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Maneuvering Modelling of a One-Degree-of-Freedom Articulated Vehicle: Modeling and Experimental Verification

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Abstract : The evaluation of the maneuverability of road vehicles is generally carried out through the use of specialized computer programs due to the advantages they offer compared to the experimental method. These programs are based on purely geometric considerations of the characteristics of the vehicles, such as main dimensions, the location of the axles, and points of articulation, without considering parameters such as weight distribution and magnitude, tire properties, etc. In this paper, we address the problem of maneuverability in a semi-trailer truck to navigate urban streets, maneuvering yards, and parking lots, using the Ackerman principle to propose a kinematic model that, through geometric considerations, it is possible to determine the space necessary to maneuver safely. The model was experimentally validated by conducting maneuverability tests with an articulated vehicle. The measurements were made through a GPS that allows us to know the position, trajectory, and speed of the vehicle, an inertial motion unit (IMU) that allows measuring the accelerations and angular speeds in the semi-trailer, and an instrumented steering wheel that allows measuring the angle of rotation of the flywheel, the angular velocity and the torque applied to the flywheel. To obtain the steering angle of the tires, a parameterization of the complete travel of the steering wheel and its equivalent in the tires was carried out. For the tests, 3 different angles were selected, and 3 turns were made for each angle in both directions of rotation (left and right turn). The results showed that the proposed kinematic model achieved 95% accuracy for speeds below 5 km / h. The experiments revealed that that tighter maneuvers increased significantly the space required and that the vehicle maneuverability was limited by the size of the semi-trailer. The maneuverability was also tested as a function of the vehicle load and 3 different load levels we used: light, medium, and heavy. It was found that the internal turning radii also increased with the load, probably due to the changes in the tires' adhesion to the pavement since heavier loads had larger contact wheel-road surfaces. The load was found as an important factor affecting the precision of the model (up to 30%), and therefore I should be considered. The model obtained is expected to be used to improve maneuverability through a robust control system.

Keywords : articuled vehicle, experimental validation, kinematic model, maneuverability, semi-trailer truck
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