Simulation and validation of a symbolic model of a of four-wheels steering off-road vehicle

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1 Introduction

Two-steering-gears vehicles are in regain of interest with the improvement of the on-board electronics. This improvement is highlighted in the automotive field by the optimisation of comfort, agility and driving safety. In other fields such as agricultural robotics, mobile robots with two steering gears or four independent wheels permits complex maneuvers in small work spaces [1]. Moreover the autonomous mobile robots that have to follow a reference trajectory have the possibility of respecting another instruction [2][3] such as the control of the yaw angle, precisely thanks to the presence of a 2nd steering gear. At INRAE (French National Institute for Agriculture, Food, and Environment), a mobile robot which four electrical steering gears, called ADAP2E (in Fig 1) robot, has been developped so as to permit agricultural tasks in a limited space and on offroad ground [4]. This robot has simple suspensions based on a arm body which permit a easy tuning. Moreover, this robot is high with regard to the track to test rollover situations.

Such vehicles requires specific control adapted for four wheels vehicle. For real-time simulation and synthesis of model-based control laws, models which can capture only main physical phenomenon with a minimal formulation and that can be inspected and manipulated symbolic level can be very useful. The aim of this paper is to present a such dynamic model of the ADAP2E four wheels steering vehicle. This model has been done with a symbolic approach with the MBSYMBA package [5, 6].

The contributions of this paper are:

- the development of a vehicle model that very simple, yet effective; especially suitable for control design and other real time application;
- the use and comparison of different tyre models (a linear model, a simplified form of the Pacejka's magic formula, a linear model with a adaptable cornering stiffness);
- the experimental validation of the dynamic model from a prototype.

Figure 1. ADAP2E platform

2 Development

A multi-body model of a vehicle based on a minimal coordinates approach has been built. No kinematic loops are considered thanks to the following assumptions: on soft contact between wheel and ground and on small displacements for the suspension. Consequently, a ODE formulation can be derived. Different tyres models have been tested: a linear model, a simplified form of the Pacejka's magic formula, a linear model with a adaptable cornering stiffness.

3 Experimental validation

Simulations have been compared with experimental data obtained from tests performed at INRAE on a dry grass ground. An RTK GPS and an inertial unit are used to measure (directly and indirectly) among other things the forward speed, the yaw rate and the slip angles.

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