リーン・オートモービルの提案とその操縦性の予測

Kentaro Goto [1] **Hideaki Murayama** [2]

1) The University of Tokyo, Graduate School of Engineering
7-3-1 Hongo, Bunkyo, Tokyo, 113-8656, Japan (E-mail: kentarogoto@gmail.com)
2) The University of Tokyo, Graduate School of Frontier Sciences
5-1-5 Kashiwanoha, Kashiwa, Chiba, 277-8561, Japan

KEY WORDS: **Vehicle Dynamics, Dynamic Model, Personal Mobility,** Leaning Trike [B1]

We propose a new minimalistic personal mobility vehicle, the Lean Automobile for the daily transportation in urban areas. It is equipped with a suspension mechanism which is capable of generating leaning moment. The leaning moment is supposed to be applied by a driver as well as the steering moment. The word "Lean" has a double meaning: to incline from the perpendicular and to be efficient. The vehicle has dimensions small enough to park four to five vehicles in one normal parking spot. This dramatically lower the parking charge which is a major burden for urban citizen. We are trying to make the vehicle minimal in order to keep it cheap and light. However, a closed cabin is essential for a daily mobility. Because it's narrow and with closed cabin, the lean control by shifting the driver's weight or by foot is impossible, so we need a mechanism to generate lean moment. We are developing a simple mechanism which can generate lean moment with simply rotating one built-in axle and makes vehicle lean parallel to its wheels. This mechanism is equipped in front axle and front two wheels handle the leaning and steering while rear wheel does the propulsion. The design study of the Lean Automobile is shown in Figure 1.

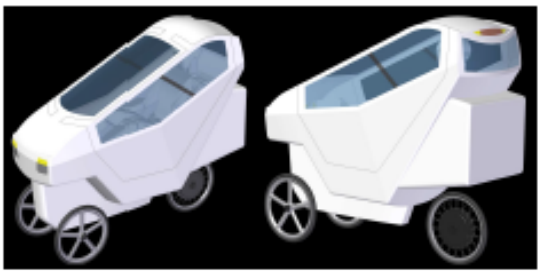
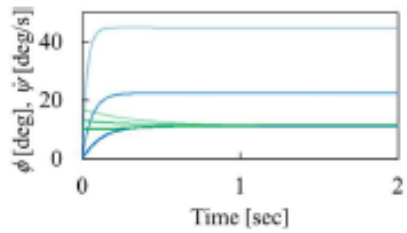


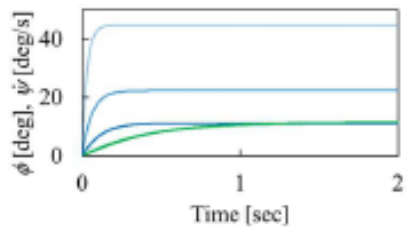
Figure 1 Design Study of the Lean Automobile

In this work, we make calculation of maneuverability of the Lean Automobile. For this purpose, the 4-DoF model for the Lean Automobile is established and the transient responses of the model are calculated. This 4-DoF model is based on a motorbike's 4-DoF model which is established by Sharp. We set the vehicle parameters according to a design value of the vehicle and specs estimation. Then state-space transformation is done for the transient response analysis with Scilab software.

Before the transient response analysis, we verify the 4-DoF model by comparing the result of the steady-state turning calculation with the dynamic model analysis. Also, we evaluate the lean angle and lean speed limitations that make the vehicle rollover however driver generate the maximum possible lean moment. This limit is instantly reached by trying to stay upright while turning so if we start to generate lean moment at the start of steering, we are going to rollover in most cases.



(a) Initial Lean Angle



(b) Initial Lean Speed

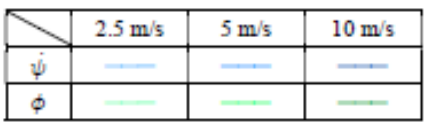


Figure 2 J-Turn Responses

We can avoid this with advanced lean motion as shown in Figure 2. An initial lean angle is set in graph (a) and initial lean speed in (b). When we input the appropriate value, the vehicle reaches to lean-with state like these graphs without any lean moment applied. Also reverse steering maneuver is effective as shown in Figure 3. The lean-with state is achieved only by this steering maneuver: without any lean moment or advanced lean motion. These indicate that the cornering lean control of the Lean Automobile can be achieved effortlessly with the tactics like these.

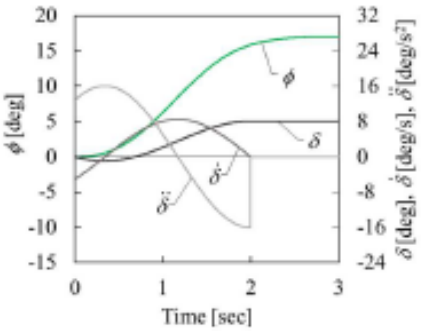


Figure 3 Reverse Steering Maneuver

We get the prospect for the maneuverability of the Lean Automobile through this work, therefore advanced model including the driver, design value evaluation/improvement, and prototype manufacturing/testing will be the next step for the development.