SMART ENVIRONMENTS PROJECT

DOCUMENTATION REPORT

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Chapter 0: Introduction

Currently, our world is plagued with a mass of different problems that are getting worse by the day. Irregular weather inducing hurricanes and drought, acidifying sea waters endangering marine life, large scale earthquakes destroying cities, forest fires ravaging habitats, and melting ice caps that raise the sea level. Right now, all life on earth, including our environment, is threatened.

When we study the root of these problems, we often encounter common underlying causes. The most substantial is called Global Warming (Oxfam, 2020), (Harvey, 2018), (NASA, 2005). This is a phenomenon where the average temperature of the earth rises, which has many disastrous effects. Our team, the Disaster Blasters, all agree that global warming is one of the most urgent and relevant problems of our time. We brainstormed various solutions, and we quickly came to a realization: we think that the solutions that have the most powerful effect on climate change-induced disasters are not reactive, but preventive. We searched for important catalysts of global warming, and we discovered that a very prominent one is deforestation (USCUSA, 2008), (Rainforest Alliance, 2018), (Bennett, 2017).

Deforestation has a triple effect on climate change, making it responsible for almost 25% of greenhouse gasses (Bennet, 2017). First and foremost, trees absorb carbon dioxide out of the air and store it in the ground. Even more emissions are released when felled trees release the carbon they've been storing. Lastly, deforestation mostly occurs with agricultural intentions. Livestock and crops account for massive amounts of greenhouse gases worldwide. Alongside that, deforestation causes a number of other problems. These include flooding, soil erosion, irregular weather patterns, loss of habitat, and a decrease in biodiversity (Rainforest Alliance, 2008).

So not only does deforestation have many negative consequences, it is also happening at an alarming rate. Every year 74-93 thousand square kilometers of forest are lost, which is equal to 48 football fields of trees disappearing every minute (Bennett, 2017). We have already cleared half of the world's forests, and if we continue on this path, at some point in the future there won't be any forests left to cut down. When that happens, we would suffer from massive extinctions of all groups of organisms, major flooding and losing enormous amounts of land to the ocean, and extreme droughts and wildfires. The earth might not be able to sustain humans anymore (Nuwer, 2019).

By tackling deforestation, we can not only positively affect the environment as a whole, but also improve life for every being on earth, help our long-term resilience to disasters, and also prevent disasters from getting worse in the future.

The solution we have come up with in order to help in the battle against deforestation is an automatic tree planting robot. The purpose of our robot is to help speed up the process of planting trees, and is targeted at converting agricultural ground back into forest. 80% of deforestation is for agricultural purposes (Rainforest Alliance, 2008). Plus, soil can only remain nutritious for around 2 years (Bennet, 2017). It is estimated that roughly 950 million - 1.1 billion acres of agricultural land have been completely depleted and abandoned by farmers (Project Drawdown, 2020). By converting these agricultural grounds back into forest, we can help reduce carbon dioxide in the air by a considerable amount. This in turn leads to many different benefits for us and the environment.

To achieve this goal, we need a team of competent and motivated individuals. Luckily, The Disaster Blasters consists of seven of such members. First, our team leader Benjamin innovates and thinks of great ideas. Our expert Marco, our explorer Hans, and our executive Frank all shine in the programming/electronics department and can solve any technical problem that stands in our way. Marielle, our driver, will use her curiosity and critical thinking to aid in our project. The innovator of the team is Veerle, who puts her design and ideation skills to good use. Lastly, we have our second driver Issa who organizes and keeps the team driving forward.

Chapter 1: Literature Reviews

Publications Reviewed by Issa

Technology Used in Disaster Relief Saving More Lives Every Year

J. Loeffler explores different approaches in which technology is currently used to help respond to natural disasters.

The first AIDR (Artificial Intelligence for Disaster Response), an AI that monitors social media. It filters through thousands of tweets/posts to identify disaster-related content, in order to receive real-time updates on where disasters happen and where the worst damage is.

The second method is using drones as first-line responders. When disaster hits, it is crucial to supply people with help as quickly as possible. Because infrastructure often also falls victim to these disasters, offering help from the ground is often impossible. Drones are often the most effective way to fill in this niche. They can locate survivors using infrared cameras, transport supplies, don't need a lot of fuel, and can map out a disaster area.

The third technology is the Public Lab DIY Spectronomy Kit. Victims of natural disasters often have to wait for hours or even days before help can reach them. During this time, access to clean drinking water becomes a major problem, as many water sources could have become contaminated. The kit allows anyone with a laptop to analyze water samples for a whole host of possible contaminants.

Waiting people are also in urgent need of shelter. The Concrete Canvas Shelter serves as a tent but offers a few extra benefits. After 24 hours, the tent turns into cement which makes it waterproof, fireproof, and offers extra protection.

(Loeffler, 2019)

What If We Nuke a City?

This video made by Kurzegesagt describes the direct consequences of dropping a nuclear bomb in a major city. The process is divided into 3 different phases.

The first phase happens within less than a second. A ball of plasma appears and grows to more than two kilometers in diameters. Within this range, everything completely obliterated, including cars, trees, and most buildings. A thermal pulse then destroys everything within a thirteen-kilometer radius.

In the second phase, winds stronger than tornadoes appear over the course of several seconds. Fire spreads throughout the rubble and a mushroom cloud appears. A destructive shockwave of wind extends up to 21 kilometers from the blast site.

The third phase happens over the course of the next few days. There may be up to millions of people, many blind, deaf, and hurt, trapped within the rubble. However, because of the complete destruction of infrastructure, it is impossible to supply these people with help. It is likely that a black rain will appear from the sky, consisting of radioactive ash. Many die from radioactive poisoning, and the contamination makes it risky for neighboring cities to supply help from the sky.

Kurzegast (in collaboration with the Red Cross and the Red Crescent Movement) declares the for the safety of everyone, nuclear weapons should be completely prohibited.

(Kurzegezagt, 2019)

Nature-Based Solutions to Disasters

The IUCN states that climate change is the leading cause of current natural disasters. Instead of inventing new technologies to help cope with this, it would be much more beneficial to mankind to make an effort to restore the environment as a preventive approach to natural disasters.

Recommended nature-based solutions include conserving forests, wetlands, and coral reefs. This will help with slow-onset events such as drought, forests help fight landslides, wetlands help regulate floods, coral reefs help reduce coastal storms, and coastal vegetation provides protection against storms and cyclones.

Investing in the ecosystem now will pay off in the long-term resilience to climate change-related disasters, and will prevent them from getting worse.

(International Union for Conservation of Nature, 2017)

Publications reviewed by Mariëlle

Advances in Remote Sensing for Oil Spill Disaster Management: State-of-the-Art Sensors Technology for Oil Spill Surveillance.

