

GPS Gaucho

GPS Navigating Autonomous Vehicle

Functional Description and Complete System Diagram

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The goal of this project is to build a control system for an autonomous vehicle using differential GPS. The vehicle will be capable of identifying its current position and then, upon receiving a new location, calculate how to reach the new location and drive there. The differential GPS system consists of two GPS units which are capable of acting as either DPGS base stations or clients and a wireless RS-232 link between them. By programming the GPS receivers to correctly produce or interpret DGPS data, a location fix can be made with enough accuracy to enable the vehicle to stay in a relatively narrow drive path.

The vehicle to be used for this project is the Gaucho. The Gaucho is a larger truck-type vehicle that has been used by projects in the past, and as such is already capable of being controlled over a serial port by a computer or other device. Because the Gaucho already has the low-level controls built into it, we will not have to implement that part of our project, and instead will be able to spend more time on the DGPS and navigation control systems. Also, unlike most of the other vehicle platforms available to us, the Gaucho is large enough that it is capable of driving in rougher terrain, where many of the smaller vehicles would have trouble if they were to ever get into the grass.

The navigation control portion of the project will run on an embedded device known as an E-Box. The E-Box is essentially a small computer that runs Windows CE. One of the main advantages we gain by using Windows CE as the environment for our system is the ability to easily interface with multiple communication protocols, which will make it easier to build a method of communicating with the E-Box. Also, Windows CE has built in support for many layers of application priority, which will provide a way that we can specify what parts of the system are most important and need to run more than other parts.

There is currently a GPS antenna mounted on the roof of Jobst Hall. We can attach one of our GPS receivers to this antenna in order to create a base station. The second receiver will then be mounted on the Gaucho and act as the client. One of the issues with using DGPS is that the exact location of the base station must be known. In order to get a good idea of the location, we intend to log data over a period of a couple of weeks and then average the gathered data. While this will give us a solid reference point that is relatively close to the correct point, it won't give the exact location of the base station. However, this is unimportant to our project. In order for the Gaucho to be able to navigate the sidewalks outside on campus, it must know where the sidewalks are first. This will require us walking around with one of the GPS receivers while it is correcting itself from the base station and gathering data on where the sidewalk really is. In this case, the only criteria that really matters is that the base station's reference point remains fixed, since the client's data will be relative to this point. As long as this is the case, our system will still work, even if the location fix of the base station is slightly off.

The diagram for how the different parts of the system interact is in figure 1 (top of next page). The main part of this system is the autonomous vehicle itself. The vehicle, which is the gaucho, will have one of the GPS receivers mounted on it in addition to the E-box. By using the wireless RS-232 link, the receiver on the Gaucho will receive correction data from the base station. Also, the E-Box will receive commands from a remote user over an 802.11 wireless network.

