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Modeling of an Overactuated Vehicle in Simscape Multibody for the Characterization of Suspension and Steering Actuation Systems

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EXTENDED ABSTRACT

1 Introduction

Overactuated systems are increasingly among us. They are used for applications in vehicles, aeronautics and robotics, among others [1, 2]. These systems have a number of advantages, among which we can mention that there are multiple (or infinite) solutions for a given problem. More specifically, in the case of overactuated vehicles, similar states of the system can be achieved in many different ways. These systems are still under development, especially in the field of vehicle dynamics. For example, there are various steer-by-wire algorithms, when the steering of the vehicles is independent, or brake blending strategies. In this work, a part of an overactuated vehicle is designed and validated. This multiphysics model allows to know the plant of the system in much more depth in order to develop control algorithms. More specifically, by modeling the delay of the systems and the nonlinear relationships inherent to multibody systems, much more accurate predictive control can be performed. These results allow a previous validation of the control algorithms in the test platform vehicle being manufactured and developed by the research group, greatly accelerating the control process of each of the overactuated systems of the vehicle.

2 Objectives

The objectives of this work are to model the suspension and steering systems in an overactuated vehicle and to establish the characteristics of the actuators. The vehicle under study has the following characteristics (Figure 1):

- Dual symmetry both laterally and longitudinally. The vehicle is composed of four identical vehicle quarters.
- Independent four-wheel drive. A 40 kW PMSM with a maximum rotational speed of 8,000 rpm at each of the wheels.
- Independent four-wheel steering system, allowing adjustment of toe-in or toe-out, as well as drift [3].
- Independent four-wheel active suspension system, allowing the vehicle's height to be adjusted constantly.
- Magneto-rheological spring-damper system, allowing to modify the damping in a controlled manner.
- Combined braking system, by means of electric regeneration or friction brake [4].

These features allow the development of different control algorithms in each of the systems. For example, in the case of traction, it is possible to decide at which operating point each motor is working, with one train driving and the other regenerating (parallel-through-the-road topology). In the case of braking, brake-blending strategies can be developed, both for energy optimization, taking into account several variables, and for optimization in terms of braking distance, developing a combined ABS of friction and electric brakes. As for steering, it also opens up a range of possibilities. Steering algorithms can be developed using the rear wheels, as well as acting independently on the wheels of the same axle, as they lack a common rack. It is possible to maximize lateral acceleration, minimize the radius of curvature for maneuvers, or even correct the vehicle's trajectory in the event of loss of control (oversteer or understeer) [5]. Finally, the active independent suspension maximizes comfort or maximizes contact between the tire and the road. In addition, no torsion bar is used, so that the chassis roll can be controlled. As the actuator is in series with the spring-shock absorber, combined strategies can be established, since the shock absorber is semi-active, as its viscous properties change according to the magnetic field in which the fluid is located. For the purpose of this work, only the last two points will be studied, by performing a multiphysics model in Simscape. This model employs the full power of the Simscape multibody dynamic simulation while allowing the delays, actuators and other vehicle components to be considered. The control algorithms are implemented in Simulink, within the same environment. Once the algorithms are validated, they are transferred to a Speedgoat real-time controller, which controls the systems of the vehicle.

3 Results

The results to be obtained from this work are essentially two. The first one is to develop a model of the vehicle in Simscape Multibody that captures the dynamics of the systems to be controlled reliably. Once the model is developed, it will be used to control the overactuated steering and suspension systems. These systems seeks, on the one hand, to act on the suspension to avoid

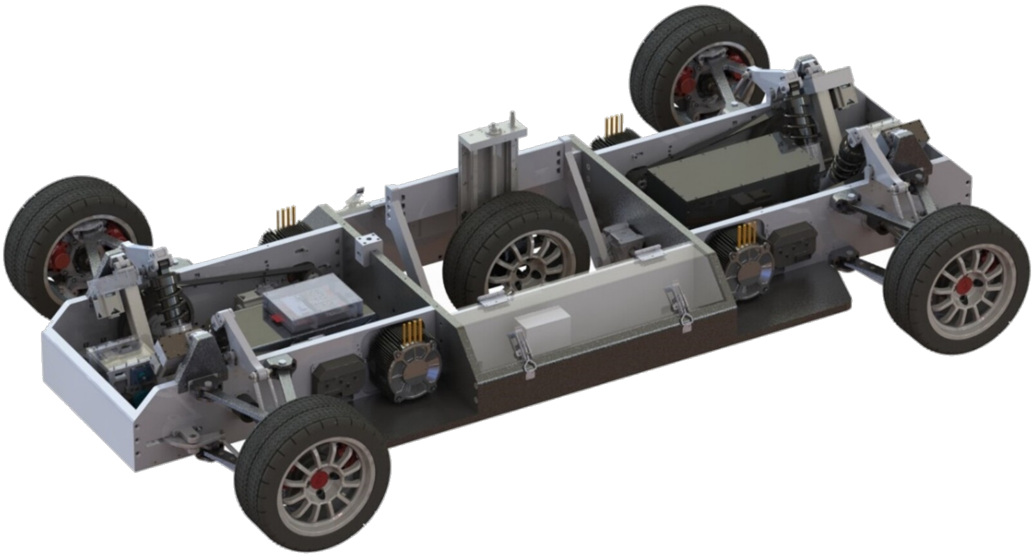

Figure 1: Overactuated electric vehicle

chassis roll in the case of pure lateral dynamics. On the other hand, it seeks to delay the understeer/oversteer process as much as possible by acting on the drift angle of each wheel independently. For this purpose, nonlinear tire-road contact models will be used. This model will also allow us to obtain the forces required in the actuators, as well as to design the control algorithms since everything is integrated within the same software Simulink.

4 Conclusions

This work opens the door to continue with the simulation of this test platform vehicle developed in the research group. Once the steering and suspension algorithms have been tested and the response required by the actuators is obtained, we will continue simulating the different systems that constitute the vehicle in order to implement them and validate the simulations. This allows us to select the correct actuator as well as to know its mechanical and electrical requirements. Subsequently, we will continue simulating the different systems that constitute the vehicle in order to implement them in the vehicle and validate the simulations.

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