This paper examines the characteristics and details of different available sensors, which can be used for providing information about oil spills. Reducing oil spill is essential for protection of the environment. Surveillance has an important role in this. Remote sensing technologies can help identify minor spills before they create real damage. If the understanding of the sensors gets better, the use of them will improve. The impacts of oil spills are big. It affects the marine environment, when spilled on the land, it impacts soil fertility and the groundwater. Information about the size of a spill is critical to help the government and industry in removing the oil. Visual detection of oil is not really reliable, as it can be mistaken for other things, like seaweed. Remote sensing, like radar or UV, have been used in responding to oil spills.
Space-borne remote sensing and air-borne remote sensing were discussed. The space-borne method was more cost-effective, but it also provided low quality data, compared to the air-borne method, although this one is more expensive. Therefore air-borne remote sensing is more often used. Infrared or UV sensors can detect oil, but they won't work in heavy rain or fog.

Laser fluorosensors are able to detect oil from underwater and on different backgrounds, like snow. These last sensors are the best ones, because they can work in different environments.

However, no sensor was able to provide all the information needed, but it worked when combinations of sensors were used.

(Gao & Jha, 2008)

Finding Community Through Information and Communication Technology During Disaster Events.

This paper presents evidence of the use of Information & Communication Technology (ICT) for orientation towards the community and production of information during disasters. Researchers studied how people used ICT during the 2007 Southern California wildfires. They interviewed affected people and used online texts.
Disasters like the wildfires are marked by information overload for emergency management personnel and an information dearth for members of the public. When information is spread through traditional media, people want to verify it and want to have more details. They do this by using their social connections and resources, often using their communities for support. When facing the problems of lack of information, people use ICT to get local knowledge, in hopes to find community. In response to disasters, people want to conduct search and rescue, give first-aid, provide shelter and orient toward long-term recovery. Sociologists consider that disasters are a unifying force. ICT uses can facilitate a bigger audience for help, it can also help communities to stay connected even when communities are scattered due to evacuation.

(Shkovski & Palen, 2008)

How Technology Can Battle Natural Disasters

This article takes a look at the technology options which are available to counter the natural disasters that had the biggest impact on human lives last year.
- Landslides and earthquakes: the solution is to make use of the tectonic motion, which can be detected and then used to make a prediction. Scientists can also use them to find patterns. This might help in an early detection of earthquakes.
- Storms: The technology used for the weather is pretty old, but AI could analyze a bigger quantity of data faster, making it that a weather prediction is much more accurate and detailed.
- Extreme temperatures: Complex algorithms can estimate the duration and demise of a heat wave. A model made with these algorithms can identify problematic regions and the rise in temperature.
- Floods: AI is able to help technologists better interpret a bigger set of data and it immediately creates a weather forecast that can alert authorities. In 2019 an AI predicted a flood in India.
- Epidemics: Forecasting models can identify hot spots of emerging diseases and predict trends about where it is most likely to expand. Satellite imagery can also be used to track the path of insects that transmit certain diseases.

(Radu, 2020)

Publications reviewed by Frank

Tropical Storm Eta hits North Carolina with deadly flooding

At least four people died after tropical storm eta made landfall, many roads and houses have been flooded and even bridges were swept away. Storm Eta causes water levels to rise quickly, causing people to be trapped in their own houses and even cars to be completely submerged. 143 people were forced to evacuate, 4 died and 2 are missing

Storm Eta has already caused many disasters in Latin America and South Florida before moving to North Carolina.
The people of North Carolina weren’t warned on time for storm Eta, so they didn’t have much time to respond.

(Villarreal, 2020)

Hurricanes stay stronger longer after landfall than in past, study says

According to a new study by Lin Li and Pinaki Chakraborty hurricanes stay stronger once they make landfall, this causes them to spread more destruction inland. The study looked at 71 Atlantic hurricanes with landfalls since 1967 and found that hurricanes from the 1960s declined two-thirds in wind strength within 17 hours of landfall. But now it generally takes 33 hours for storms to weaken that same degree.
This is because storms gain strength from warmer ocean waters, caused by climate change.

The study author Pinaki Chakraborty, a professor of fluid dynamics at the Okinawa Institute of Science and Technology in Japan says that: “This is a huge increase, there’s been a huge slowdown in the decay of hurricanes.”
Hurricane Florence from 2018, took nearly 50 hours to decay by two-thirds causing $24 billion in damage.
There conclusion by Chakraborty:: “As the world warms from human-caused climate change, inland cities like Atlanta should see more damage from future storms that just won't quit”

Brian McNoldy university of Miami hurricane researcher, who wasn’t part of the study, reacted and said: “If their conclusions are sound, which they seem to be, then at least in the Atlantic, one could argue that insurance rates need to start going up and building codes need to be improved ... to compensate for this additional wind and water destructive power reaching farther inland,”

This study joins previous studies, many by Kossin, that show tropical systems are slowing down more, wetter, moving more toward the poles — and that the strongest hurricanes are getting stronger.

(Chakraborty & Li, 2020)

(Fox News, 2020)

Climate change: Better warning systems needed for extreme weather

Recorded disasters have increased 5 fold in the last 50 years in part because of climate change.
A new study by the UN shows that a third of the world is not covered well enough by warning systems, that's why the UN says that the world needs to rapidly raise investment in early warning systems for extreme weather events.

The new report says that over the past 50 years, around 11 thousand disasters have occurred that have claimed in total two million lives and caused more than 3.5 trillion dollars in damage. In 2018 allone around 108 million people needed help from international agencies with natural disasters. The authors of the new UN report say that that could increase by 50% by 2030 at a cost of around 20 billion dollars a year.

The poorest nations are often the victim of the natural disasters and a good warning system could save millions of lives and a lot of money.
Yet according to the WMO, just 26% of weather observation networks in Africa meet their standards.

(McGrath, 2020)

(WMO, 20020)

Publications reviewed by Veerle

Damage from the Great East Japan Earthquake and Tsunami - A quick report

March 11th 2011, an earthquake occurred just off the coast of Tohoku, Japan, with a magnitude of 9.0, the maximum recorded value in Japan. The earthquake along with the ensuing tsunami and other major problems (such as damage to the Nuclear Power Plant stationed in Fukushima), caused over 24000 deaths and missing person reports.

Japan is no stranger to tsunami disasters, but still the measures taken to prevent any future damage caused by tsunami's weren't enough. This has to do with the fact that this disaster turned out larger than anticipated considering previous records of tsunami's. The coastal dykes and bay-mouth breakwaters managed to prevent at least some damage before they finally did collapse due to the combined height and strength of the tsunami.

