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Overhead Collision Alerts and Overhead-obstacle Aware Navigation Planning Using Onboard Sensors and Vehicle-to-Vehicle Communication

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ABSTRACT

A common type of single-vehicle accident involves a vehicle entering a passageway with insufficient clearance. Variable vehicle dimensions, e.g., oversized trucks, automobiles with roof-mounted bicycles, etc. pose a special challenge since the dimensions of the vehicle are non-standard for just the duration of the trip. Little is done today to alert drivers of impending overhead collisions. Vehicles today utilize no more than clearance lights to signal their oversize dimensions to other vehicles. Navigation tools that account for low-ceiling passageways do not account for non-standard dimensions. This disclosure describes the use of cameras and LiDAR sensors to determine both the dimensions of the vehicle as well as oncoming passageways to warn the driver of potential overhead collisions. The dimensions of the vehicle are utilized along with dynamically updated maps to chart a route that is free of overhead obstacles.

KEYWORDS

- Low-clearance passageway
- Low bridge
- Low tunnel
- Oversize vehicle
- LiDAR
- Clearance-aware navigation
- Constraint-aware navigation
- Vehicle-to-vehicle communication
- Navigation

BACKGROUND

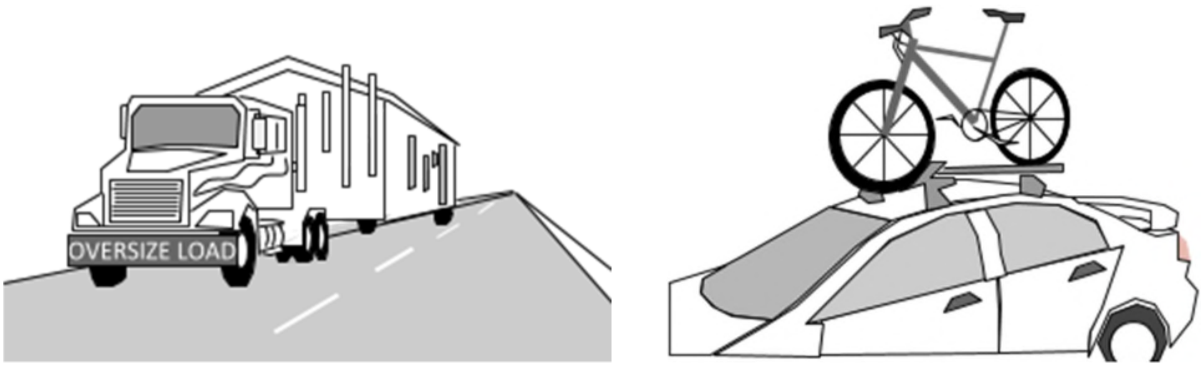

Fig. 1: Vehicles with variable dimensions

A common type of single-vehicle accident involves a vehicle entering a passageway, e.g., a tunnel, a garage, or a low bridge, with insufficient clearance. Variable vehicle dimensions, e.g., oversized trucks, container trucks or trucks transporting prefabricated homes, vehicles with roof-mounted bicycles or other cargo, nonstandard or variable-size cargo holds mounted on a truck chassis, towed trailers attached to otherwise standard-sized cars or SUVs, standard-sized consumer trucks carrying tall items such as furniture pieces, etc., as illustrated in Fig. 1, pose a special challenge since the dimensions of the vehicle are non-standard for just the duration of the trip.

Little is done today to alert drivers of impending overhead collisions or to prevent such collisions. Vehicles today utilize no more than clearance lights to signal their oversize dimensions to other vehicles. Navigation tools that account for low-ceiling passageways do not account for non-standard dimensions. Also, current navigation tools do not include up to date knowledge of overhead obstacles and clearance signage, as curated datasets generally do not exist and need to be specially obtained. Preventing collisions with static landscape features is almost completely dependent on driver alertness.

