Hardware research

**Introduction**

The Mapping module of the robot is responsible for scanning the area around the robot to create a zone in which the robot can see where obstacles are. This is to ensure it will pas through any environment safely.

The robot needs to be able to see any obstacle near it in a full circle, in front of itself to see if any obstacles are in it’s path, but also behind itself in case someone might suddenly come up from behind it.

Based on this I’ve determined that the minimal required components are: a distance sensor, a motor and a microcontroller.

In this document I will look into various components and based on that research make a decision on what components I will use to build the module.

**Distance sensor**

There are three sensors types I will be researching. An ultrasonic sensor, a radar sensor and a lidar sensor. There are ofcourse more types of sensors but I’ve decided to look into these specific three because these are most commonly used sensors. Each have a different method of measuring distance which each has their own advantages and disadvantages.  
All distance sensors work by transmitting some sort of wave and then calculating how long it took for it to return to the sensor.  
Research strategies used: Field and Library.

**Ultrasonic sensor**

Ultrasonic sensors use sound to determine distance, they do this by sending small bursts of sound very rapidly.

Because these sensors use sound, the type of material is less relevant, it will easily reflect from most materials as long as they are solid.  
Because they use sound waves they are most accurate with close rangers, the further it tries to measure the more diluted the sound wave becomes, making it less likely to accurately return if it returns at all.  
The effectiveness of an ultrasonic sensor starts dropping at around 4 meters.  
Another issue of ultrasonic sensor is that they are high effected by factors such as the temperature of the air, or if these is something like dust or smoke in the air.

higher temperatures result is sounds travelling faster and cold temperatures in the opposite, so this can result in unreliable readings.   
And dust in the air makes it harder for the sound wave to travel through, it increases the interference which distorts the signal. Or alternatively if the amount of smoke or dust is high enough it might accidentally bounce back from that, instead of the desired obstacle.

**Radar sensor**

Radar sensors use an electromagnetic pulse to measure distance instead of sound.   
this immediately gives a huge advantage over the ultrasound in that it won’t be nearly as effected by things like dust or smoke in the air. Nor will it be affected by temperature changes.

The biggest drawback of radar sensors is that it can only detect certain types of materials. A radar wave will pas right through any material that is not (or barely) conductive and/or very dry.

Another issue could be that a lot of machines use radar waves to communicate, this means that if our robot uses radar too scan in such an environment, it might cause interference with these signals.

Depending on the final application it can be an advantage or disadvantage that a radar sensors gets more accurate with distance. This means that it would be perfect at very quickly being able to know if an object might be near it soon, but when it actually is it won’t be as good at detecting it.

High grade radar sensors will be accurate up to 40 meters, but won’t start to be accurate until around 3.

**Lidar sensor**

Lidar stands for light detection and ranging of laser imaging detection and ranging. It uses infrared light to determine distance. Because it uses light it extremely fast and accurate, and does not suffer from any of the interference issues the previous sensors have.

Lidars are a very commonly used sensor in modern appliances already, due to how reliable and accurate they are. Two notable examples of robots using a lidar sensor is a Roomba, and spot from Boston Dynamics.

A minor drawback would be that although highly accurate, being that the lidar uses a laser, it does not scan in a cone like an ultrasonic sensor, it can only look directly in front of itself.

The only real drawback of lidar sensors is that some models have more trouble with detecting transparent materials like glass.

**Motor**

The motor component will be responsible to make sure the sensor is able to see in a full circle around it. To make sure the map stays accurate these motors have to both be fast and accurate.  
Research strategies used: Library.

**Servo**a servo motor is pretty much an upgraded dc motor. Unlike a regular dc motor a servo will have a position encoder and a gearbox among other parts.  
Servos are very strong and retain most of their torque at high speeds, this makes them good at accurately carrying a load while remain accurate.

The main disadvantages of a servo is that because of these high standards, they require the aforementioned extra parts, which drives up complexity and maintenance. This increases the risk of something breaking down sooner compared to other motors.