Beyond prevention of damage by building structures, we should also consider reworking society based on the high risk coastal areas. For example, people should live higher up and only work in risky coastal areas to create a higher chance of survival if a tsunami of these proportions were to strike again.

(Mimura, Yasuhara, Kawagoe, Yokoki & Kazama, 2011)

Predicting Wildfires

Out of control wildfires become less present the better out prediction methods become. But what do we use to make these predictions and how can we put them to good use?

Let's start off with some basic causes of wildfires, these range from fuel (deadwood and debris) stacking up across vast spaces of land that can cause extreme fires when it meets heat, extensive dry weather paired with heat and ignition by humans. Not all wildfires are bad considering they are important to the health of ecosystems and plants developed further thanks to them. However, we're talking about the fires that cause devastating damage to the environment and society.

By now, many programs and models have been developed to help predicting wildfires as to deal with them as fast as possible. Algorithms can, based on previous dry season records, estimations of tree growth, fuel in and on the ground etcetera predict when and where a new wildfire could surface. These programs enable firefighters to strategize and act quicker in order to keep the situation under control as well as evacuate citizens from the danger-zones This also means money spent on extra firefighters and other resources to suppress fires will be lessened considerably.

The modelling programs are already at a point that they can predict over the span of several years or more, when and where, considering the current situation and possible future developments, wild-fires might blaze up again.

(Andrews, Finney, Fischetti, 2007)

Carbon Monoxide Poisoning

It's still a long way until we can all switch from gas stoves to electric stoves, so until the day comes everything will work on electricity, carbon monoxide will play a silent but deadly role in homes across the world. To start off, what is CO? CO is an odorless, tasteless and overall not empirically observable gas for humans, making it hard for us to recognize and act upon.

Stoves are, of course, not the only cause of possible CO poisoning in a home setting. Other sources include: Gasoline engines, generators, lanterns and the burning of wood and charcoal (basically burning any fossil fuel can cause CO poisoning). Dangerous exposure to CO mostly happens in enclosed spaces such as kitchens, basements, workrooms and garages.

There are CO detectors, but that doesn't take the risk of acute CO poisoning away in a home setting. Acute CO poisoning is hard to diagnose for nurses and thus silently makes its kills every year. CO affects the whole body effectively depriving your body of one of the most important elements, O2, to keep functioning like normal. Depending on the concentration of CO the symptoms can range from a headache and dizziness to convulsions, respiratory arrest and eventual death. Underlying issues such as heart failure, enmia, drug ingestion and smoke inhalation can add to the severity of the symptoms.

(Castner, 2008)

Publications reviewed by Hans

Power outages and possible solutions

Lots of power outages are caused by the weather. Resulting in a lot of losses and possibly dangerous situations in this day and age. Implementing proper tree trimming schedules, putting power lines underneath the ground and implementing a smart grid could be solutions.

(Campbell, 2012)

High accuracy methane detector

Gas is a relatively high risk resource for household appliances since there is a risk of explosion. These days natural gas is mostly used, and the main component of natural gas is methane. The sensor introduced uses light going through a chamber to sense the concentration of methane present.

(Wei, Liu, Li, Wang & Zhang, 2019)

Waste Management by Sensing

Not managing waste properly can have serious consequences, thus it is important to do this. A method for separating residual and recyclable household waste is introduced. Mainly sensing if the waste is wet or dry which are associated with residual (wet) and recyclable (dry).

(Ahamad, Mohamad, Midi, Yusoff & Rahman, 2018)

Publications reviewed by Benjamin

Impact of landfill leachate on the groundwater quality: A case study in Egypt

To detect the impact of a landfill on the environment, the groundwater around it was collected and examined. It was found that the leachate was contaminated with organics, salts and heavy metals. The leachate was bio-degradable and un-stabilized.

The groundwater itself that was found near the landfill did not have severe contaminations, although some values, for example conductivity, total dissolved solids, chlorides and sulfates, exceeded the WHO and EPA limits.

The results that were found within the tests showed that the factors that are responsible for the unstabilized leachate need to be adjusted.
Also it was suggested that there is permanent monitoring of the groundwater.

(El-Salam & Abu-Zuid, 2015)

Causes and Consequences of Air Pollution in Beijing, China

The text says that China is one of the worst countries when it comes to pollution. Within the 20 cities with the worst air condition, there are 16 cities located in China. This is due to the fast economical growth over the past 3 years.
More reasons for this are higher numbers of motorized vehicles, higher number of population, and also a high output from manufacturing.
The motorized vehicles contribute to nearly 70% of the pollution.

The four most dangerous things that cause the pollution are Sulfur Dioxide, Nitrogen Dioxide, Carbon Monoxide and particulate matter.In China, new vehicles have lower emission standards and therefore emit more of those things into the air, making the air quality even worse.

Another problem is that Beijing is surrounded by mountains, which keeps the polluted air within the area of the city.Air pollution is measured with the “Air Quality Index”. While a value of 500 is more than 20 times more pollution than the safe level, as the WHO said, China's value is 755. It was said in 2003 by the Chinese academy for Environmental Planning that 411.000 deaths were due to air pollution.

(Mason, 2020)

Fukushima Accident

In 2001, the Nuclear Power Plant in Fukushima exploded, due to tsunami waves, as said in the article. The tsunami waves damaged the backup generators of the power plant. All reactors could be shut down in time, but because of the power loss, the cooling systems failed, which eventually caused the fuel rods to melt partially, leading to radiation leaking out.

Due to the buildup of pressurized hydrogen gas, 3 explosions happened.The explosions and also the melted rods made holes into the containment vessel, exposing the nuclear material. The water around the nuclear power plant was also contaminated, because of cracks in the power plant that led to radioactive water leaking into the ocean. Until today, some fish near the area are contaminated and there are still high levels of radiation around the area of the accident.

(Encyclopaedia Britannica, 2020)

Publications reviewed by Marco

Urban congestion inquiry

Traffic congestion is becoming a more and more worrisome problem. Not only are more people wasting more of their time by being stuck in traffic, but also the amount of gasses in the air is increasing rapidly, resulting in an increasingly polluted environment. This is why new methods to battle traffic are being thought of every day.

These methods can roughly be divided in two categories. The temporary and the virtuous ones.The temporary solutions are the ones that will be less effective, because for one reason or another, traffic will come back or other problems will arise. The virtuous ones are the ones that have the best chance of working.This is why I will only focus on the virtuous ones here.

The first possible solution is to improve cycling infrastructure. By doing so, people will take the bike more easily and not go by car. Secondly, improving bus services. Bus services have seen a decrease in patronage since 2008. So by implementing this solution, more people will take the bus again and the roads will become less congested. Lastly, charging people for parking at their workplaces will also reduce the amount of people that travel to their work by car. If this is combined with more showers and other facilities to encourage cycling to work, this can be a very good means to reduce traffic congestion.