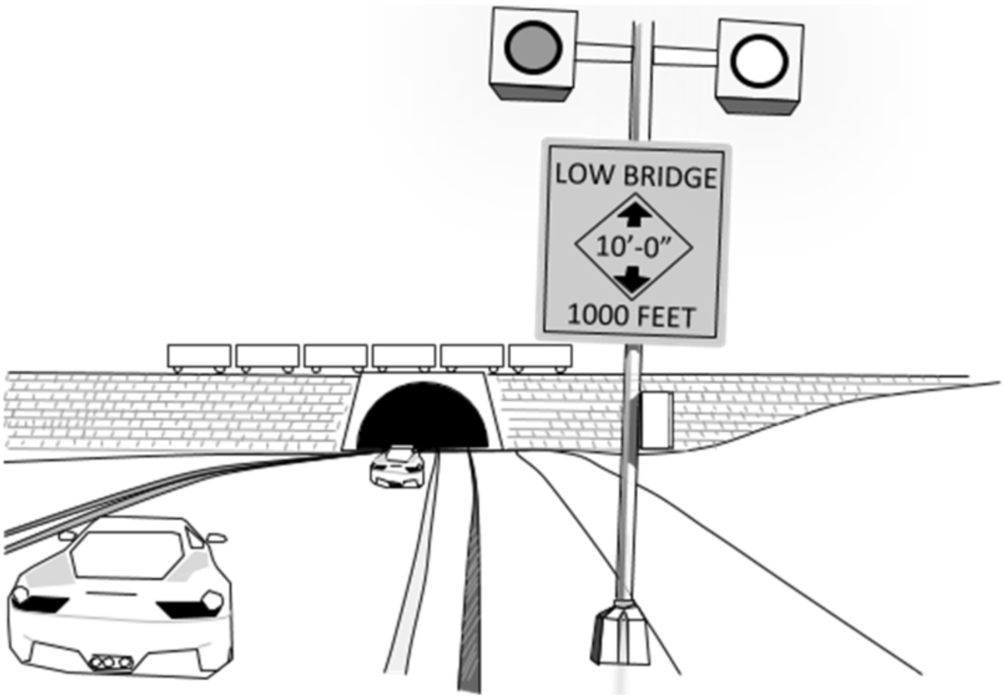

Fig. 2: An example of a warning sign for insufficient vertical clearance

A substantial amount of photographic and dimensional data relating to streets has been gathered over the past decade. Today, an accurate, three-dimensional picture of streets and nearby surfaces and regions has become available with the use of LiDAR. The corpus of street-level imagery also records the locations of various clearance signs and warnings, e.g., as illustrated in Fig. 2, listing the maximum clearance values for a road segment. This data, when regularly obtained and analyzed, provides a reasonably good and relatively up to date picture of the static conditions of the road network.

DESCRIPTION

This disclosure describes the use of on-board cameras and LiDAR sensors to determine both the dimensions of a vehicle as well as oncoming passageways to warn the driver of potential overhead collisions. The dimensions of the vehicle are combined with dynamically updated maps, e.g., with real-time information and/or information crowdsourced via vehicle-to-vehicle communications, to chart a route that is free of overhead obstacles.

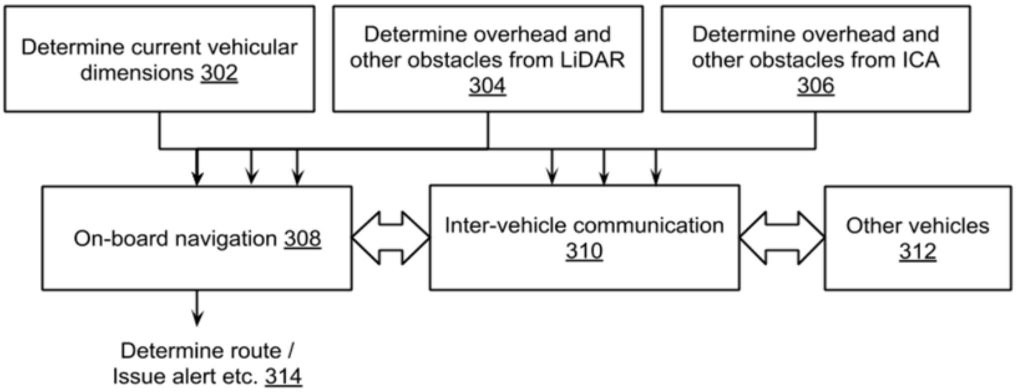

Fig. 3: Overhead collision alerts and navigation planning

Fig. 3 illustrates generating overhead collision alerts and overhead-obstacle-aware navigation planning, per techniques of this disclosure. The current total dimensions of the vehicle, including any changes to its width and height due to cargo, towed trailers, etc. is determined (302) using LiDAR sensors mounted in key places on the vehicle, e.g., one or more on the roof of the vehicle and one on each of the sides. LiDAR sensors have become cheaper and more compact with time and can be included as standard vehicular features.

