UNIVERSITEIT TWENTE.

SMART ENVIRONMENTS PROJECT

DOCUMENTATION REPORT

West Zakspeed Racing

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Chapter 0: Introduction

We are team Zakspeed racing. Our team consists of 6 people. Erik, Oscar, Thijs, Gijs, Tobias and our team leader Tico.
Our focus is to prevent wildfires from spreading and causing extreme damage. We want to do this because wildfires are a problem that we personally think aren't handled well enough and we could make a change in. They destroy forests, kill animals, people and generally decrease CO_2 absorption.
We would like to accomplish this goal by inventing a device that can utilize sensors to detect and signal if there is a wildfire nearby. This device will contain smoke, temperature and humidity sensors. If one of these sensors detects a concerning value it will send out a message containing the value to another local sensor. This will keep going until the message reaches the local fire department.
We chose this solution for several reasons. One of the best ways to prevent damage from wildfires is to be there as soon as possible, once the fire has gotten too big it's harder to extinguish and the best course of action is to evacuate the area. Of course we would like to prevent that. Another thing is that small sensors like this are easily scalable, which is very useful for something like a forest, which doesn't have a fixed size. We hope that it will reduce fire fighting response times by a significant amount.

Chapter 1: Literature Review

1) *Agriculture and the effects of potting soil.*
Video about how bad potting soil is for the environment. When extracting the main ingredient (peat), an enormous amount of CO2 is released, because peat consists of old plant remains. [1]

2) *Effects of climate change on groundwater.*
This research article addresses what the consequences are of climate change when it comes to groundwater and the only conclusion is that it only has a negative effect. For example whether it's going to rain more or less, it doesn't matter because they both cause alterations in the hydrological cycle which is bad for the environment. [2]

3) *Effects of climate change on health.*
Climate change affects the social and environmental determinants of health – clean air, safe drinking water, sufficient food and secure shelter. Between 2030 and 2050, climate change is expected to cause approximately 250 000 additional deaths per year, from malnutrition, malaria, diarrhea and heat stress. That will increase the costs. The direct damage costs to health is estimated to be between USD 2-4 billion/year by 2030.[3]

4) *The impacts of climate change on marine mammals: early signs of significant problems.*
Several marine mammals such as dolphins, whales and narwhals are negatively impacted by climate change. This isn't immediately obvious as most of these animals are quick to adapt to their environment. It is especially apparent in the polar regions, although it also happens at places like Galapagos or the Gulf of Mexico. [4]

5) *Effects of climate change on agriculture.*
Climate change causes a lot of problems for agriculture. Things like large temperature fluctuations and different rain patterns make it hard to grow crops. Pests and diseases that affect crops will also be spread more easily. Other negative effects are the amount of available water and a loss of land due to rising sea levels. [5]

6) *Rising sea levels due to global warming.*
Due to global warming, the poles are melting. As a result, in 2300, sea levels may rise by 1 to 2.5 times. Worldwide, 150 million people live in coastal areas that will be underwater in 2050. [6]

7) *Climate change due to livestock. This contains emission of greenhouse gasses, use of water and deforestation.*
In this video, Arjen Lubach satirically talks about the effect that livestock farming has on the climate.
Watch these timestamps: 5:48 - 9:00. [7]

8) *5 Natural disasters that are caused by climate change.*
Due to climate change natural disasters occur more often but also get more extreme. There are 5 types of natural disasters that occur the most. Cyclones are one of those. They are powerful storms that destroy everything in their path. Third world countries suffer the most.
Secondly there's wildfires. The amount of wildfires increases every year. Thousands of football field sized nature reserves are lost due to the fires. This causes extra Co2 to be emitted into the atmosphere but it also destroys ecosystems and kills a lot of animals.
Climate change causes increasing temperatures. Because of this many African countries experience extreme droughts to the point where people die.
Large floods also have been occurring more often.
Due to the changes in the weather a lot of agricultural problems are happening lately. And some poor countries are having famine due to this. [8]

9) *Projected climate change will reduce habitat suitability for bumblebees in the Pacific Northwest.*
Climate change is causing lots of bees and bee species to lose their habitats. This paper specifically talks about bumblebees in the pacific northwest and what the negative effects are on these bees.[9]