(Leigh, 2016)

Overpopulation

In the last 50 years, the population of the world has more than doubled. This does not only mean that we will produce more chemical waste and damage the environment, but it also means that we will have to find near impossible solutions for ever growing problems, such as how to feed all those people, or where to home all of them.

Cities are growing larger and larger, and more forest is being cut down every year. By removing trees, the soil will have a reduced ability to hold the water and grounds will turn into deserts. Also, less oxygen can be generated and the overload of carbon dioxide will damage the environment beyond our control.

We are consuming more and more food. This overfishing leads to empty seas and more extinct species. On top of that, we need land to grow the crops and this means we have to cut down forest to make room for all of that. Deforestation will lead to its own problems eventually. These are just two of the countless examples of why overpopulation is a problem that needs to be addressed now.

(Project TO, 2020)

Wildfires

Wildfires have been in the news lately quite a lot. They are fires that burn down uninhabited areas and can therefore sometimes spread widely before they are noticed or can be extinguished.
This can sometimes lead to mass destruction when they reach inhabited areas and burn down whole towns.
The burning itself isn't the only problem when it comes to wildfires. The smoke that is produced from the fires can pose great health problems. It mainly affects the elderly, children and people that already have problems with breathing for some reason, but it is deadly to the "average" person as well.
When a forest burns down, all the vegetation is destroyed and therefore the ground will become dry and is unable to soak up the water. This can lead to floods or in some cases landslides.
Another problem is that when chemicals burn, their remains are still in the air and can spread very easily, posing big threats to the environment and the life inside.

(Philanthropy, 2020)

Chapter 2: Identification of General Problems and Challenges

Problem 1: Poor countries need extra help during disasters

Possible Solution: A cheaper and more readily available disaster warning system

Problem 2: Landfill that contaminates groundwater

Problem 3: Waste Management

Possible solution: Smart trash can that automatically classifies and recycles its waste

Problem 4: Wildfires

Possible solution: Putting fires out with sound waves

Problem 5: Dangerous methane leaks that cause explosions

Problem 6: Finding family and friends during a disaster

Possible solution: A smart system that can immediately track your friends and family without needing wifi/mobile signal.

Problem 7: Smog in cities

Possible solution: A sensor that alerts dangerous smog levels. For example, a bracelet that changes color.
Possible solution: smart mask

Problem 8: Power outages

Possible solution: In case of power outage, the city will be divided into small areas. These areas can be powered by a generator separately.

Problem 9: Getting lost/separated after a disaster

Possible solution: A smart system that can navigate a person back to the nearest city

Problem 10: Nuclear blast survivors often need to survive for hours/days before help arrives

Chapter 3: Identification of Relevant Problems

Problem 1: Air pollution (contamination from pandemics, smog etc)

At many points in the world the air is very polluted, for example in China. The contaminations are harmful to the environment and humans. There can be many different contaminants in polluted air, which sometimes makes it hard to find the cause of certain damages.

Problem 2: Deforestation

Deforestation leads to numerous problems that all have some impact on the severity of disasters. Some of these include more greenhouse gases in the atmosphere, soil erosion, and loss of habitat and biodiversity.

Problem 3: Locating family/friends during disaster

During a disaster, lots of people lose their homes and panic is unavoidable. This means people also lose their friends and family or are uncertain about their fates. This psychological factor adds to the gravity of a disaster and therefore must be addressed adequately.

Problem 4: Tsunamis

Tsunamis reach coasts with great force and quantity, this causes a lot of destruction on impact. The amount of water a tsunami carries also causes long-term water damage and problems with electricity throughout the area that was hit by the tsunami.

Problem 5: Smart methane/CO sensor

Methane or CO overloads in the kitchen are the cause of poisoning and explosions. These are serious problems that cost lives and cause great inconvenience.

Chapter 4: Problem Selection and Motivation

We have decided to focus on deforestation. Our motivation for this is the fact that currently, climate change is one of the leading causes of disasters. During our research we realized that tackling the issue at its source would have a much bigger impact in trying to find new ways to fix or react to disasters. In addition, restoring the environment would lead to many other beneficial side-effects to humankind besides preventing disasters.

Investing in the ecosystem will help our long-term resilience to disasters, and will also prevent disasters from getting worse in the future.

More specifically, deforestation itself harbors many problems. First and foremost, less trees means less CO_2 being pulled out of the air, which leads to an increase of greenhouse gases (Nunez, 2019).

Rainforests also have a huge influence on rainfall, water and soil quality, and flood prevention. Taking them away causes soil erosion, higher chances of flooding, and irregular weather patterns. Further effects also include loss of habitat for many animals, and a decrease in biodiversity (Nunez, 2019).

For these reasons, we believe that focusing on deforestation is extremely urgent and relevant. Preventing it will lessen the severity of many different disasters, and positively affect the environment as a whole.

Chapter 5: Potential Solutions

Solution 1: Inspiring people to eat less meat

Encouraging people to eat less meat would lead to a decreased need for agriculture. Agriculture is the leading cause of deforestation, so this would have a huge positive impact on deforestation. A possible design could be a smart environment that analyzes the contents of your fridge, that gives warning messages if there is too much meat present. Alternatively, it could give encouraging or rewarding messages if the meat supply is low.

Showcase: A fridge or a simulation of a section of a fridge which checks how much meat is in there. If the amount passes a certain threshold then the fridge will give notifications. If you don't place meat in the fridge for a certain amount of time then positive notifications will be given. Other animal products could be implemented for a more advanced version.

Solution 2: Early wildfires detector. Gives warning before fire gets out of control.

In many parts of the world wildfires destroy trees and whole forests. This leads to deforestation. By inventing a device that can analyze certain parameters to foresee wildfires to give warnings, people would be able to take action early enough to prevent wildfires. Parameters could be for example the ongoing weather. If it's too hot for too long and there has been little to no rain for too long that could be a big indicator for wildfires. Also the carbon content in the ground can be analyzed in those times, because big amounts of carbon in the soil would make potential wildfires bigger. By taking all of these things into account it can be possible to give warning early enough.

Showcase: small scale representation of a forest with multiple sensors. As soon as the sensors pick up an overload of CO_2 or heat they will relay this to a base.

Solution 3: Automatic tree planter

An automatic tree planter could speed up the process of planting new trees. A possible design could be a little navigating robot, possibly controlled from your phone, that digs tiny holes and drops a seed in them. It could be equipped with sensors that analyze the ground, so it could decide whether the patch of ground could host a tree sapling, or so it could measure what the soil lacks.

