be educated. The frameworks I plan on utilizing in this are *responsible innovation* and *techno-politics*. Technics refers to modern technology and methods while politics refers to the allocations of power associated with governing a country. The specific relationship between technics and politics in this case is defined as "Second are cases of what can be called inherently political technologies, man-made systems that appear to require, or to be strongly compatible with, particular kinds of political relationships." (Winner, 1980, p.123). Going off the definition from Winner, fracking's relationship with politics can be considered an exploitation of US government power and authority. Policies supportive of fracking, such as the Halliburton loophole, are commonly backed by government officials from fracking-heavy states that take money from oil and gas companies in exchange for them pushing their motives. Given this abuse of power, I will break down the life cycle of these ill-intentioned policies and how they are unfairly pushed to becoming legislation. I will also address the unintended consequences of fracking and how they are overlooked by corrupt politicians when they block policy meant to alleviate them. Responsible innovation is a framework that desires to promote innovation that is socially beneficial and reduce macro-ethical failure as evidenced by, "As the limits of technical expertise become exhausted, there is a need to turn to developing additional competencies and broader skill sets to address the multitude of macro-ethical issues that arise throughout the engineering process." (Foley & Gibbs, 2019, p. 20). I will use responsible innovation because oil and gas companies fail to take into account the environmental and social consequences from their hydraulic fracturing processes that have led to unanticipated harmful effects. Through my research, I will explore how to apply the framework's System

Thinking and Anticipation aspect to ensure alignment with hydraulic fracturing's design specifications. This is because companies have made minimal efforts to remediate the effects of wastewater, only treating the byproduct if it allows them to reuse it. Therefore, I can use this framework to innovate how companies can come up with better, more ethical ways to treat wastewater. The institution of these methodologies would at least eliminate the harmful effects of wastewater contaminating drinking supplies and polluting ecosystems.

Research question and methods

The research question in my prospectus is: What is the State of the Fight against Fracking in America and its Environmental Effects in the Northeast and Gulf Coast? I believe that this is a topic in society that doesn't receive enough spotlight for the scale of the issues it causes.

I plan on researching this topic using content of case studies analysis and policy analysis methods. Examining specific examples where energy companies have fallen short of holding up their promises to communities are great points for bolstering my argument. I have already found case studies from the Environmental Protection Agency (2019) analyzing hydraulic fracturing in 2 locations in Pennsylvania and 1 in Texas. For each case study, I want to take notes on why the specific area was investigated, what the findings were and how damaging the consequences were, if any.

Policies that have encouraged companies to overstep boundaries also need to be examined to realize the root cause in fracking's rise. This includes the Halliburton Loophole which exempted oil and gas companies from the Safe Drinking Water Act, removing them from federal oversight. Analyzing policies like this that popularized fracking and researching how fracking itself encouraged the institution of those policies provides solid points for my argument.

By analyzing these case studies, I can examine specific areas that have been environmentally affected by hydraulic fracking and understand how each community is impacted differently. And by analyzing policies that are/were in place, I can examine the chain reaction of events that cause practices like fracking to rise in prominence and create the aforementioned case studies.

Timeline and expected outcomes

In regards to carrying out the research for the technical project, Siyuan and I have been working since September on simulating data sets to feed to professor Tian's models. We are currently testing a simulated data set on one model and are working on building the simulated dataset for the LSTM (Long Short-Term Memory) model. We aim to be finished with the new dataset by mid-November and hope to explore more areas of optimization going forward into the new year. Analyzing items like time-frequency-data ratios will help us learn which sensors may not be reporting timely readings. Through this, we expect to achieve a certain threshold of accuracy and false positive rate from the model as our expected outcome.

For my research project, I plan on spending the remainder of 2019 (November and December) and beginning of 2020 (January and mid-February) gathering specific case studies from the Environmental Protection Agency, Greenpeace and other sources that focus on environmental and social effects in the Northeast and Gulf Coast that came from fracking. At the same time, I want to assemble the collection of policies discussed above from information journals and law journals. To measure what the public sentiment was in the area before/after the introduction of the process, from mid-February to mid-March, I will interview those who have been affected by fracking in the Northeast and Gulf Coast to hear their opinions/observations on

the matter. These people will be selected constituents from counties in Pennsylvania, Texas and New York that have displayed active involvement in the fracking debate. Using case studies, policy analysis, first-hand accounts and what I learned from my own research, I expect to have the necessary materials to put forth a research report by mid-April.

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