10) *Quantifying Economic Damages from Climate Change*
It's necessary to prevent the climate from changing even further by taking measures and research. This takes a lot of time and effort, but also a lot of money, and that's also a big issue. That money comes mostly from taxes, but is that enough? The gas prices have increased a lot the last few years and providing your house of electricity is also not as cheap as it was. This has ofcourse a huge effect on the economy. People who don't have a lot of money really have to watch their spendings and maybe can't even drive a car anymore because it gets too expensive. Furthermore the government also has to invest in climate change, so there's less money leftover for other spendings, such as infrastructure or social benefits. [10]

11) *Climate change, global warming and coral reefs: Modeling the effects of temperature*
Coral growth takes place within narrow limits of temperature, irradiance, salinity, pH and turbidity, all variables that are influenced by climate.
Coral bleaching is caused by coral corals losing their pigmentation, this is due to the abnormal high sea temperatures caused by global warming. Bleaching causes a decrease in the growth rate of corals or even the death of corals, it can cost several years or decades for coral to recover from a bleaching event. Small changes in temperature and rates of temperature change can significantly influence coral colony growth rates. [11]

12) *Climate Change Increases the Risk of Wildfire*

Climate change results in more frequent and larger wildfires. Global warming has already led to a global increase and severity of fire weather, which increases the chances of wildfires. There are several climate trends that could influence fire weather, a higher global average temperature, global increases in different factors of heatwaves and more frequent durations and intensities of drought. [12]

13) *Extreme sea levels on the rise along Europe's coasts*
A result of global warming is the rise of sea levels. By the end of the 21st century, the sea level of the European coastline is set to increase by an average of 57 to 81 centimeters. The coast line alongside the North Sea will likely have the highest increase, almost 100 centimeters increased. The study also researched climate extremes. Northern Europe will likely suffer more from climate extremes than the Southern part of Europe, with an exception of the Portuguese coastline. In 80 years, 5 million Europeans who are currently under threat of a 100 year coastal flood event, could be at risk from coastal flooding every year. [13]

14) *Effect on species due to climate change*
Due to climate change, animals have to adapt in order to survive. They need to be able to find enough food and that they are living in the right temperature zone in which they should live. But the earth is warming up, with more rainfall and longer, hotter summers. WWF scientists have estimated that most animals and plants have to move faster than 1000 meters per year in order to stay in the climate zone in which they can survive. Otherwise the animals that can't do that, may become extinct. [14]

15) *Effect on glaciers due to climate change*
As the temperature rises on earth, more ice will melt, especially when it comes to glaciers. Glaciers shrink and many of them have disappeared in the last few decades. And as they melt, they will also accelerate because the glaciers are thinner. That means that they will disappear even faster as they will be faster in the sea. And because of that, the sea level will rise as there comes more melted ice in the sea. [15]

16) *Effect on taxes due to climate change*
Another effect of the climate change is that the carbon taxes will be raised, as that is one of the best solutions to collect money to decrease the negative effects of climate change. As everyone might notice, the gas prices have increased in the last few years. Gas for your car gets more and more expensive, but also the energy you use at home won't get cheaper. This is because they want people to watch how much energy they use and switch to more environmentally friendly alternatives, such as electric cars for example. Also the extra money can be spent on saving the environment by taking measures. [16]

17) *Causes of climate change*
This article talks about the causes of climate change. Beginning with greenhouse gasses such as carbon dioxide, methane, nitrous oxide and fluorinated gasses. These are released by burning fossil fuels, deforestation, increasing livestock farming and fertilizer, which all cause global warming to occur. [17]

18) *COP26: What was agreed at the Glasgow climate conference?*
In this article, the main points of the Glasgow COP26 meeting are summarized. These consisted of the following: Reduce emissions and the usage of coal, to support developing countries more and to find substitutes for fossil fuels.
Besides that, there has been an agreement between the US and China to cooperate more in order to reduce emissions and go greener.
Deforestation should be stopped by 2030 in more than 100 countries, the usage of methane will be cut by 30% by 2030 and an investment in green technologies will be made. [18]

