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Research Results

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Project Title:
Connected and Automated Vehicle (CAV) Infrastructure Development

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Network Differential GNSS Corrections for Connected and Autonomous Vehicles

Develop, evaluate, and demonstrate software to implement the State-Space Representation (SSR) correction server approach for CAV applications

WHAT WAS THE NEED?

Autonomous vehicles, connected vehicles, and driver's assistance applications are placing much stricter position accuracy and reliability specifications on navigation systems than was required for previously consumer applications. For example, stated specifications (e.g., SAE J2945) require horizontal and vertical position accuracy of 1.5 m and 3 m with at least 68% probability, respectively.

The Federal Highway Administration, state Department of Transportations, and auto manufacturers are investigating such vehicle applications that will benefit from real-time, Earth Centered Earth Fixed (ECEF) position estimates achieving such specifications. Pilot projects are ongoing in at least three locations (Wyoming, New York, and Florida). These pilot projects use differential Global Navigation Satellite Systems (DGNSS) for vehicle position (and state) determination.

All pilot projects to date are using DGNSS data from local base stations (i.e., observation state representation). Such local base station approaches work well within about 30km of the base station location even with a small amount of communication latency; however, with hundreds of thousands of intersections in the US, these local approaches do not scale to the statewide, national, or global levels.

Commercial on-vehicle implementation of DGNSS positioning achieving such specifications will require widely and reliably available differential corrections. Such approaches are referred to as State-Space Representation (SSR) DGNSS. SSR DGNSS uses a significantly smaller number (i.e., 10-100) of base stations that cooperate to estimate each GNSS error component separately (i.e., satellite vehicle position and clock error, Ionospheric delay, satellite biases), then broadcast models of each error component. Users or correction distributors then use the models to construct locally applicable corrections.

The SSR approach advantages include: the user or correction distributor does not need to install and maintain a local base station; SSR communication bandwidth is much lower than that of sending corrections from local base stations with global coverage; SSR reliability is much higher than that of local base stations.

WHAT WAS OUR GOAL?

The goal of this project was to provide a new (currently unavailable) free online resource that provides differential GNSS correction applicable to the vicinity of a client location, without the client needing a differential GNSS base station.

WHAT DID WE DO?

This research performed the following tasks:

1. Connected to online sources of real-time SSR model data, such as the National Oceanic and Atmospheric Administration for United States Total Electron Count (USTEC) maps and International GNSS Service (IGS) for satellite vehicle position and clock error.
2. Accepted connections from clients. Each client sent its approximate local position (accurate to about 10 km). Stationary clients such as signal Phase and Timing (SPaT) controllers sent approximate position only once.
3. Broadcasted to the client the real-time Radio Technical Commission for Maritime (RTCM) format corrections applicable to the vicinity of the client. If the client was a vehicle or user, the client passed the RTCM correction to its GNSS receiver. If the client was a distributor (e.g., a SPAT controller), it communicated the RTCM correction to its local users.
4. Developed the hardware and software for this experiment.
5. All the documentation and software were uploaded to the Github along with the user manual.

WHAT WAS THE OUTCOME?

The outcome was the implementation of client-server architecture, as depicted in Figure below. The server accesses DGNSS SSR correction information in real-time, from which it computes Observation Space Representation (OSR) corrections suitable for each client (i.e., user) location. The user connects their receiver to the server through a client program. The client (a) establishes communications with the user receiver through a receiver port; (b) receives an estimate of the receiver location Pb; (c) enables differential operation on that receiver; (d) establishes communication with the server via ethernet TCP/IP, (e) communicates the virtual reference station location Pb for this client to the server; (f) relays correction information using the RTCM format from the server to the user receiver.

WHAT IS THE BENEFIT?

The direct benefit of this project is a) availability of high accuracy Differential GPS solution for stationary and moving platforms and that surpasses the SAE specifications b) Open up opportunity for lane level accuracy for Connected and Automated Vehicle (CAV) applications.

LEARN MORE

The code and user manual can be downloaded from the following link:

GitHub - jaffarrell/WADGNSS: Virtual Network Differential GNSS Application