Interacting Motion Control

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Background & Motivation

Motion planning problems occur in different areas. One example is development of improved vehicle-safety systems by means of optimal control of road vehicles in time-critical maneuvers. It is discussed in thesis works [2] and [4] where a method for solving optimal maneuvering problems using nonlinear optimization is presented. An example of such maneuvers is a hairpin turn (Figure 1). The considered method allows to get trajectories for different combinations of chassis and tire models, for maneuvers under different road conditions (Figure 2). The method could be used for off-line motion planning, but for area of autonomous driving on-line methods are needed that would allow to use advanced dynamic models to find at-the-limit maneuvers for critical situations.

Figure 1: An example of a hairpin turn. Photo courtesy of RallySportLive.

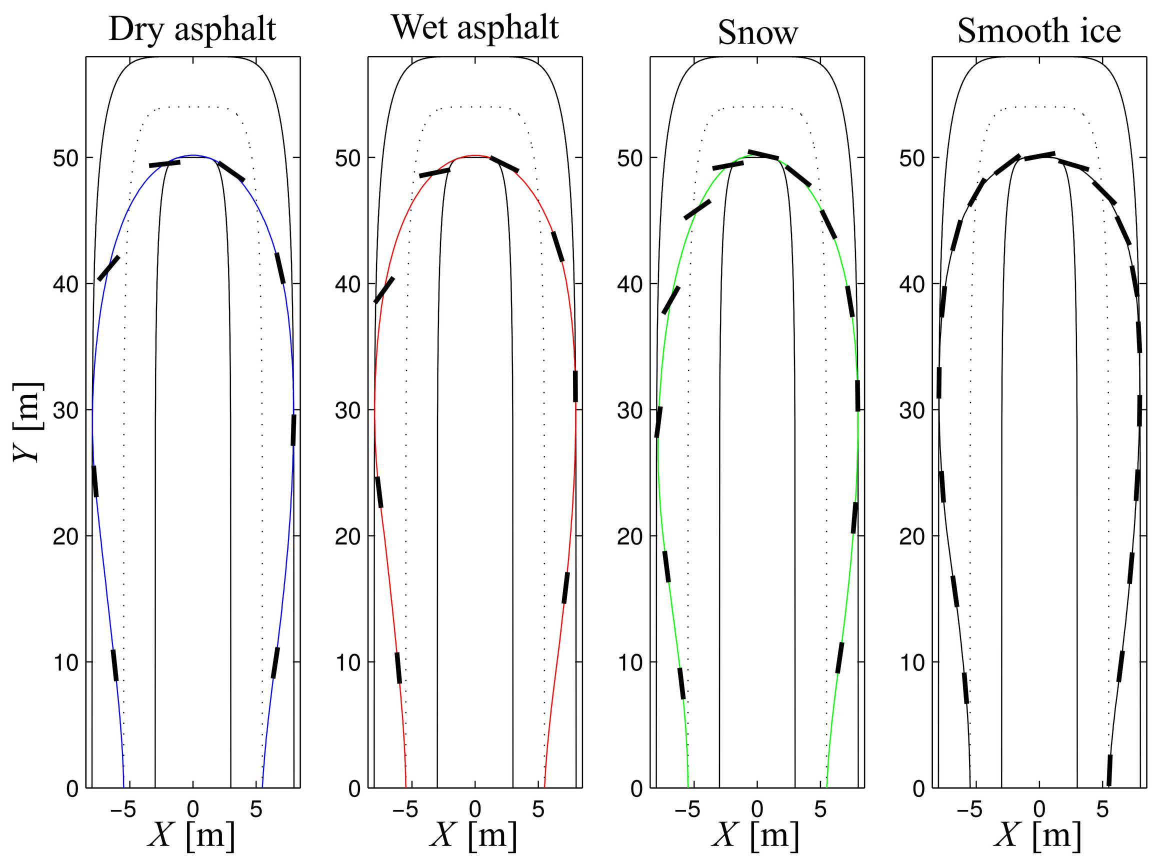

Figure 2: Trajectory in the XY-plane for the different road surfaces. The black rectangles indicate the position and direction of the vehicle each second [5].