19) *Extreme weather: What is it and how is it connected to climate change?*
This BBC article discusses what extreme weather conditions have to do with climate change. The first point is about hotter and longer heatwaves. This is explained as a parabola/bell curve. Warmth is caused by the hot air rising but a high pressure patch of air pushing it back down, compressing the air and making it even hotter. The record of heat is 49,6 degrees celsius in Lytton, Western Canada. This temperature would not have been possible without climate
change. The second topic is more persistent droughts. The rising temperatures play a role in this as rainfall is less.The third point made is that there is more fuel for wildfires. Drier and hotter conditions make it so that wildfires are more likely to be lit naturally. The fourth and last point is about heavy rainfall. The heat, causes droughts, causes mass water evaporation. All this collected evaporated water collects in the clouds which will lead to heavy rainfall, recently seen in the Netherlands, China and Belgium. [19]

20) 'Tikkende tijdbom' voor haven Jemen: 200 miljoen liter olie kan Rode Zee in stromen

In Yemen, a civil war has been going on for years. As a result, an oil tanker off the coast of Yemen (the Al-Safer) was no longer maintained. The ship contains 200 million liters of oil. The ship is slowly beginning to rust, the chance of an explosion is increasing. If this happens, the whole of the Red Sea will be covered in a layer of oil, which will have a huge impact on the environment in this area. It is difficult to intervene, because various groups want to profit from the enormous amount of money that can be earned with the oil. This shows how the environment could (probably) suffer as a result of conflicts. [20]

Chapter 2: Identification of General Problems and Challenges

1. Increase in ocean temperature as the earth warms up.

2. Rise in global sea level due to more melting ice that floats in the sea.

3. More frequent and more severe extreme weather like floods and droughts because for example the rising sea levels due to the melting of ice caps.

4. Decrease in animal and biodiversity, as they need to adapt themselves to the climate and temperature change as quickly as the climate changes which is really fast.

5. More carbon dioxide in the air causes many problems, the main one is that the earth will get warmer and warmer, and it also has a negative effect on humans and animals health.

6. More frequent natural disasters. Think about the increasing surface temperatures, the possibility of more droughts and increased intensity of storms will likely occur. As more water vapor is evaporated into the atmosphere it becomes fuel for more powerful storms and rains to develop.

7. Climate change has a negative impact on the quality of groundwater, causing problems for human beings to consume this water, this will have more consequences.

8. Climate change affects farmers of all kinds. Weather, pests, disease and loss of land make farming crops and livestock more expensive and less viable to farm.

Chapter 3: Identification of Relevant Problems

1) Oil spillage in the seas. When there is an accident with for example an oil drilling platform or an oil tanker and the oil drops in the sea, it has huge consequences. The oil spreads out really quick and it is difficult to get it out. Also animals and plants will get hurt and might even die if they do not get rescued.

2) Carbon emission raising the carbon tax. Due to the measures that need to be taken in order to decrease climate change, money is really necessary. That is why the carbon tax will increase and for example also the gas prices, people have to pay more in order to save the environment.

3) Increase in ocean temperature as the earth warms up. Species who live in a cold climate have to go up and up towards the north as the temperature rises in their environment, otherwise they are not able to survive.

4) More frequent and worse droughts resulting in more insect pests and crop losses. Due to the hot droughts insects are able to digest their food even faster and thus need more food to survive and eat more from the crops of farmers for example. Also without rain or water the crops cannot grow that well and farmers suffer large crop losses.

5) Endangerment of living species. Due to increasing wildfires and rising temperatures, more and more species will decrease or even get extinct. That is really urgent, as many species contribute to the maintenance of ecosystems and keep humans and each other alive.

6) The increase of wildfires and the danger of it. In the last few decades the number and the intensity of wildfires have increased. More and more fires burn down the forest and everything in it. Think of houses, animals and even humans. Everything gets destroyed.

Chapter 4: Problem Selection and Motivation

For our problem selection, we have decided to select problem number 6, “The power of wildfires”, as the problem that we would like to address.
The reason that we chose this problem is because this is a problem that is occurring almost everywhere in the world, especially around the equator. Huge fires burn down a whole forest in no time, which injures or kills animals and humans, destroys houses and buildings and helps decrease the absorption of CO_2 and the emission of oxygen. This all makes forest fires disastrous for humans, animals and nature.

Nowadays longer droughts are more common and this is the same for intense heat. These are two big factors why wildfires start. But mother nature is responsible for just 25% of the wildfires. The other 75% is caused by humans, on purpose or by accident. Examples of how humans by accident forest fires could start are cigarettes, left campfires or electric cables.

