Geographical Tracking

One of the major objectives in this project is for the robot to track its position inside the storm drain, so that the surface can be marked and indicate where the said obstruction is located from the surface (Figure x.xx). There are a handful of possible ways of doing this, but most exceed the allocated budget, or are too complex.

A picture containing iPod

Description automatically generated

GPS

An idea that was brought up, but immediately rejected, was the use of a Global Positioning System (GPS). GPSs are found in many appliances and applications, such as cellular devices, computers, satellite phones, and more. Originally, the use of a GPS was for military use, but has then been extend to commercial and public use. The way a GPS works, is by taking advantage of the many satellites that orbit the Earth and use triangulation to pinpoint the location of the device using GPS (Figure x.x1). As to why this idea was rejected, it’s because in order for a GPS to work, it has to be within the sight of multiple satellites. Since the environment in which the robot will operating in is underground, there is no line of sight for the satellites, making this idea unsound.

A picture containing object, first-aid kit

Description automatically generated

It is possible to create a makeshift GPS for the robot, but that would require additional components that would have to be separate from the robot, as well as requiring financing from the budget.

Radar

The use of radar is within the scope of the project, it would allow for tracking distance traveled in an accurate fashion, as well as be used to detect any obstructions inside the storm drain. The way a radar functions is by transmitting signals with an antenna and receiving the bounced signal to determine the distance, size, and location of an object (Figure x.x2). By using radar, another object may have to be lowered in alongside the robot, to act as a starting marker for the robot, but detecting cave-ins and obstructions would be easy, and efficient on time.

A picture containing object, gauge

Description automatically generated

Radar would a good option for tracking distance traveled, but it would require more financing, and advanced code in order to properly use the radar. Additionally, more components would be needed in order to construct the radar, increasing the complexity and maintenance of the robot. In addition, there are several conditions in which the radar would not function properly, or to its full potential. The first condition would be that the storm drains aren’t always leveled, meaning that if the robot was traversing the pipe with deviations in terrain, there is a chance that the marker that was placed as a starting point, may not be detected by the radar due to difference in elevation, thus ruining the point of the starting marker. Secondly, there are slight turns within the storm drain pipes, meaning that the starting marker may be out of sight, and thus ruining the point of the starting marker again. Thirdly, any obstacles that are inside the drain can possibly prevent the sonar from functioning.

Another use of radar is Ground Penetrating Radar (GPR). This allows for finding objects located underground, from the surface. Using radar in this fashion would be practical in finding cave-ins and obstructions inside the storm drain, but it doesn’t allow for the user to evaluate the conditions inside the storm drain, along with the fact that pipes may run under buildings in which the user won’t be able to properly follow the layout of the storm drain pipes. To further reason as to why GPR isn’t a good idea is the fact that obtaining a GPR is expensive and would require funding over the designated budget.

Overall, radar is a good idea as a concept, but it adds onto complexity as well as financing. There are also many things that can inhibit the radar from functioning, meaning that the radar would need specific or perfect conditions for it to operate as expected. Furthermore, with the conditions inside the storm drains, using radar would not be the most optimal or practical option to track the robot’s traveled distance.

Sonar

A similar idea that was considered, was the use of Sonar, which is very similar to radar (Figure x.x2). Instead of radio waves, sonar uses and manipulates sound waves at a high frequency in order to locate any objects. This concept is similar to how bats use echolocation, in which a pulse of sound is released, and a receiver then calculates the position and distance of an object based on the time it takes for the echoed sound to return. Just as the radar had its specific conditions in which it would function properly, sonar has conditions that mirror that of radar, such as using a starting marker. Furthermore, sonar would be more complicated and complex due to the fact that sound waves will bounce off the surrounding walls more inside the storm drains, and overwhelm the receiver, thus inhibiting the sonar from operating properly.

In this case, using sonar would be inconvenient to implement, especially in the conditions that the robot would be working in; it would require additional funding and advanced math techniques to properly map out and understand the incoming data. Overall, sonar seems to be one of the less likely ideas, due to its inconvenience and complications.

Tether Length

A rudimentary idea that is taken into consideration is to just measure out the length of the tether once the robot discovers any cave-ins or obstructions inside the storm drain. In order to do this a few concepts were brought up that could help with measuring.

One concept discussed was to place the tether on a reel and calculate the length of tether used based on how many rotations the reel has gone through. One reason as to why this concept was rejected was because of its inaccuracy. By pulling the tether off the reel, the radius would constantly get smaller, thus requiring a remeasurement of the radius in order to calculate how much tether has been used.

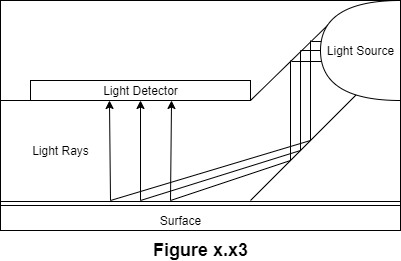
Another concept, involving the reel, would be to mark up the tether to indicate a unit of length, feet, yards, meters, etc. and then have the tether run through a sensor that would count each mark, resulting in a total distance traveled. This idea proved to be practical in the sense that it is easy to implement, cost efficient and practical. By having a marked tether run through a sensor, there is no room for error and would also be easy to program. The complexity of this concept is also very low, allowing for quick use and measurement.

