Autonomous Vehicle Navigation via Global Positioning Systems

Introduction

The Global Positioning System (GPS) provides information about location on or near the earth. Satellites send information such as their position in orbit and the time the signal is sent to receivers that interpret the data into latitude and longitude coordinates. When GPS information is given to an autonomous vehicle, the computer in the vehicle must interpret the data and make a decision on how to reach its destination. The hardware components and algorithms behind autonomous GPS navigation are constantly changing. This paper reviews state of the art commercial applications and the technology behind them that make autonomous GPS navigation possible.

Commercial Applications of GPS for Autonomous Vehicle Navigation

Autonomous Vehicle Platform

Autonomous navigation using GPS requires at minimum a device to acquire positional information and a computer to use the data to make navigation decisions. The CompactRIO Control and Acquisition System by National Instruments is a platform that unifies the ability to acquire and process GPS data. This system consists of an embedded real-time processor (400 MHz Freescale MPC5200 processor) and an embedded FPGA chip [1]. The CompactRIO is also extendable through C Series I/O Modules, which are developed by National Instruments and third parties [1]. The whole system is brought together by the programming language LabView, which is also developed by National Instruments. This allows the CompactRIO to be a complete GPS navigation solution, that sells in the $4000 to $3200 range depending on the microprocessor speed, RAM, and storage required [2, 3].

GPS Acquisition

The ability to gather GPS data is not provided directly by National Instruments. This functionality is provided through modules developed by companies like Marine Innovations. The Mar-In GPS is a C Series Compatible module that is built with a Garmin GPS chip at its core. The accuracy of this module is within 1 microsecond, and is sensitive to -165 dB [4]. The Mar-In GPS also includes sample code for LabView.

The second GPS module option is provided by Science & Engineering Applications (S.E.A). Although the module is made by a German company it is capable of receiving signals from the U.S.
NAVSTAR network. The GPS by S.E.A is a C Series module and can be connected directly to the CompactRIO [5]. These modules cost roughly 700€ or about $1000 U.S. dollars [6].

**Technology behind Global Positioning Systems**

*Infrastructure*

The ability to track a location using GPS is possible because of a network of satellites operated and developed by the United States Department of Defense called NAVSTAR (Navigation System with Timing and Ranging Global Positioning System). According to [7] NAVSTAR will have 32 operational satellites orbiting the earth on six different orbital planes to ensure that at least four are in radio communication with any given point on the earth. Three more of these satellites will be launched in the year 2010 beginning in May. According to [8] these are the Navstar-2F one, two and three. They, like their predecessors, will operate by continuously sending data to GPS receivers which collect the information and can calculate an initial position in about 12.5 minutes [9].

*GPS Chips*

The primary component of a GPS device is the receiver chip inside. The chip collects information from the satellites in space and calculates position. It can be packaged and placed into any number of devices such as the modules mentioned above or as standalone products such as a personal car navigation systems. The quality of a GPS chip is measured by their sensitivity and accuracy. [10] reviewed several top performance chips and found that the QinetiQ Q20 H was so sensitivity it was able to be used indoors.

**Implementation of GPS in autonomous vehicles**

For GPS to be useful in an autonomous vehicle, the computer driving the vehicle must be able to retrieve data from the GPS receiver. The standard output protocols for a GPS receiver are defined by National Marine Electronics Association (NMEA). NMEA 2000 is the newest protocol and improves upon NMEA 0183 by mandating a physical layer in addition to a data link layer, network management, and an application layer [11]. After reading information in using the proper protocol, the on board computer knows its current location, and possibly its velocity. The drawback to GPS is that it updates roughly one time a second and can be prone to signal loss. For this reason other sensors are typically used in autonomous vehicles. [12] suggests using an inertial system to supplement the GPS when the signal from a satellite is degraded or lost. The end result is that to reliably implement GPS into an autonomous vehicle, determining when not to use GPS data can be just as important as the information streaming from the receiver.
References