As said before , wildfires are a huge problem nowadays, we have to find a solution to prevent or at least decrease the size of these fires. The two most important actions about decreasing the number and intensity of wildfires are detecting the fire as soon as possible and taking action as soon as possible. As the wildfire is in its 1st stage, it can be extinguished very quickly and easily. Once a fire has spread throughout the whole forest, it usually is very difficult to extinguish and takes a lot of effort. Way more than when the fire has been discovered early and has not yet grown as large.

Chapter 5: Potential Solutions

Seven potential problems for our first challenge: “Safe animals from dying.”

1. Mapping and tracing the endangered animals to get more knowledge about what is threatening them. If the endangered animals are being traced in a smart way. For example, we could make a device that is noticeable for the animal that he can carry around where he goes. The device is connected with a gps tracker. This way we can have data about its habitat and patterns. In the end this could help to prevent them from going to dangerous places like areas where wildfires are very likely.

2. There is a lot of microplastic in rivers around the world, these microplastics can be very dangerous for the fish swimming in them. A small device that can measure the amount of microplastic per liter water flowing in the river can be very useful to detect how much microplastic there is in that particular river. The device can send the collected data, how much microplastics there is, immediately to the local government. This way they can take action if necessary. If these devices are placed in many different rivers in a country and also in different parts of those rivers, an image can be drawn of how bad the situation with microplastic in rivers actually is.

3. Create sensors in the habitat of endangered animals to periodically see if it is still habitable. By testing air quality, soil temperature or water temperature, you can keep a good eye on habitats. Soil quality alone directly affects water quality, biodiversity, wildlife habitat, plant growth, and crop production. Sensors could detect a change in pH in soil, weird temperature fluctuations and foreign particles in the air.
   This could not completely solve the problem, since it is such a big problem. The risks are all in the costs of the sensors. It’s all hardware, which will just patch data through either to an automated system or a human who parses it.

4. Cut back on the consumption of meat per person. This makes for a positive change in climate change as eating livestock consumes lots of water, produces lots of greenhouse gasses and it ultimately uses a lot of land which causes deforestation. This is a partial solution as it reduces climate change. It is not a direct solution for animal extinction. The sole requirement for this is human involvement. This needs to be a “team effort” as it is something we all need to take a step back on. The potential for this is huge, as long as people realize how important this is. They actually need to want this to succeed, or else, it won’t have a big impact. The validation for this will be seen in the decrease of supermarket livestock sales. It has succeeded (for the first part) if sales go down. If they stay low, long term succession is reached. This would need a huge campaign to promote the idea of eating less meat. It needs to reach and affect the most possible people. This solution is relevant, effective but not that realistic.

5. Placing sensors in nature reserves to detect wildfires so they can be extinguished before the fire burns down entire ecosystems. This system uses multiple heat sensors to detect if there is a rapid change in temperature in a certain area. This system can send out a message to the local fire department so they can try to extinguish the fire before it is even noticed and notified by humans. The risks of this solution could be that the systems themselves could short out which could cause a fire. They can easily be tested using the sensors in a model and having the arduino connected to the cloud so it can send out a message. This system clearly wouldn't solve the problem from the source but it can prevent a lot of damage to nature.

6. Have a system that warns drivers when there is wildlife on the roads. This system uses motion and heat sensors to detect if there are any animals on the road. This doesn't solve the problem of animals getting killed by vehicles completely but it can prevent a lot of roadkill. There aren't many risks involved in using this as a solution. This system can be tested using a model or in real life.

7. Reuse and reduce products. Buy products that produce less packaging waste, especially made of plastic. If you do that, you help to reduce the energy that is needed to produce these products and also reduce the waste that is produced. Think about the plastic soup in the oceans.

Seven solutions for our final challenge: "Prevent the spread of wildfires."

1. Sensors:

   Placing sensors in nature reserves to detect wildfires so they can be extinguished before the fire burns down entire ecosystems. This system uses multiple heat sensors to detect if there is a rapid change in temperature in a certain area. This system can send out a message to the local fire department so they can try to extinguish the fire before it is even noticed and notified by humans. The risks of this solution could be that the systems themselves could short out which could cause a fire. They can easily be tested using the sensors in a model and having the arduino connected to the cloud so it can send out a message. This system clearly wouldn't solve the problem from the source but it can prevent a lot of damage to nature.

