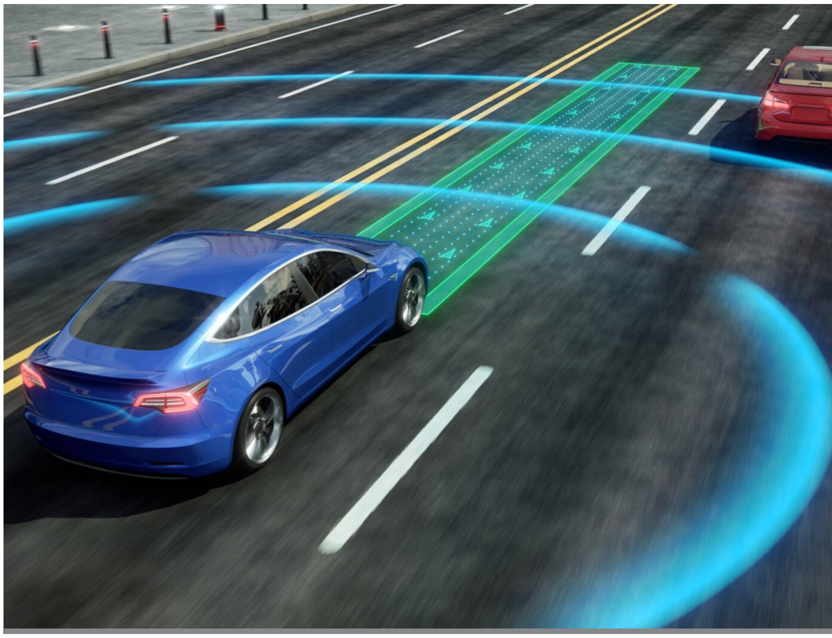


National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Sensors

More Reliable Doppler Lidar for Autonomous Navigation

Sensor algorithm salvages compromised lidar signal data

NASA pioneered Navigation Doppler Lidar (NDL) for precision navigation and executing well-controlled landings on surfaces like the moon. The lidar sensor utilizes Frequency Modulated Continuous Wave (FMCW) technique to determine the distance to the target and the velocity between the sensor and target. Specifically, homodone sensors obtain the changes in signal frequency between the received and reference frequencies for calculating both speed and distance. However, homodyne detection cannot provide any phase information. This is a problem because the current sensor cannot determine the sign (+/-) of the signal frequencies, resulting in false measurements of range and velocity. NASA has developed an operational prototype (TRL 6) of the method and algorithm that works with the receiver to correct the problem. Using a three-section waveform and an algorithm to resolve ambiguities in sign when the signal is compromised, the algorithm analyzes historical phase information to interpret the sign of the remaining frequencies and recover the phase information that contains valuable measurement information.

BENEFITS

- Increased reliability of lidar data: reduces ambiguities that are due to partial loss of a signal
- Easy implementation: algorithm works with current homodone sensors
- Optimal data use: recovers valuable information from partial data signals
- Improves safety and efficiency: reduces the chance of errors due to misread signals.

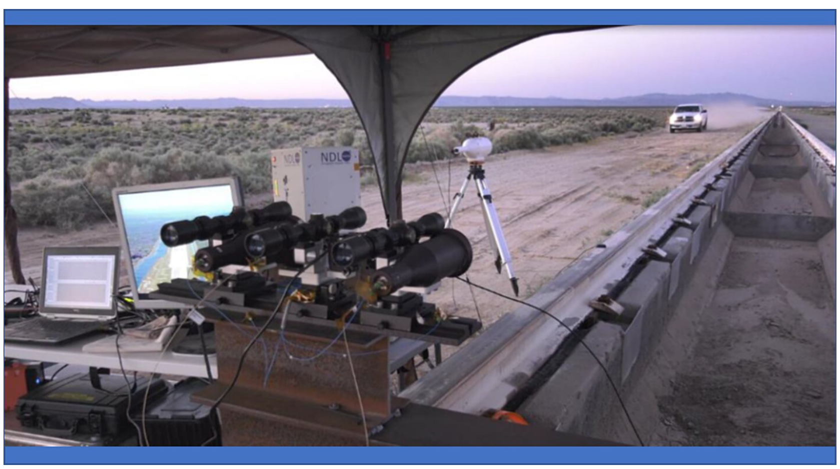
APPLICATIONS

The technology has several potential applications:

- Self-driving cars: provides both 3D range and Doppler (velocity) images of surroundings
- Aircraft Navigation: system allows navigation in GPS-denied environments
- General Automated Rendezvous and Docking: provides relative position, approach velocity, and relative orientation and attitude of the docking port.
- Space: NDL can enable precision navigation to the desired landing location for future large robotic and crewed landing missions,.

THE TECHNOLOGY

The NDL uses homodyne detection to obtain changes in signal frequency caused by a target of interest. Frequency associated with each segment of the modulated waveform collected by the instrument is positive or negative, depending on the relative range and direction of motion between the NDL and the target. Homodyne detection offers a direct measurement of signal frequency changes however only the absolute values of the frequencies are measured, therefore additional information is necessary to determine positive or negative sign of the detected frequencies. The three segmented waveform, as opposed to conventional two-segmented ones, allows for resolving the frequency sign ambiguity. In a practical system, there are times when one or more of the three frequencies are not available during a measurement. For these cases, knowledge of the relative positions of the frequency sideband components is used to predict direction of the Doppler shift and sign, and thus make correct range and velocity measurements. This algorithm provides estimates to the sign of the intermediate frequencies. The instrument operates continuously in real time, producing independent range and velocity measurements by each line of sight used to take the measurement. In case of loss of one of the three frequencies, past measurements of range and velocity are used by the algorithm to provide estimates of the expected new range and velocity measurement. These estimates are obtained by applying an estimation filter to past measurements. These estimates are used during signal loss to reduce uncertainty in the sign of the frequencies measured once signals are re-established, and never to replace value of a measurement.



The new algorithm has been tested with the homodone sensor in performance tests like this one in which the NDL and its three transmit/receive telescopes are placed on the end of the rocket-sled track

NASA's new algorithm helps NDL enable safe and reliable landings on surfaces.

PUBLICATIONS

Patent Pending

Amzajerdian, Pierrottet, et. al. Navigation Doppler Lidar Performance at High Speed and Long Range. 2020 AIAA SciTech Forum. April 2020.

Farzin Amzajerdian, Glenn D. Hines, et al. Characterization of a Coherent Doppler Lidar for Operation Onboard Aerial and Space Vehicles. OSA Laser Congress September 29 - October 3, 2019.

More Information

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