Showcase: A little robot, which can be navigated with your phone, that digs tiny holes in the ground and then drops a seed in it. The robot has a small basket, from where the seed rolls into the ground. It has those weird tracks as wheels, so it is not only able to drive on even ground, but in a lot of different environments. Maybe we can put a moisture sensor at the bottom on the ground, that only lets the robot drop a seed when the moisture level in the ground is enough.

Solution 4: Smart device that encourages new sapling growth. Monitors their health

When people replant forests, a chance exists that a part of the planted saplings die (NFF, 2021). New saplings therefore often need some follow-up monitoring to ensure their health and their growth. A possible solution is building a smart environment that monitors the conditions of the saplings, such as temperature, humidity, nutrients in the ground, and other factors that help the seedlings grow. This way, saplings can be produced quickly, healthily and effectively, giving opportunity to regrow trees at a steady and high speed.

Showcase: Make some sort of greenhouse with some sensors and things like humidifiers and nutrient dispensers to make sure that we can adjust the variables to the right settings.

Solution 5: Restoring agricultural ground

Agriculture has a very negative effect on soil, and after regrowing crops a certain number of times the soil is completely dry and devoid of nutrients. Also, after farmers no longer see any benefit to the soil, they abandon the area and start growing their corps somewhere else. Globally, the amount of abandoned farmlands is equal to the farmland in use (WWF, 2020). A possible solution would be to help restore the soil in abandoned farmlands, so it can be converted back into forests. Another possible solution is to help farmers revive their overused soil.

Showcase demo**:** find a patch of barren grass and show how it works; it quickly checks/scans the soil and injects fertilizer to help the soil recover. You won't be able to show the result because it will probably take a long time to actually see results.

Solution 6: Smart Sprinkler system

Agricultural ground makes use of sprinklers to revive their soil. A possible solution could be to improve already existing sprinklers. A smart sprinkler would be able to sense where and when the ground needs nutrients or water, and distributes them accordingly. This could prevent eutrophication and unnecessary water usage.

Showcase demo: (Testing required beforehand with the same soil used in the demo) Have a small patch of land (for example 1m^2) and place the mart sprinkler in the soil. Moisture sensors in/around the sprinkler measure how wet the soil is and whether it requires sprinkling. If the soil needs sprinkling, the sprinkler would be enabled for an 'x' amount of time.

Solution 7: Ground analyzer

A small ground analyzer could be a possibility to solution 3 and 5. This would consist of a small device that analyzes soil in farmlands and measures exactly what the soil lacks. This way, we would know exactly the amount of nutrients needed to help the soil restore. This would enable plants and trees to regrow in the area.

The analysis would be done by sticking a device in the ground with various sensors on it, that are tasked with measuring specific nutrients in the ground. Examples of these are iron, potassium, calcium, magnesium, or sulphur (Toppr, 2020). Furthermore, we could make the information easily accessible by sending it to an app on your phone.

Showcase demo: Test on 2 different kinds of soil from which we know the amount of nutrients and also which ones are in the 2 kinds of soil. Show that the data that we receive from the device matches with the nutrients and their amount from the sample soils. Then test the device on a third kind of soil from which we don't know the nutrients. The device then can tell which ones and how much there are.

Chapter 6: Solution Selection

The solution that our group has chosen is the little automatic tree planter. We have a few different ideas of how this could look like, so we decided to divide our idea into a basic version and an advanced version. Our goal is to at least build the basic version, and afterwards we can look at how much of the advanced version is feasible given the time we have left.

The most basic form is a robot that:

- Drives in a straight direction across terrain
- Stores seeds
- Periodically drops a seed into the ground

Preferably, we would have liked to achieve more with the basic version, but due to the circumstances with Covid, which makes meeting up and working together on this project very difficult, we had to alter our plans a bit. The more advanced form has multiple possibilities:

- Adding a small drill to the robot, so that the seed is dropped into the ground instead of on top of it. This ensures an increased survival rate for the sapling.
- Adding a sensor that enables the robot to detect obstacles on its path
- Changing course automatically after detecting an obstacle
- Adding sensors that analyze the ground before planting a seed
    - Check whether the ground has enough moisture or whether the ground contains enough nutrients
    - If the ground lacks anything, the robot could even add it itself, such as a small amount of water or nutrients
- Keeping track of GPS locations where seeds are planted
- Sending GPS of its location to for example a phone app
- Changing its course remotely from a phone app
- A sensor that detects when the seed box is almost empty and gives an alert
    - E.g. if a seed hasn't been planted three times in a row, the box must be empty

The reason that we chose this solution over the other candidate solutions is because we think that not only is this one of our more feasible solutions, it also seems like the most fun project to make! The validation also seems the easiest compared to our other solutions. Based on our research so far it is also possible to build this while staying within the budget. Lastly, our robot has a lot of potential to be used in many different ways. As explained above, we have a basic function that our robot fulfills, but in it's more advanced form it can fulfill many different tasks.

Chapter 7: Methodology

In this chapter we will be elaborating on our methodology.

Equipment & Data

Firstly, we will need some specific equipment in order to build our robot:

- electrical motors
- arduino
- servos
- seeds
- wiring
- ATV tires, either bought or 3D printed
- a storage box for the seeds + contraption so the seeds fall out
- batteries.
- our robot will be operating outside so a special casing is needed that protects the hardware against rain, dirt, animals and other damage.

Furthermore, our robot will be using sensors to gather data about its surroundings. For now we are not sure how many of these are feasible given the time we have, but these are the sensors that we would like to incorporate into our robot.

- GPS sensor - keeps track of where the robot is, and where it has planted seeds.
- Moisture sensor - measures moisture levels in the patch of ground where the robot is planning on planting a seed.
- Infrared sensor - Using infrared this sensor will enable the robot to avoid obstacles that lay in its path.
- Bluetooth sensor - communicates with for example a phone app

The data that our robot gathers will need to be analyzed and put to use. Again, these are possible advanced scenario options and might not be included in the final product.

- The data from the GPS can be logged and displayed visually on a map. This map could be accessible from a computer or even a phone app. The route of the robot could be displayed on the map, as well as the location of the planted seeds.
    - Using GPS could also make it possible to remotely set a route for the robot to follow, or even complete remote control.
    - Give the robot a returning point once the seedbox is empty.
- The data from the moisture sensor will activate a response from the robot whether to plant the seed or not. The sensor will have to be calibrated and assigned a threshold moisture level where a response will be initiated. Also, dry/wet areas could be mapped out using the GPS.
- The infrared sensor will activate a response from the robot whether to alter its course. The sensor will need calibration in order to measure distances correctly. The challenge that comes with this sensor is making sure that the robot tries to get back on the right path after avoiding an obstacle.