2. Water Sprinklers:

   One of the best ways to prevent forest fires is to keep the forest wet. Should a fire occur, the fire will spread much slower. Keeping a forest wet could be done in several ways. The most convenient is the use of airplanes. Other ideas would be a sprinkler system, also used in buildings like the Horst. But this would be very inefficient when used in forests.

3. Controlled fires.

When an area has a high risk of bass fires, controlled fires could ensure that subsequent fires are less severe. You are taking away the fuel for the next fire, which could extinguish it.

4. Barricades.

   When an area has a high risk of bass fires, controlled fires could ensure that subsequent fires are less severe. You are taking away the fuel for the next fire, which could extinguish it.

5. Drones.

   Drones could help detect forest fires. Using cameras, heat sensors or smoke detectors, fire can be detected. A drone could be piloted, or fly around on its own. When controlled by a human, the pilot can look over the screen and spot the forest fire. The drone could also do this itself using sensors. If a drone detects something, it will send out an alarm.

6. Cameras.

   Cameras with heat sensors should be used in places where people visit with any regularity. In this way the risk of human caused forest fires spreading would be considerably reduced. This has some similarities with using drones.

7. Inform people by alerts.

   Many of the forest fires are caused by humans. If there is already a high risk of forest fires due to the weather, notifications are sent to all phones in a certain area. If people are in a certain natural area they get a notification with rules they have to follow to reduce chances of forest fires. Or tips for staying ahead of forest fires.

   It is also important to inform people about forest fires who are not in high risk places at the time. This can be done with (interactive) games. For example, you can make a game on a square, school room or telephone in which you have to try to extinguish the forest fires. In this way you can find out how to prevent forest fires and how to fight them.

Chapter 6: Solution Selection

Sensors in nature which can detect a wildfire and send out useful information.

We choose solution 1 (or 5 in the first seven solutions) as our best option to detect and prevent wildfires with the help of Arduino. Wildfires are a huge threat to the species that are living in the forest and the acres in the last few years. In 2019 in Australia, almost 3 billion animals got killed or injured. It's also realistic and relevant to build something for this problem, which can be implemented pretty easily and promising for the future. The other solutions we provided were either not specific enough to be implemented with Arduino, or they don´t have a direct influence on the decrease of wildfires.

Solve the problem completely or partially?
Since it is impossible to detect and prevent every wildfire, our solution we choose only solves the problem partially. But like we said before, the period between when the fire starts and gets detected is the most important period, as action can be taken quickly and the fire can be extinguished as fast as possible and prevent it from spreading any further.

Risks?
This project is meant to operate on a larger scale. This means that there are a lot of physical components in different devices. Any of the hardware in the devices could potentially fail. It would be difficult to retrieve the broken hardware as the devices are usually in very remote forest locations.

Requirements?
The requirements are:

- The sensors should detect the temperature, humidity and smoke
- The sensors should send a message with the values of the data in order to conclude if there is a fire starting or going on.
- The sensors should be protected from the fire itself.
- The sensors should be protected from animals, maybe with the help of camouflage.
- The person who gets the message should know where the sensor is.

Hardware/software/humans involved?
We are going to use both hardware and software. Most of it is hardware but also software, as we have the Arduino that needs to be programmed with the detectors. Once the detectors send a signal to the fire department, the fire fighters (humans) can take action.

Potential? Impact?
This solution has a lot of potential. It will be easy to implement the sensors and will always monitor the risk levels of a wildfire. It can work completely remotely so no humans will have to check for potential fire risks. This is very useful in remote areas like Australia where it is

not so easy for people to access these remote, extreme regions. The sensors themselves will not be able to extinguish the wildfires but they can detect them very early on and send out important data. With this data, we can check for patterns when a wildfire starts. For example when the sensors detect very low humidity and high temperatures in one area.

How to test/assess/validate?
We can test the sensors by creating a small network of monitoring sensors in a forest, and then simulate a small fire by holding up lighters or blowing smoke. If we leave the network in the forest some time before testing we'll know the 'standard' circumstances and can adjust based on that. We then measure the time it takes for our data to be processed and for our response to be sent to the "fire department" (Which in testing is actually us). According to a paper published in January 2020, most fires are reported within about 15 minutes of ignition.[23]
Our goal is to be faster than that.