Research Goal & Question

The project will consider interacting motion control by means of trajectory planning and optimization. It will take maneuvering capabilities of the vehicle, other vehicles, and traffic situation into account in order to formulate objective functions, constraints and choose vehicle models. First example to consider is the "moose test" (Figure 3) — the lane change maneuver that was transfered to the International Standard ISO 3888-2. The task is to combination of on-line planning and optimal decision making. Consideration of the vehicle's dynamics is required to compute at-the-limit maneuvers in the motion planner. To speed up commutations precomputed data is usually required, but it is unclear what should be precomputed, one example could be a lattice-based motion planner with dynamics for limited set of maneuvers.

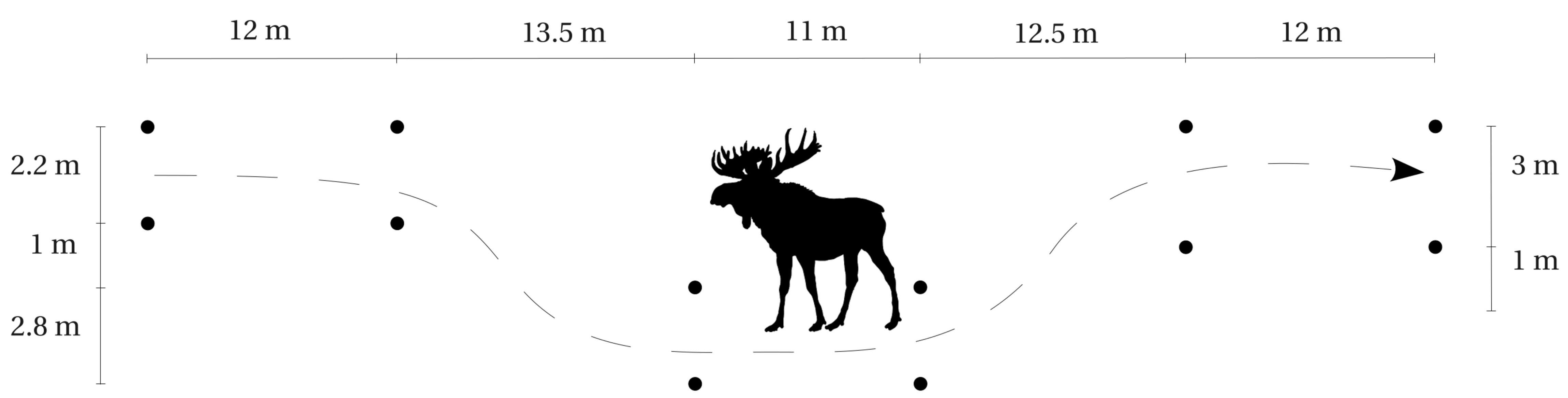

Figure 3: A sketch over the double lane-change maneuver, based on [3].

Methods

To verify different ideas of how dynamic constrains could be incorporated in the motion planner vehicle models to obtain reference data are needed. Such models are available in thesis works [2] and [4] for JModelica.org platform [1]. That platform is used for optimization, simulation and analysis of complex dynamic systems. These models would allow to verify solution of "on-line" motion planner for "moose test" for different road widths and traffic situations.

Bibliography

[1] Johan Åkesson, Karl-Erik Årzén, Magnus Gäfvert, Tove Bergdahl, and Hubertus Tummescheit. Modeling and optimization with Optimica and JModelica.org—languages and tools for solving large-scale dynamic optimization problems. *Computers and Chemical Engineering*, 34(11):1737–1749, November 2010.

[2] Kristoffer Lundahl. *Models and Critical Maneuvers for Road Vehicles.* PhD thesis, Department of Electical Engineering, Linköping University, Sweden, May 2016.

[3] Kristoffer Lundahl, Jan Åslund, and Lars Nielsen. Vehicle dynamics platform, experiments, and modeling aiming at critical maneuver handling. Technical Report LiTH-R-3064, Department of Electrical Engineering, Linköpings Universitet, SE-581 83 Linköping, Sweden, 2013.

[4] Björn Olofsson. *Topics in Machining with Industrial Robot Manipulators and Optimal Motion Control.* PhD thesis, Department of Automatic Control, Lund University, Sweden, August 2015.

[5] Björn Olofsson, Kristoffer Lundahl, Karl Berntorp, and Lars Nielsen. An investigation of optimal vehicle maneuvers for different road conditions. In *7th IFAC Symposium on Advances in Automotive Control*, Tokyo, Japan, 2013.