The LiDAR sensors also collect information about the route itself, e.g., up to date and accurate information on the vertical clearances in the upcoming road segment (304). Clearance signs and warnings are picked up from street level imagery with a machine-learned system, e.g., an image content analysis (ICA) engine that uses real-time images captured by onboard cameras (306). Alternatively, vertical-clearance warnings can be picked by specialized street-sign detectors.

The information generated from the cameras, LiDAR, and other onboard sensors is fed into an onboard navigation (308) unit and, with driver permission, to the inter-vehicle communication (310) unit. The navigation unit uses the determined width and height dimensions of the vehicle to determine a route in a manner that accounts for the vertical clearances required by the vehicle (314). Similarly, real-time alerts are issued based on a comparison of the current vehicular dimensions and vertical clearances in upcoming road segments. In cases where re-routing is not possible, e.g., entering a garage or a low-clearance parking lot with a bike-rack on top, a strong warning is issued to the driver to stop and unload before proceeding further. Further, in compliance with applicable rules and with user approval, the vehicle can be configured to be automatically brought to a gradual halt in the event that the vertical-clearance warnings are not heeded to. The sensors can communicate with the navigation and inter-vehicle communication units via Bluetooth or other onboard communication mechanism.

With driver permission, up to date and accurate information gathered by onboard sensors is shared with other vehicles (312) after suitably treating the data to remove identifiable information. Processing of the sensor data can be performed on-board the vehicle, with resultant data that indicates road clearance requirements being shared with other vehicles, if permitted by the user.

Similarly, information received from other vehicles can be used to determine the route as well as issue alerts to the driver. For example, in an instance where on-board LiDAR of a first vehicle is not able to detect an oncoming overhead obstacle, e.g., due to a sharp turn in the road, a second vehicle that has already passed the obstacle in the opposite direction can communicate a warning to the first vehicle. The disclosed techniques can be applied in a setting where vehicles communicate with each other or with standalone devices fixed onto streetlights, etc., including transmitting and receiving information about vehicle properties, such as size, height, etc. Thus, even vehicles that lack sensors can receive and act on the information in the context of the planned route, so long as they can communicate with sensor-equipped vehicles or stationary roadside devices.

Alternatively, in a setting where vehicles are equipped with appropriate receivers, local authorities can install stationary LiDAR sensors in strategic locations, e.g., on utility or light poles at some distance before low-clearance passageways. Such LiDAR sensors can scan passing vehicles and transmit a warning to vehicles that are detected to possibly not fit in the upcoming passageway. Further, such stationary sensors can turn on a flashing sign or other visual or audio indicator.

The image content analysis engine used to detect road signage uses text transcription to accurately gather clearance numbers from signage encountered along the route. In certain circumstances, e.g., due to lack of recent travel by a LiDAR-equipped vehicle, lack of a cellular signal, etc., the navigation unit may not have accurate information about upcoming obstacles. In other circumstances, the obstacles, e.g., tunnel ceilings, bridges, etc. may not be visible to onboard LiDAR, e.g., due to sharp turns in the road. Under these circumstances, the time taken by LiDAR-based equipment to evaluate and confirm an upcoming overhead obstacle may be high. In this situation, onboard ICA processing of warning signs coupled with text transcription of clearance values enables the provision of the advance warning.

CONCLUSION

This disclosure describes the use of cameras and LiDAR sensors to determine both the dimensions of the vehicle as well as oncoming passageways to warn the driver of potential overhead collisions. The dimensions of the vehicle are utilized along with dynamically updated maps to chart a route that is free of overhead obstacles.

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