Modules

We have divided our proces into the following modules. Below each module is the team member that will work on it.

M01: Presentations, introduction, writing the documentation, incorporating feedback
- Issa

M02: Research on feasible sensors
- Veerle
- Marielle

M03: Hardware purchase/wiring
- Hans
- Frank
- Marielle

M04: Robot terrain navigation
- Issa
- Frank

M05: Mechanism that plants seed & seed purchase
- Ben
- Hans

M06: Design and making of casing
- Issa
- Veerle

M07: Programming/data analysis
- Marco
- Frank

M08: Validation
- Veerle
- Marielle
- programming/hardware team

M09: Preparation of the final demo
- Issa
- Veerle
- Presenting of demo is a team effort

Time Plan

Week 4

- Idea is now concrete and methodology is described
- Everyone starts their research on their own modules
- Start with purchasing equipment

Week 5:

- Purchasing of equipment is done
- Start of hardware building
- Start of programming
- Modeling of tires
- Add introduction to documentation

Week 6:

- Hardware and programming further developed
- Casing and tires are 3D printed
- Building process in documentation
- Casing design

Week 7:

- Further development of robot
- Re-define methodology based on experience up to now

Week 8:

- 5-minute demonstration of first prototype
- Incorporation of feedback and further development of robot
- Feedback report in documentation
- Validation
- Results, finding & conclusion in documentation

Week 9:

- Preparation of final demo: robot is in order, presentation, demo video, etc
- Last adjustments
- Documentation is finished

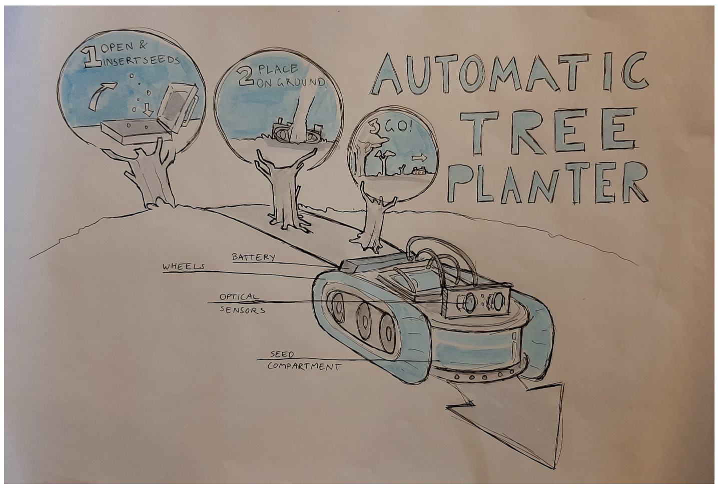
Week 10:

- Final demonstration

Chapter 8: Results and Conclusion

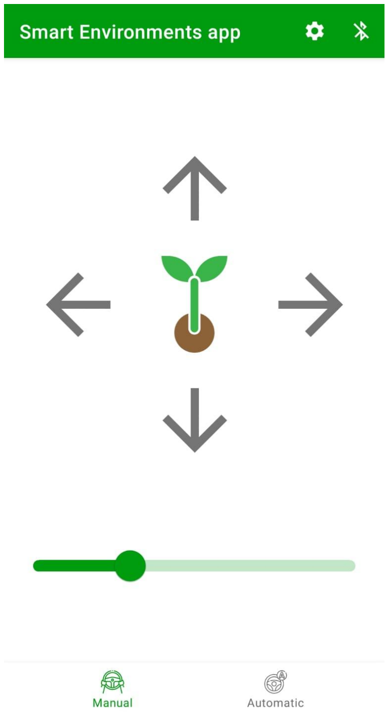
Building process

We started off by roughly illustrating what we had in mind for our project. After that, each module team member made sure the components they needed were ordered and did the necessary research for their module.

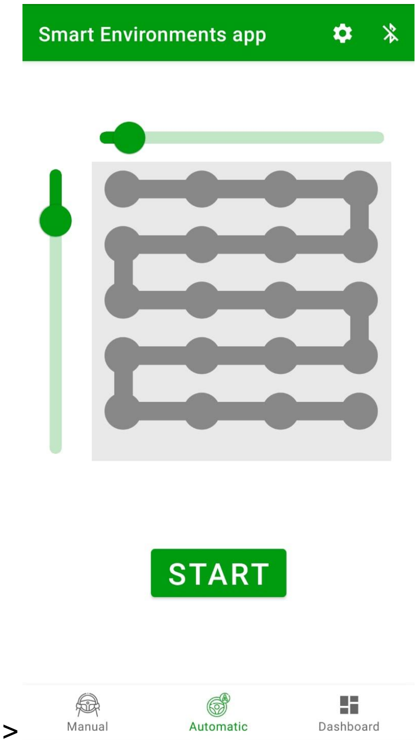


The programming team designed a phone app that enables users to remotely control the navigation and seed planting of the robot. It has a manual and automatic mode. In the automatic mode, the robot will simply drive forward, and periodically plant a seed in the ground. In manual mode, you can use the arrow keys to control the movement of the robot. When you press the seed button in the middle, the robot will plant a seed. The green slider below adjusts the speed at which the robot moves. In Automatic mode, you can adjust the speed of the seed planting and the amount of seeds you want to plant. The arduino sends strings of data to the app, containing a prefix so the app software can decode the data. The scale of the automatic mode is not relative to distance but the amount of seeds. Each seed has two seconds between them, and this time is adjustable within the app.

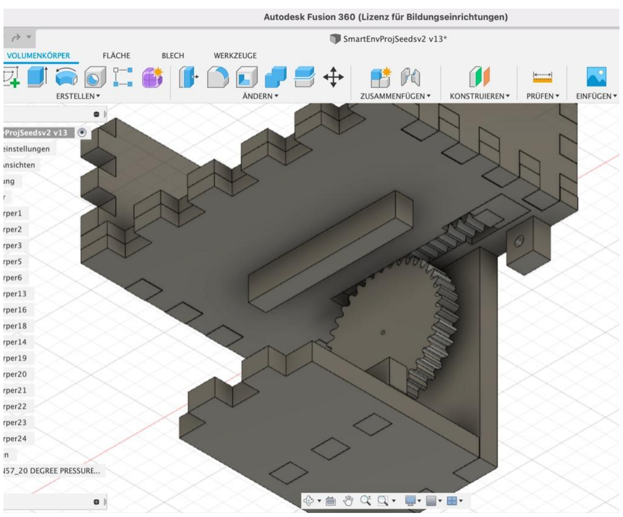
Manual Mode >

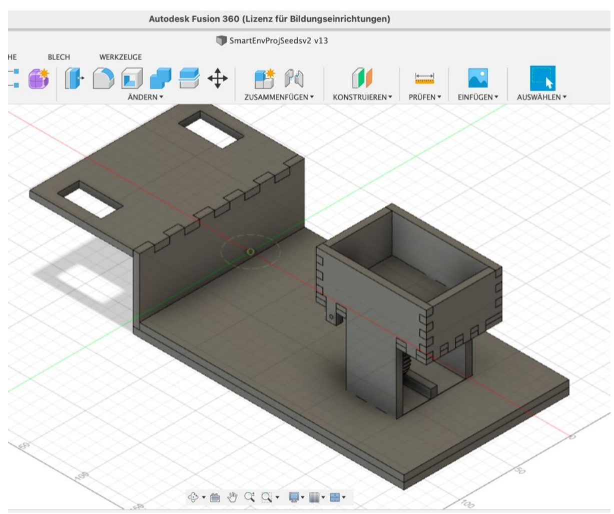


Automatic Mode >



The seed dispensary team designed and laser cut the physical components using Fusion 360.

