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 IS 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 previous consumer applications. For example, stated specifications (e.g., Society of Automobile Engineers J2945) require horizontal and vertical position accuracy of 1.5 meters and 3 meters with at least 68% probability, respectively.

The Federal Highway Administration (FHWA), State Department of Transportation (DOTs), and auto manufacturers are investigating such vehicle applications that will benefit from real-time, Earth Centered Earth Fixed 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 30 kilometers of the base station location even with a small amount of communication latency. However, with hundreds of thousands of intersections in the United States, 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 Global Navigation Satellite Systems (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 ARE WE DOING?**

This research entails the following tasks:

1. Connect 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. Accept connections from clients. Each client will send its approximate local position (accurate to about 10 km). Stationary clients such as signal Phase and Timing (SPaT) controllers will send approximate position only once.
3. Broadcast to the client the real-time RTCM format corrections applicable to the vicinity of the client. If the client is a vehicle or user, the client will pass the RTCM correction to its GNSS receiver. If the client is a distributor (e.g., a SPaT controller), it will communicate the RTCM correction to its local users.

**WHAT IS OUR GOAL?**

The goal of this project is 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 IS THE BENEFIT?**

The outcome of this project decreases the cost and time required for DOTs, FHWA, and others to setup demonstration and evaluation sites for connected vehicle, autonomous vehicle, and driver’s assistance applications. It also provides DOTs and FHWA with its first resource for evaluation of the SSR approach, which is foreseen as the approach that would be utilized in national and global commercial connected vehicle, autonomous vehicle, and driver's assistance applications. This will place California at the forefront of this technology area.

**WHAT IS THE PROGRESS TO DATE?**

The implementation of the client-server architecture, as depicted in Figure 1 is complete. The server access DGNSS state-space representation (SSR) correction information in real-time. 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
c. Enables differential operation on that receiver
d. Establishes communication with the server via ethernet TCP/IP
e. Communicates the virtual reference station location for this client to the server
f. Relays correction information using the RTCM format from the server to the user receiver.

**IMAGE**

![Figure 1: Client Server architecture](image-url)