How to present/demonstrate?
We are planning to test the sensors and the data values that have been given by them and compare them to each other. As we don't live in a country where there are big wildfires, we can't investigate the wildfires. It is also not possible for us to put a forest full of sensing devices as we don't have that many available. It's more a potential idea for the future, but we can present the idea that we have different protected sensors working and sending important data, which can show the pattern a wildfire develops in.

Chapter 7: Methodology

The resources we need are:
- Arduino Uno
- Working code
- MQ-2 sensor
- Breadboard
- Wires
- Sim800L + sim card in order to send sms
- Case for the sensors.
- Battery 3.7 Volt 2000 mAh

Would the sensors need calibration?
The package of sensors do need calibration to acclimate to a new environment. Australia can highly differ from, for example, California. These differences can consist of the air quality or the gasses which are flowing in the air. Another issue may be the connection in the middle of the forests, as the arduino do need connection to send the sensor values to the fire department. Placing antennas could be a solution.

Would the equipment be used in a controlled environment or not? In the latter, would a special casing be needed?
It will not be necessary to protect our sensors. We are going to look into the latency of our sensors sending a message before the fire will catch up to our sensor. We are debating the price/quality of a protected sensor opposed to a non protected sensor. The reason for this is that it is very unlikely for a fire to start after it has been controlled as all of the fuel has burned away. Saving these sensors could be a high cost while it does not give a big advantage. When proven that a casing does give a significant advantage, we will look into the quality of the sensors and if they can still perform under the same quality. At least we should protect the sensors against animals, by making a case for the sensors.

How to collect data? When do you collect data?
Data would be collected and send to the fire department by the sim800L. Significant changes in temperature, humidity or smoke that would indicate a fire would be noticed and then action can be taken. If you measure the values in a long period of time, also a pattern can be noticed when there is a wildfire starting.

How to analyze data?
Data will be continuously coming in but when the program detects unusual data it would be seen as a warning to, as said in the previous point, us and to the local authorities by making a message that smoke is detected and the temperature is rising, or a long period of drought for example.

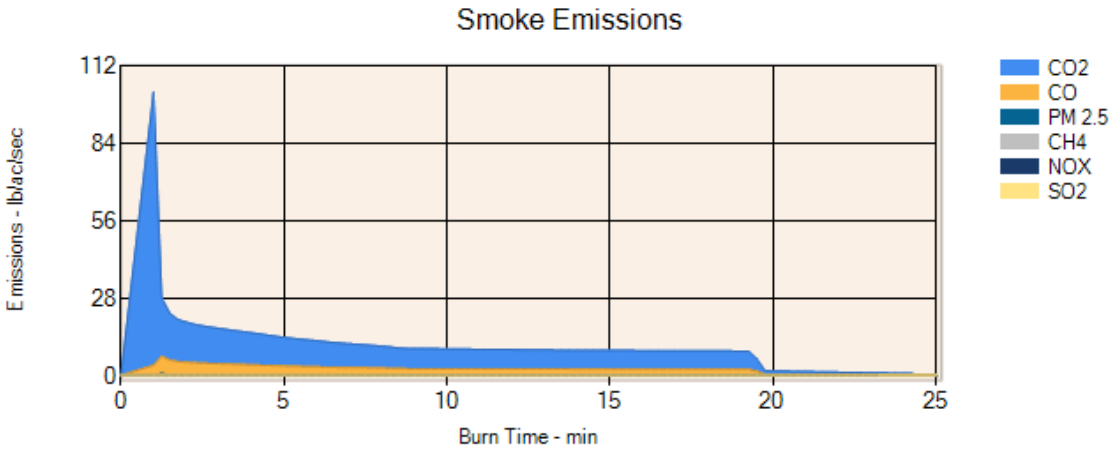
Chapter 8: Validation

The way we are going to test our device is by creating a small fire with, for example , a lighter in order to see if the sensor can detect the gas and high temperature of the fire. We will make a graph to visualize the data we collected to make it easier to understand. We also need to go outside and test the device there to see what the values of the MQ2 sensor and the DHT sensor are when we receive them on our phone. We will carry out this experiment for multiple places but our hypothesis is that the values outside are approximately the same, as we can't create a huge fire outside or make measurements in another climate such as Australia for example, where it is really dry and hot.

