DRISI

Caltrans Division of Research, Innovation and System Information

Research Notes

Advanced Research

JULY 2020

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

Task Number: 3746

Start Date: January 1, 2020

Completion Date: December 31, 2020

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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 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 Transportations (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

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DRISI provides solutions and knowledge that improves California's transportation system 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?

The research team at the University of California, Riverside (UCR) will develop, evaluate, and demonstrate software to implement the correction server approach. The correction server will:

- Connect to online sources of real-time SSR model data, such as the National Oceanic and Atmospheric Administration for United States Total Electron Count maps and International GNSS Service for satellite vehicle position and clock error.
- 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.
- Broadcast to the client the real-time Radio Technical Commission for Maritime (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.

Once developed, the research team will begin evaluation with UCR users. The goal of this step is to achieve a stable and reliable implementation with multiple users prior to expanding the evaluation. Within the scope of the project, selected users would be invited from across the state and nation to use and evaluate the system.

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 DGNSS 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 Correction Server (CS) has been implemented and is functional. The CS computes the corrections suitable for users in the vicinity. The CS computes the satellite transmission time and propagation time for a receiver. The CS then computes the pseudo-range and carrier phase measurements. Once computed, the CS implements and sends to a user RTCM message types 1002 and 1005. The CS is a C++ multi-thread program that runs on a Linux platform that broadcasts RTCM messages using Transmission Control Protocol/Internet Protocol (TCP/IP).

Testing has also been performed on a u-blox M8P GNSS receiver through its serial port. With the reception of correction messages, the u-blox M8P GNSS enters DGNSS mode. Based on this initial testing, the research team achieved the goal of showing that on-line Precise Point Positioning (PPP) data can be formulated into corrections for remote users to improve positioning accuracy during the times that those corrections are available. The methods to improve the reliability of the data that we receive from the online PPP data sources (e.g., International GNSS Service and US-TEC) is still under investigation. The testing to date has used a direct (i.e., wired) connection between the machine hosting the CS and u-blox receiver. The research team is working to achieve communications from the CS to remote users by TCP/IP connections.