A few concerns that arose for both concepts are the fact that the tether can get tangled or misaligned when reeling in said tether. Although the robot and tether system will be handled by professionals, there is still a possibility that the tether will get tangled in the reel, in which it would add more time to the operation to untangle. Another concern is the fact that the robot would need extra torque and power in order to pull the tether off the reel. Realistically, the robot should only have enough torque and power to pull itself, and not have to unwind the tether from a reel.

Overall, the second concept is effective and has a high chance of being the main method of measuring distance traveled. The pros, in this case, outweigh the cons and allow for simplicity to take place when implementing this system. It contains practicality, simplicity and efficiency when achieving the goal of measuring distance traveled, by the robot.

Optical Mouse Sensor

One such solution to tracking the distance traveled by the robot is the use of an optical mouse sensor. An optical mouse sensor uses a light source and a light detector in order to calculate movement in relation to the surface it’s on (Figure x.x3). Like the sensor underneath a computer mouse, the robot can use this sensor to achieve the same functionality. By using this sensor, the robot can track what direction it’s going, as well as how far it’s gone.



In order to successfully implement this idea, several optical sensors will have to be used, since just having one sensor will not be enough. These sensors will have to be placed all over the robot, locations that track the robot’s actual movement in three-dimensional space. The level of complexity to program this would be moderate since it would only involve vectors and matrices in three-dimensional space.

To properly execute this system of optical sensors, there will have to be at least eight different optical sensors, four on top of the robot, and four underneath the robot. This implementation would be effective because some sensors may be blinded by mud, or anything that can be found in the storm drains, and by having more than one sensor, there will be other optical sensors to take its place along with the fact that by having more sensors, the more accurate the calculation of distance travelled will be.

In total, using optical mouse sensors is a good idea, but there are some inconveniences that make it difficult use this idea. One such problem is the wide range of optical sensors, ranging from low quality and basic sensors to high quality and advanced sensors. Each of these tiers will of course have a different price range, making these sensors either very cheap or extremely expensive. Another problem is that most optical mouse sensors require a flat surface in order to properly function. Inside the storm drain, the surface will not be smooth, instead it will be wet, rough and made of concrete. What this means is, the light being used by the optical mouse sensor will be diffused or refracted, resulting in the sensor not being able to receive the bounced light. Depending on the quality of the sensor and its source of light, this problem can be overcome, but may be impractical and inefficient with the budget.

Wheel Rotation

An obvious idea that is highly leaned towards, is the calculation of distance travelled based on how many times the wheels on the robot have rotated. This concept is basic, practical, and not complex at all. Even though it may be the most basic idea, it redeems itself though its effectiveness and efficiency. By adding a sensor to count how many wheel rotations have occurred, a program will have to just use an equation, with wheel diameter taken into consideration, to find the total distance travelled by the robot.

Though this method has a high chance of being used, there is one major concern that is taken into consideration, the problem of wheel slippage. Wheel slippage will most likely occur within the storm drain, especially with the conditions the robot will be operating in. Slippage occurs when the wheels on the robot can’t get enough traction on the surface it’s operating on, and so rotation of the wheel occurs but no directional movement is achieved. This can be detrimental for the goal of tracking distance because, based on this method of tracking, any excess wheel rotation will contribute to the totality of wheel rotations.

By having extra wheel rotations that do not contribute to actual distance traveled, the distance traveled may be misrepresented and misinform the user. Being that this robot is being used and operated to find any cave-ins, and or obstructions in a storm drain underground, its severely important that tracking the robot’s location must be accurate so that operations above ground can take place in an efficient manner.

Methods of how to prevent slippage have been narrowed down to the type of wheel to be used. Several wheels have been discussed, and only a select few characteristics have been chosen to be mandatory.

One such characteristic is the fact that the wheel should be heavy in order to allow the robot to stay stable on the surface of the storm drain. Also, in order to make the wheels heavy, the wheels will most likely be made of a solid material, with minimal air. This is beneficial, such that by having solid wheels, they will sink in water and not float. Furthermore, by having solid and heavy wheels, the robot can remain stable when maneuvering.

Another characteristic is treading on the wheel. Treads are useful because they allow for the wheel to stay in contact with whatever surface they are operating on top of. In addition, treads are designed to repel water from the contact surface, which in this case is very beneficial for the robot and for the environment the robot will be operating in.

Overall, using wheel rotations as the method of tracking distance traveled is the most appropriate approach for this project. This method contains minimal problems, in which can easily be corrected, if errors were to occur. In addition, this method proves to be most practical, intuitive and budget efficient way of tracking distance traveled by the robot.

Communication Methods

An important component for the robot to operate properly is its method of communicating with the computer and user. There are a handful of ways that communication can be achieved, such as ethernet cable, and wireless connections.