Objective

To demonstrate lane keeping of vehicles in normal and snow-covered lane by modifying electromagnetic (EM) signature of the pavement using EM modified and sensing it with custom made magnetometer array.

Motivations

- Adverse weather lane keeping.
- Autonomous vehicles and vehicles with advanced driver assistance systems (ADAS) have safety critical limitations during adverse weather conditions.
- Sensors like GPS and camera have lower positional reliability when lane markings are obstructed by snow, water, ice, or due to shadow and varying lighting conditions.
- Currently AVs do not interact with road.
- Roadway can be modified with passive materials to create a sensing system to supplement the current system and improve lateral positioning during adverse conditions.

Methodology

- Passive Sensing: Create unique and repeatable (EM) signature on the lane.
- Used concrete blocks with cross section area of 3 inch x 3 inch containing metals like steel fiber and metglas.
- Placed the concrete blocks on the surface of pavement at the center of 12 ft. wide and 150 ft. lane.

Vehicle position estimation

- Center of vehicle at each time step was determined from two side cameras, front camera, and magnetometer sensor array.
- Cameras used computer vision techniques of perspective transformation followed by canny edge detection algorithm and Hough line transformation to determine the lane markings. The distance be
- The magnetometer array detected the EM signal, the peak of which corresponds to the center of the lane.

Test Results

- Normal
- Snow <1 inch
- Snow > 2 inch

Test conditions

- Test was performed in normal (dry surface with visible lanes) conditions and when the lane was covered by less than 1 inch of snow (partially obstructing lane marking) and more than 2 inches of snow (lane marking not visible).

Error estimation

- Vehicle’s true position (ie. ground truth) was estimated by taking the average of position determined by two side cameras.
- At any time, the error of front camera or magnetometer sensor was computed as absolute difference between the reading of corresponding sensor and ground truth.

Findings

- EM signature can be used for vehicle localization in both normal and adverse conditions.
- The error of camera increases significantly with partial lane obstruction by snow and fails to perceive lane marking with > 2 in. snow.
- Magnetometer array can determine vehicle position with statistically similar error irrespective of surface weather conditions.

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