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Memo

To
Autonomous Car Co.

From
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Re
Assignment 12

Introduction:

Autonomous vehicles are widely sought after by your company and competing companies because of their amazing capability to simplify the driving process. There's a demand for autonomous vehicles because it frees consumers to do other things during their morning or afternoon commute. No longer do they have to be awake and attentive during their commute, they could continue sleeping until they got into work for the day, write emails on the ride, etc. I think consumers also yearn for autonomous vehicles because of their simplification of long road trips. How much easier would a long road trip be if you're able to sleep during the drive? On top of the convenience factor for consumers, vehicles could also keep drivers safer. Autonomous vehicles take the capability for human error out of the equation when it comes to driving.

Autonomous vehicles will not be able to lower the rate of crashes without proper safety systems in place. Autonomous vehicles need to prove that they can be safer than human drivers before they are accepted commercially. Among all kinds of safety sensors and other important features that need to be implemented in autonomous vehicles. One important feature that needs to be implemented is calculating relative velocity for these vehicles. Relative velocity helps inform autonomous vehicles how fast other cars are moving around on the roadway with respect to themselves. This calculation is important for critical features like keeping safe following distances, making lane changes, and stopping before coming into contact with

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objects. Calculating relative velocity not only keeps consumers safe inside their autonomous vehicle, but also keeps other people safe on roadways. If a company adopts autonomous vehicles as a technology, that company is also responsible for making sure their vehicles aren't causing any damage or causing legality issues. Keeping autonomous vehicles safe on roadways can help cut down future legal costs or other costly problems. I think it's very important to invest in this technology early on to cut down on future expenses and issues.

Calculating relative velocity has a multitude of different solutions. Each of these solutions has positives and negatives. I'd like to introduce two solutions for the issue and then discuss how we can combine the two, cutting costs, and synthesize a safe solution to this issue. (1) Using the TTC (time to contact) algorithm, (2) Using radar for velocity calculations. Each of these proposed solutions have weaknesses. My recommendation is to combine these two technologies, and integrate them together in the calculation of relative velocity. Combining sensors will be the best way to calculate relative velocity because different sensors will carry different weights when they calculate variables. Combining the outputs of these different sensors will be very simple and attainable if we use some sort of a filter. This filter will take both outputs and average them, creating one single output that the car can read. I will also go into detail about how we can save money by implementing both of these solutions as cheaply as possible.

Time to Contact:

Using the Time to contact algorithm will utilize a camera, and its internal camera coordinate system. I won't go into much scientific detail about the TTC but just know that it is the ratio of depth/speed. The time to contact literally tells us how long it will take for us to contact or touch another object. This ratio is crucial in object detection and computing a time variable to tell us how long we have before a potential collision. Normally, to calculate the time to contact we would use a camera to calculate depth. Then we would use a different camera to calculate the speed of the object. If we estimate the TTC value instead of computing it, then use this estimated ratio to compute relative velocity, then we can cut costs by using one camera instead of two. This cuts costs in half while still retaining adequate relative velocity calculations. Using this calculation, we still need to use some other device like a radar to calculate the distance of the object. This is one of the downsides. Another key feature of this solution is using a CPU to compute the values obtained by the camera. Thankfully the image processing using this camera is very simple and doesn't require a lot of computational overhead. The CPUs required for this operation can be something simple like ARM processors. These image processing calculations can be computed relatively easily on similar CPUs that run smartphones.

Radar for Relative Velocity Calculation:

The benefits of using radar is that they're able to calculate the speed of objects and the distance. This leads to one sensor being able to compute everything we need. Radars use the reflective waves from objects to calculate the distance and the speed. These radio frequencies that are sent out from the radar are reflected back, and the shift in between the two frequencies are used in calculating how fast an object is moving. This can pose some issues for smaller objects, as they're reflective frequencies might not be as powerful as the frequencies of a big object. For example, if you have a cyclist and a truck next to each other, then you might not be able to see the cyclists reflected waves because they would just be overpowered by the truck's waves. This is one of the downsides with radar. Using a radar for distance and velocity calculations will be the cheapest option, but because you're not utilizing different sensors all of your speed calculations will come directly from the radar. As discussed before this radar can lead to inaccurate calculations if some objects differ in size.

Conclusion:

Even though utilizing the radar alone is the cheapest option, I don't think it's advisable. Depending on all your velocity calculations from one sensor is extremely dangerous. Any noise in the signal will lead to inaccurate calculations that could lead to catastrophic events. Combining the two sensors will lead to improved reliability in calculations, and extra security in case one sensor doesn't detect an object. Using the radar to calculate relative velocity as well, will be extra insurance with our TTC calculation. Using some kind of a filter to combine the relative velocity calculation outputs from the TTC algorithm and the radar calculation, will ensure that we are getting an accurate reading for relative velocity.

The combination of these solutions will be the safest way to calculate relative velocity for your autonomous vehicles. Adding on the TTC camera methodology only requires one extra camera and one low-cost processor. I hope you'll consider and understand the importance of keeping your product and others safe on roadways. I think this combined implementation of the two will be the most efficient solution to keeping costs low and consumers safe.