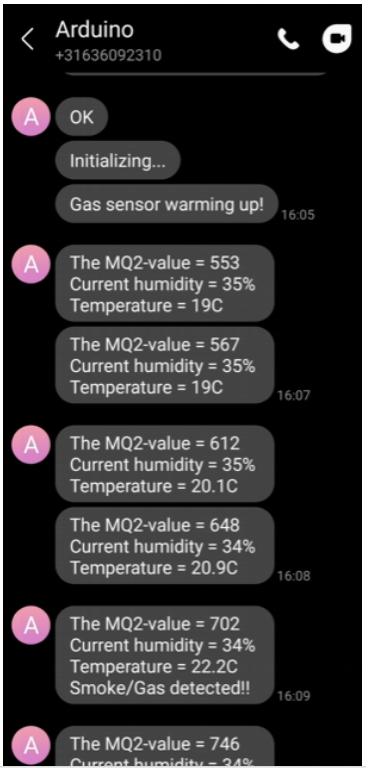
That is the reason why we will create a small fire with a lighter in order to validate the results we are getting texted by Arduino on our phone. After we have received the data from the sensors we can copy the values in order to visualize them in a graph to show that the sensors can detect a fire or drought.

Chapter 9: Results and Conclusion

We tested our setup in- and outside, and we got the messages within our aim of 15 minutes. According to FOFEM (a First Order Fire Effect Model), a computer program that allows you to study some data from forest fires, most of the gasses we're sensing gain a massive spike in the first minute. There's a peak at 103lb/acre/second.



This means our sensors would be quite effective, provided there are enough of them available. For reliability it might be better to incorporate more types of sensors, like IR cameras. We do however think that a network of these sensors could make a proper difference in preventing forest fires.

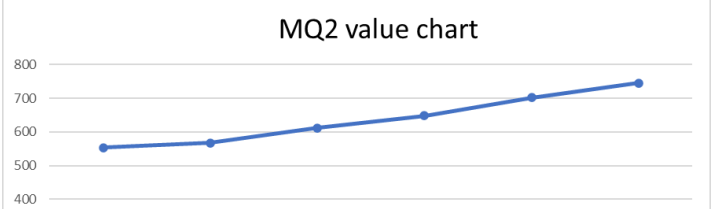


When you operate at a larger scale you can use machine learning algorithms in order to recognize signs leading up to a forest fire. Since there is already a lot of data available on forest fires, you could even use supervised learning to feed the algorithms. The multiple sensors could also communicate with each other to create a proper network, and work together to determine whether there's actually a forest fire going on. This was however out of the scope of our project.

The screenshot on the left is a still from an inside test. As you can see, once the MQ2 value reaches a threshold of around 700ppm it will report the detected smoke as soon as possible.

Leading up to the testing we've had problems with the SIM800L not working until we added an extra antenna, and the DHT sensors were overheating a lot. This was mitigated by using more resistors.

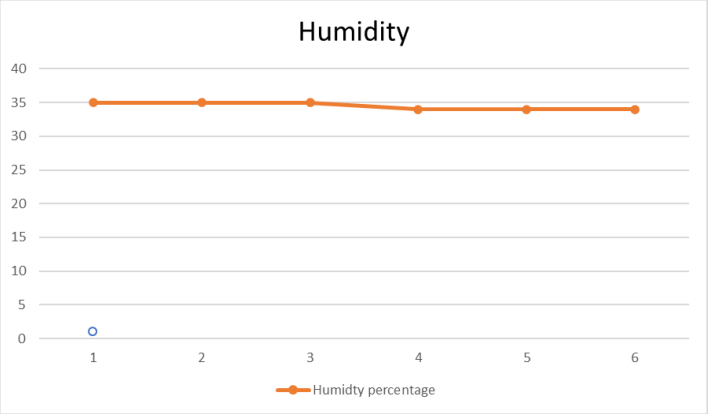
Data charts



The chart showing the data collected about the humidity is stable throughout the 6 moments when the data is sent. This is just like we expected because we couldn't simulate a wildfire where the humidity of the air would change. In a real wildfire the humidity would decrease.

The temperature chart shows a steep increase when we tested the device. The temperature started out at 19 degrees celsius and got up to 22.7 degrees celsius. This is just like we expected before doing the tests.

Charts with information about the sensor data



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