Distributed Localization

Abstract

Working in conjunction with University faculty, our team is developing a testing platform which can effectively evaluate a possible solution to the problem of localization. Our team is developing a platform that implements their work using vehicle to vehicle (V2V) communication. Current industry leaders in autonomous vehicles are working on localization and V2V communication. Millions of dollars have been invested into developing these vehicles and still no economically feasible solution is available. Our team is developing a simple, inexpensive alternative to the current V2V and localization technologies. The University faculty interest is aimed at localization, specifically GPS systems need to be improved to provide sub-meter accuracy. The research completed with this platform will increase inexpensive GPS module accuracy through a system of averages. The communication will be done through a ZigBee board with IEEE 820.15.4 standard V2V protocol and CSMA enabled.

Problem Definition

The objective of this project is to develop a testing platform that can be used to analyze the success of various algorithms in order to improve upon the accuracy of a GPS module. This testing platform is going to be used by the client in his personal research, which involves a weighted averages algorithm to determine the precise location of several nodes over a decentralized network. By knowing the location of a node down to sub meter range or error, the benefit can be seen in a vehicle implementation, where low position error is needed to locate the vehicle to a specific lane. Even though this level of accuracy can be achieved using a differential GPS module, the price of a base station for these modules can range from $10,000 up to $30,000 and, the price of the mobile unit that communicates to the base station can range from $100 up to $500. If a solution can be developed that uses inexpensive GPS modules in the range of $10 to $50 then this would be more practical for implementation in vehicles.

In terms of constraints, the project must consist of a large number of mobile nodes as well as several fixed nodes. These nodes will be representative of moving vehicles on a road and roadside units with precise confirmed locations. The customer, suggested having 6 fixed nodes and 18 mobile nodes, for a total of 24 nodes, in order to effectively test his algorithms. In addition, all of the nodes must have some type of collision avoidance and all-to-all communication between the nodes must be avoided.

In order for this project to succeed we must deliver a system that allows the client to effectively test his algorithms and determine if they are working properly. To achieve this, we will have data storage units on each node that the assumed GPS location will be written on to as well as time stamps and velocity vector estimations. These results will be compared to data from a LIDAR with a fixed location that would be measuring the distance from itself to the nodes for comparison.

Background

A research platform that is directly related to the one that our team will develop was started before this year. This platform's goal was proof of concept rather than testing and implementation. The project originally used a microcontroller with a Bluetooth dongle to achieve communication between other units, but it was never fully finished.

In order to pursue the use of the IEEE 802.11p standard in this project, five companies were contacted that sell products that used the standard. The pricing that was received from these companies ranged anywhere from $1,500 to $10,000 per unit. The units varied in configuration, from a complete unit solution to a programmable board. Since there will need to be 24 nodes or more, this made the use of a commercially available product far too expensive for this project's budget and a new solution needed to be found.

For the localization aspect a few GPS modules were looked at for consideration. Improving upon the accuracy of the module was the overall goal, and the two primary concerns were the base accuracy of the module and the compatibility of the module with the microcontroller. The modules being considered have position accuracy that ranges from 2 to 5 meters. All of the modules were compatible with the microcontroller, and the next concern aside was the update frequency. The moving nodes will be traveling at considerable speed and the position needs to update multiple times per second in order to detect small changes in position.

Potential Solutions

1. The customer desires a solution in which he is able to test his research. This entails a solution that meets all the defined criteria and constraints. In doing so, multiple solutions were generated. The first solution enlist the use of 24 volunteers and their cell phones. Cell phones are the ideal implementation method because they already implement the 802.11P protocol requested be used. The platform in which our customer would test his research on would be in the form of a mobile app that would be downloaded onto each volunteer's devices. The app would use the phone's' built in GPS module and would log the tracked location and send it back to a central data reclamation unit at the conclusion of the test.

2. The second alternative involves implementing the computational platform onto a preexisting network. The proposed network would be a golf course with the mobile nodes being attached to golf carts while the stationary nodes would be placed throughout the course. The benefit of using this alternative is that the mobile platform is already established. The problem with this alternative is that the platform cannot be easily managed by the customer who would have no control over the movement of the nodes.

3. The third alternative comprised of mobile units implementing a Wi-Fi network. While this is a viable solution for the problem at hand, our customer has requested that we implement the 802.11P protocol. Wi-Fi protocol was not designed to be an ad hoc network used for mobile communication. Because our target implementation area is a highway situation with multiple mobile nodes the customer has requested that we use the

standard mobile communication protocol (802.11P).

4. Finally, building off of the large number of mobile nodes required to meet our customer needs, a mobile platform consisting of RC car could be used. These cars will be outfitted with a microcontroller, GPS module, a transceiver/receiver (ZigBee), and a data reclamation unit. The GPS data will be logged to the data reclamation unit so that data validation can be made. The transceiver/receiver unit will allow for decentralized communication and will avoid all-to-all communication due to its short transmission length.

Proposed Solution

To fulfill all the requirements of this project, the most viable solution is #4. This decision was based on many things the first of which being mobility. Our customer desires a solution in which he is able to test his research at his discretion therefore it is not reasonable nor feasible to use a mobile platform in which there is a need for 24 volunteer participants (#1). Secondly, the solution needs to have semi controllable mobile nodes and be fairly inexpensive. This eliminates the golf course solution because of the range of the transmitters/receivers would make them expensive and, there is no control of the nodes.

The design will be granted mobility through the use of an off-the-shelf RC car that will be interfaced with the microcontroller. The OEM circuitry/microcontroller will be removed and replaced with the new microcontroller. Granting the microcontroller access to the motors will allow an automated aspect to be implemented in the system. It will also add the ability to gather crucial information such as speed and velocity.

As mentioned in the background section, the researched units that use the 802.11p standard are expensive, and with a project requiring 24 nodes, this makes the use of such a transmitter/receiver device not feasible at the moment. The implementation of the ZigBee communications board will allow for faster prototyping and verification of GPS localization algorithms that are to be implemented.

Manufacture

As previously stated, this project require that 18 mobile units and 6 stationary units be produced. The RC car will be the foundation of the build. The Arduino board will be mounted to the upper frame of the RC, right on the bumper sub frame. Attached to the Arduino will be the ZigBee controller, memory modular, and motor controller shield. Four small screws will secure the Arduino to the RC car. The wires that control the motors on the RC vehicle are located below the bumper sub frame, but on the main frame. Small holes will be drilled on the side of the frame to neatly run the wires from the frame to the Arduino and its connected components. The RC vehicle shell will have a portion cut out to allow it to be re-secured to the bumper sub frame.

The 6 stationary nodes will contain everything that the mobile nodes contain except the RC car and the motor controller shield. These nodes will be mounted to a small wooden plate using four screws so they can be placed outside at a desired location. By mounting these stationary nodes we can get the nodes up off the ground while also allowing for adjustment in the placement of the nodes as desired.