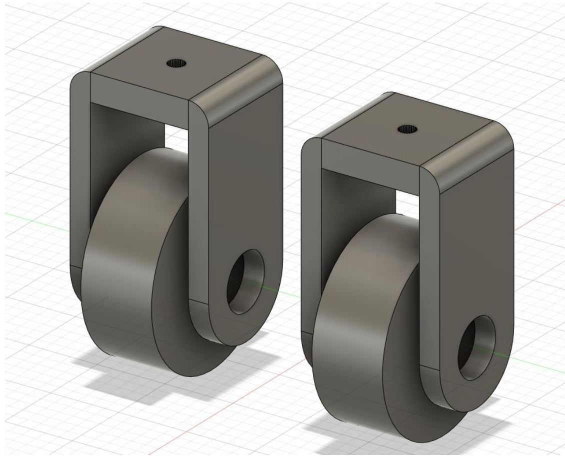




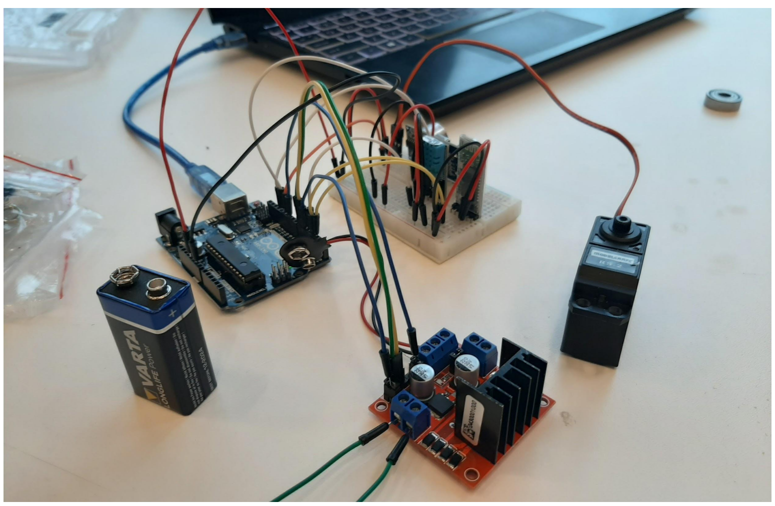
^The seed dispensary

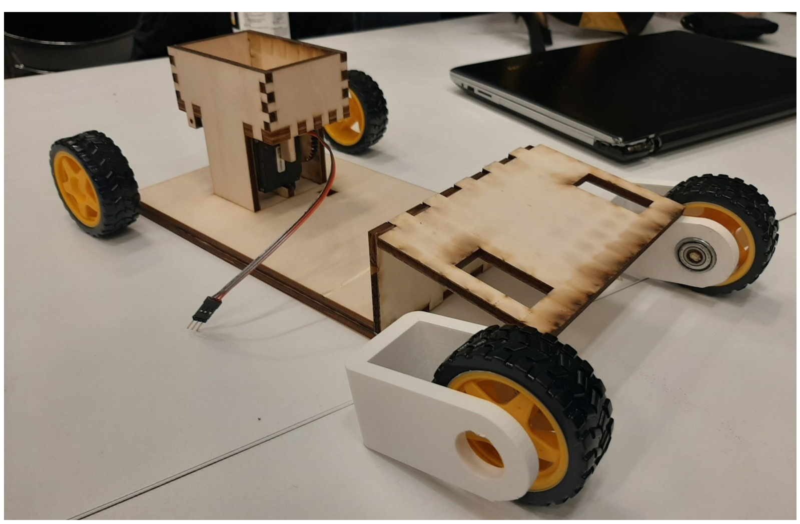
^Main plate

The navigation team ordered wheels and designed a casing in order to connect the wheels to the base plate.

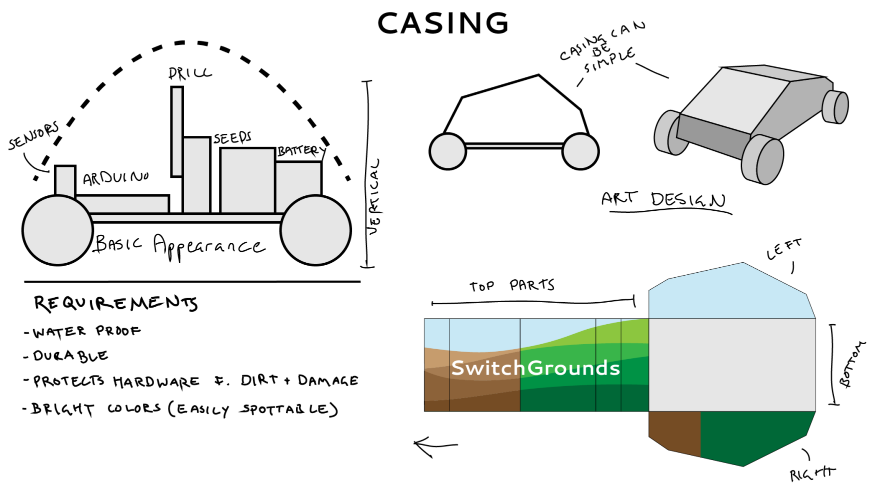


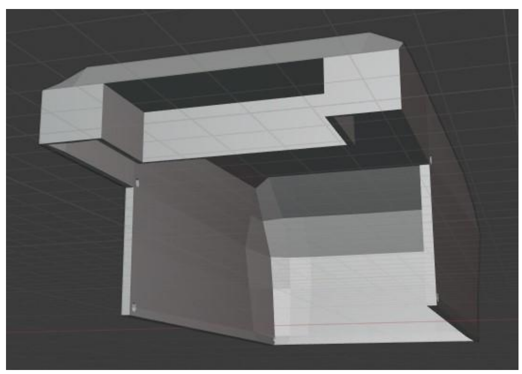
The hardware team wired the electrical components to an arduino. These include the motors that control the wheels, the bluetooth sensor, the mechanism that operates the seed dispensary, and the servos for steering.