**Stepper**Stepper motors have way more magnetic poles than a servo, this allows for much more precise movement, and a are a lot easier to control due to their simpler mechanics.  
Due to the design of a stepper motor it can hold a constant torque without the need of a motor.  
They are also very cheap and highly available.

The disadvantage of using a stepper motor is that it will loose a lot of torque when moving at a higher speed, which also makes it harder for it to carry a load when moving at these speeds.

**Controlling unit**

The controlling unit process all the data to make the map which it will send to the brain unit. So it is necessary for this component to be able to quickly process large amounts of input data.  
There are of course more types of microcontrollers, but being that in this module it only needs to do high speed data processing, a more advanced microcontroller is not needed.  
Research strategies used: Lab and Library.

**Arduino**

An Arduino is a micro controller, it’s small and very fast. But can only run one small program repeatedly, so it’s good for simple repetitive tasks.  
it can easily run small scale applications, but won’t be able to run any heavy programs or operating system.

**Raspberry pi**

A raspberry is a fully fledged computer capable of running large programs, and perform multiple complicated calculations at once.  
If you need to keep track of a lot of different factors and at the same time decide what to do, you have to go with raspberry pi.

**ESP32**

The esp32 is a microprocessor just like the Arduino, but is much faster and has larger memory. And although not applicable in the current prototype. This processor has built in Wi-Fi and Bluetooth which could be advantageous in future versions of our robot.

**Conclusions**

Based on all the research above, I’ve decided for each component what type I will use to design the final version of the module’s prototype.

**Distance sensor**

I’ve decided to use a lidar sensor. Because lidar sensors have the least interference issues, are already seen being used in successful existing products.   
The problem with the ultrasonic was that there would be too many variables to trust the results, and although the radar sensor is more accurate, the electromagnetic signals might interfere with other machinery in places where our robot could be implemented.

The transparency issue some lidars have can be avoided by possible having a requirement for it be that there can be no glass walls at sensor hight.

**Motor**

For the motor component I will use the servo. This is because even though the stepper motor is more accurate, this module will need to rotate at very high speeds and retain accuracy. So even though the servo might be as accurate as a stepper, it will easily outperform the stepper when moving at the high speeds that will be expected in this module.

**Controlling unit**

the controlling unit needs to be able to process a lot of information and be able to transmit it onto the brain unit very fast. All three controls are good enough to do this so we must look at the one best fitting for this task. First the raspberry pi will fall of, although more than powerful enough it’s is a full on computer, using this would be overkill and therefore cost inefficient. this leaves me with having chosen to use the esp32, the Arduino is also very fast at processing but the esp32 is both stronger and faster, and has an extra core which is useful for asynchronous programming.

**Other requirements**

The robot needs to see in a full circle around itself. This can be achieved by either placing a bunch of sensors around the robot, or place a single sensor on top of the motor so it can spin to measure.

This is both more cost effective and makes the software more efficient.

A research needs to be done to conclude the way to set this up.

**Resources**

**Distance sensor**

<http://www.instrumentation.co.za/papers/C18646.pdf?a>

<https://www.apgsensors.com/about-us/blog/radar-and-ultrasonic-sensors>

<http://lidarradar.com/info/advantages-and-disadvantages-of-lidar>

<https://www.nde-ed.org/EducationResources/HighSchool/Sound/tempandspeed.html>

<https://www.explainthatstuff.com/how-roomba-works.html>

<https://www.bostondynamics.com/spot>

**Motor**

<https://www.lifewire.com/stepper-motor-vs-servo-motors-selecting-a-motor-818841>

<https://automationforum.in/t/what-are-the-advantages-and-disadvantages-of-servo-systems-servo-motors/1017>

<https://automationforum.in/t/basics-of-servo-motor-its-advantages-and-disadvantages/3186>

**Controlling unit**

<https://www.engineerathome.com/elektronica/arduino+vs+pcduino+vs+raspberry+pi/63>

<https://www.makeuseof.com/tag/arduino-vs-raspberry-pi-which-is-the-mini-computer-for-you/>

<https://makezine.com/2015/12/04/admittedly-simplistic-guide-raspberry-pi-vs-arduino/>