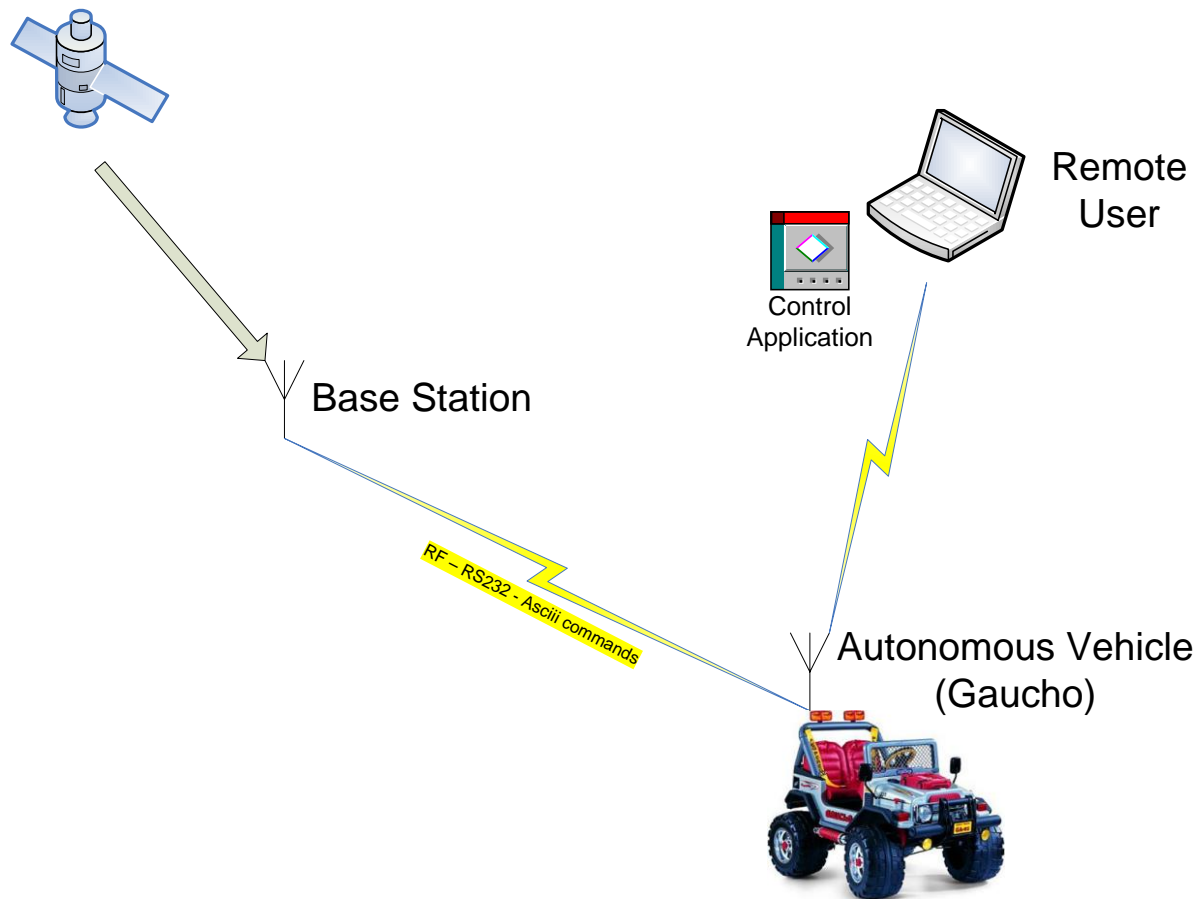


Figure 1: Parts of the system and the communication between them

The majority of the work in the system will be done by the E-Box on the autonomous vehicle. While the remote user will have some capabilities, that portion of the system mostly consists of an app that sends commands to the vehicle and receives data back. In the main controller however, there is a much larger amount of logic. Figure 2 (top of next page) shows the primary logic process of the system. Upon start-up, the E-Box will communicate with the GPS receiver to determine if a differential fix can be made or not. If it is not possible to obtain a valid fix, then the system will go into a standby state where it can either accept manual commands from the remote system or wait until it obtains a valid fix. When a valid fix is made, then the system will begin to accept position commands to move to a new location. Upon receiving one of these commands, the system will calculate the movements needed to reach the new location based on the current location reported by the GPS receiver. If at any time the system loses its differential fix, it will then return to manual mode and quit performing auto-navigation tasks. In order to correctly calculate the correct path to take to go from the current location to the target location, it may be advantageous to have an electronic compass on the Gaucho. This is mainly useful because depending on which direction the Gaucho is currently facing, it may have to turn around before it can start moving in the correct direction. It is possible though to detect the current orientation using the GPS data, so this is something that may be added later on as time permits.

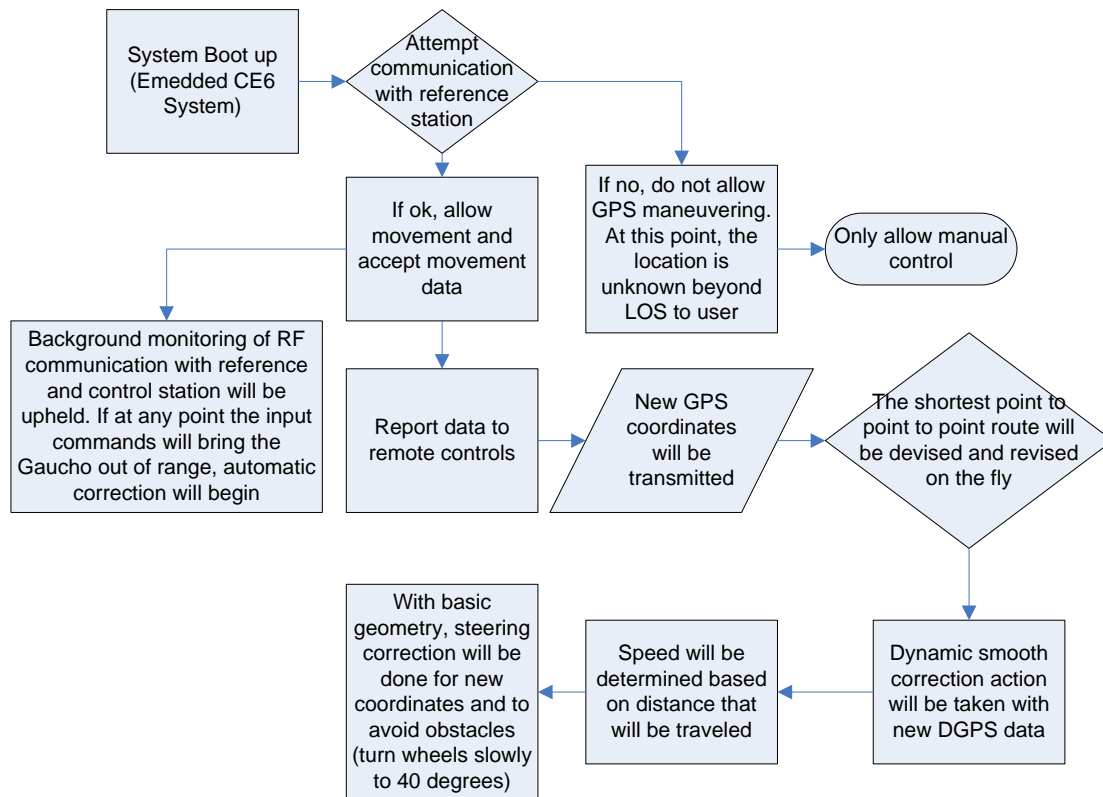


Figure 2 – Primary logic process for the embedded system

There are also a couple of other ideas that we have that can be added when time permits. These include a distance sensor to determine if there are obstacles in front of or behind the Gaucho, a camera that streams data to a remote location so that a user knows what is happening when the Gaucho is under manual control, and implementing the rotation sensors in the front wheels of the Gaucho to correctly detect how much the Gaucho has moved. The rotation sensors and compass would especially be beneficial in cases when the GPS signal is lost. If the Gaucho still has dead-reckoning sensors available to it, then it will be able to better handle GPS outages.