The casing team designed the outer casing in Blender. The requirements for the casing are that it needs to be waterproof, durable, protects the hardware from dirt and damage, and that it is easily spottable. To achieve this, they decided to 3D-print this in plastic, and they hot-glued the separate parts from the inside. Multiple holes on the bottom enable the casing to be screwed to the wooden base plate. This ensures that no water or dirt will be able to leak through to the inside. Using acrylic paint and plastic sealer, they painted the top of the casing.



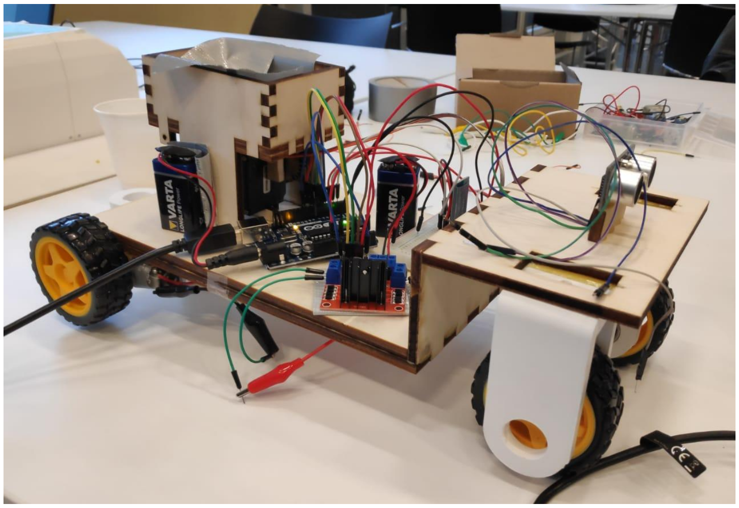


Meanwhile, the documentation team recorded every process in the documentation, created the presentations, and incorporated feedback. The demo team put together the demonstration video and presentation.

Feedback on demonstration

In week 8 our team presented our prototype so far. The feedback we received included that our project looked good and that we were well underway, which was nice to hear. A good point that Andreas mentioned is that we might want to move the GPS function of our robot to the basic scenario, seeing as it's quite a crucial aspect to know where the robot is and where it has planted seeds. We discussed this and we decided that unfortunately, with the time we had left, it might be unrealistic for us to achieve. When we did some research on using GPS sensors we realized that we would have to learn how to code quite difficult things such as using maps and plotting locations. We still had a lot on our to-do list at this point so we decided against it.

Validation



To check for any errors or points of improvement, the validation team checked how well our robot did in practice. From the validation, we were able to conclude a couple of things.

The functions of the robot that did well during the validation were:

- Working of the motors and wheels
- The bluetooth connection to the phone app
- The controls for the manual driving
- The behavior of the robot during automatic driving.

Unfortunately, there were also some problems that arose during the validation.

- The servo that opens the seedbox malfunctions sometimes. This could be because there are too little Amps passing through it.
- When driving backwards, the robot seems to curve off to the right
- The casing doesn't quite fit to the base plate properly. This is because the back wheels are in the way. Currently, the casing rests on the wheels which make movement impossible.
- Paint job on the casing needs one more layer.
- A part of the front casing piece collapsed while it was printed, which formed a hole on top. This needs to be covered up with a waterproof material.

Fortunately, we still have more than a week before the final demonstration. Within this time, we want to accomplish the following:

- Fix the seedbox servo.
- Find and attach material to the front part of the casing to cover up the hole.
- Cut out space on the back casing to make space for the wheels.
- See what other things we could implement last-minute from the advanced scenario.

Results & Findings

At the 10 week mark, the basic scenario and some of the advanced scenario for our robot have been completed. What we managed to achieve is a little robot car that can store seeds, and periodically drop them on the ground. It can drive forward and plant seeds automatically, or it can be manually controlled using a phone app. The current battery range is hard to say specifically because the battery is influenced by the roughness of the terrain and outside temperature, but it is roughly 30 minutes. The ultrasonic sensor can send an alert to the phone app when an obstacle is close. We weren't able to achieve the rest of the advanced scenario, mainly due to a lack of time

Click here for a short demo video.

For Treevie to actually be applicable in the real world, it would need to be equipped with our complete advanced scenario. These include a smarter navigation system that could automatically change course after avoiding obstacles. It would also need more sensors to determine whether the soil is suitable to host a plant, for example by measuring the moisture level of the ground or analyzing the composition of the soil.

If treevie were bigger, it could even be equipped with certain nutrients that it could inject into the soil at the locations where seeds are planted. Treevie would also need a fully functioning GPS system, so users can keep track of where it is and map out where seeds have been planted.

We are very proud of what we have made, and we've learned a lot during the project. Now, we are familiar with laser cutting and 3D-printing, we practiced using Android Studio to build simple apps, and we explored many more libraries and code from arduino.

In the future we will do even better, because of what we've learned from our mistakes. Some of these include managing our time a little better. We spent a lot of time on the orientation period, so we had a bit of a time shortage in the last couple of weeks. It was also very easy to get caught up in small details, such as the name of our robot, and waste too much time on that.

Building-wise, we realized that it's very useful to work less destructively. This means being less hasty in making permanent changes, such as super glueing parts together without a proper plan. This leaves more room for adjustments and it makes mistakes more forgiving. Next, we'll also make an effort to measure our components more accurately during the 3D-modeling phase, so the parts fit together a bit better.

Conclusion

With the automatic tree planter Treevie, we can help revert many agricultural grounds across the world back to forests. Our robot still needs a lot of improvements and modifications (and a bigger budget) to become fully automated, but our mission for this project was to build something that could at least help speed up the process of planting trees.

Deforestation is a serious global problem with many complications, so completely solving this problem is still a long way away. Of course, it would be more beneficial to stop cutting down trees in the first place. However, if Treevie were to be mass produced and used in many different locations, we could tackle at least one aspect of deforestation without much time and effort.

It is estimated that roughly 950 million - 1.1 billion acres of agricultural land has been completely depleted and abandoned by farmers (Project Drawdown, 2020). The biggest forest in the world, the Amazon, is 550 thousand acres (Wikipedia, 2020). It takes 65 years to completely regrow a forest. This means that if we were to deploy an improved version of Treevie in these areas, within 7 decades we could regain the Amazon Forest 1800 times! This enormous undertaking would benefit everyone and ensure long term safety against natural disasters.

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