The Role of Sensors in Autonomous Navigation

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As autonomous vehicles are rapidly becoming a large part of present day society, necessary precautions must be taken to ensure that they are capable of successfully detecting the environment around them and avoiding potential obstacles. In order to detect these obstacles a variety of sensors are necessary to alert the internal navigation of the vehicle to react appropriately

Introduction to Autonomous Vehicles and Sensors

The vision of a car that can drive itself has been around since just after the introduction of mass-produced automobiles. Despite the fact that the concept has been worked on for the past century, very little progress was made in the field until the past decade. The immense difficulty of this task stems from two different important factors: the ability to sense what is around the vehicle, and the ability to always react appropriately (Birdsall, 2014). However, despite these challenges autonomous vehicles are extremely important to the future of mass transportation. If perfected, it will increase the time efficiency, fuel efficiency, and safety of modern transportation. This note focuses on examples from three main groups of autonomous vehicles: Google self-driving cars, military Unmanned Aerial Vehicles (UAVs), and Amazon Prime Air Drones.

Types of Sensors

Four primary sensors types are used by autonomous vehicles to gather information on surrounding objects. The first three sensors (Ultrasonic, Radar, and LIDAR [Light Detection and Ranging]) rely on determining the distance to an object and collecting that data over time in order to derive the speed relative to the primary vehicle. This data can then be used to determine the patterns of objects as they move around the autonomous vehicle. The fourth type of sensor (Visual Cameras) takes images of objects, as determined by the previous sensors, and determines exactly what those objects are. More information about each sensor type can be found in Table 1.

Interface with Autonomous Navigation Algorithms

Once continuous distance measurements have been recorded using any of the above methods, that data can be extrapolated into speed relative speed and acceleration between the vehicle and the object using a simple differentiation. The next step is to use this data, in combination with positional sensors, to determine other objects' projected movement. These positional sensors are generally active GPS or passive car sensors. Active GPS uses a connection to the global positioning satellites to obtain a precise location for the vehicle. This is then interfaced with detailed maps of the roads which have been obtained by previous data collection in order to get a predictive path for other objects. In addition, onboard vehicle monitoring sensors, such as magnetic wheel speed sensors or flight recorders, will provided information about the vehicles current speed and heading, which can be used to predict the future position of the autonomous drone or car and how it will have to be adjusted to avoid collisions (Birdsall, 2014).

Two common methods of predicting the future movements of other objects and vehicles are used to collect data and react appropriately to prevent an accident.. The first method is writing an extremely comprehensive algorithm that is capable of taking in numerous input variables (speed of all objects, what each object is, weather, etc.) and outputting the autonomous vehicle's next move (Sirini, 2006). Ideally, this would be the perfect solution, however the complexity of the algorithm that could actually analyze all possible situations and avoid collisions would be extreme. The more practical and more commonly used

Table 1. Types of Sensors and Their Roles in Autonomous Vehicles

Type	How it Works	Pros	Cons	Uses
Ultrasonic	• Emits sound waves and measure time taken for them to return	• Cheap • Accurate at short distances and very consistent	• Can vary based on weather • Inaccurate at longer distances	• Find distance between cars • Ensure that an object is not hit when backing up
Radar	• Emits electromagnetic waves and measures time taken for them to return	• Very accurate at most distances	• Expensive • Multiple sensors has strong likelihood of interference	• Get accurate distances to specific objects detected by LIDAR
LIDAR (Light Detection and Ranging)	• Emits electromagnetic waves and analyzes the physical wave that returns to obtain more accurate data	• Provides extremely accurate data on many objects • Can paint a "picture" of the surrounding	• Expensive • Computationally demanding	• Get a broad picture of all objects in the area of the vehicle • Identify hazards in the path of a drone
Visual Cameras	• Compares an image of a specific object to a database of known objects	• Can accurately detect color • Can compare objects to a database	• Only useful once you know where an object is • Time consuming to decide if options are not already narrowed down	• Determine what color a traffic light is • Decide if an object is a bicycle or a motorcycle

solution is to design a learning algorithm that can take inputs from previous tests and use the results to develop an intensive bank of past situations and how to appropriately maneuver whenever they come up. This is the method that the Google Cars use, so as each car goes through testing they record all situations and all of the cars will sync their memories so they can all have the same possible situations (Guizzo, 2011).

Conclusion

While we will not be implementing any sort of autonomous navigation for our senior capstone project, it has been looked into for future iterations of this project. Being able to autonomously navigate through a forest fire would be extremely advantageous in real life, as it would allow a computer to make split second decisions in order to more accurately fly an aperture and collect a high quality image of the situation. The different categories of sensors discussed above are all applicable and would be in consideration to upgrade the current drone in order for it to be better equipped to handle possible autonomous navigation in the future.

References

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