

JOINT TRANSPORTATION RESEARCH PROGRAM

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TScan–Stationary LiDAR for Traffic and Safety Applications: Vehicle Interpretation and Tracking

Introduction

Learning about traffic operations and improving traffic performance and safety requires the ability to accurately measure traffic, including motorists and other vulnerable road users, at road intersections for sufficiently long periods. The efficiency of collecting and analyzing intersection data is particularly important given the expectation of a growing presence of autonomous and connected vehicles in traffic. Project SPR-3831, conducted by the Center for Road Safety, has demonstrated that it is feasible to detect and track various types of road users (e.g., trucks, cars, pedestrians, and bicycles) using a LiDAR-based system called TScan. The mentioned study provided a set of specifications recommended to build a trailer-based prototype. This project, SPR-4102, was intended to progress towards a real-world implementation by further importing the design and performance of the original TScan unit and building two trailer-based prototypes with full end-user documentation.

Findings

The previously developed detection and tracking algorithms have been modified to increase their tracking accuracy, and the software has been converted from the research code written in MATLAB to its implementational version written in the C++ programming language. This conversion increased the real-time execution capabilities of TScan.

Two trailer-based TScan units have been built. Although they follow the operational specifications, due to the unavailability of the LiDAR sensor recommended in specifications, a two-sensor setup was selected as an alternative. To decide the types of sensors and their relative positioning in the TScan head, we simulated the data points' density in the individual fields of view of the candidate sensors. The design of the prototype was iterated multiple times to account for component placement, ease of maintenance, etc. The part of the prototype containing all the sensors is detachable from the trailer for easy storage in a secure location.

The expansion of the TScan system from a one single-sensor unit to multiple units with multiple LiDAR sensors necessitated transforming all the measurements made in their local reference systems into a common spatial and temporal reference frame. This process also included a GPS-based time synchronization method.

One of the envisioned uses of the TScan system is detecting traffic conflicts, which requires sufficiently accurate positions and velocities of objects moving within the system's field of view. The signal processing algorithms developed as part of SPR-3831 were modified or replaced to significantly enhance tracking quality. This modification has significantly reduced the false positives conflicts detection. The evaluation results are provided in the research report.

Engineering applications for performing traffic counts, analyzing speeds at intersections, and visualizing pedestrian presence data were developed. The limitations of the existing SSAM for traffic conflicts analysis with

computer simulation prompted the research team to develop and implement its own traffic conflicts detection and analysis technique applicable to real-world data.

Implementation

Two trailer-based prototypes were built as part of this project. The algorithms were implemented in C++ with extensive use of parallel processing and careful memory management to achieve real time tracking. A post processing module was implemented to further improve tracking accuracy and also allows data from multiple trailers to be combined into one set of results, thus making the TScan system scalable. The report also provides user manuals for setting and operating the TScan research unit and for the various engineering applications mentioned above.

Efficient use of the development system requires proper training of its end users. An INDOT-CRS collaborative process was developed and its execution planned to gradually transfer the two TScan prototypes to INDOT. This process involves a sequence of informational meetings and joint field data collection exercises

of growing comprehensiveness. The role of CRS personnel will be gradually reduced in these exercises, while involvement of the INDOT end users will increase. This period will be also an opportunity for collecting feedback from the end user and for making limited modifications of the system, where possible, and in the documentation as needed.

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Two trailer-based TScan units used together to improve effective coverage.



TScan "head unit" in its carrying case for transport.

