Jan Čech
Center for Machine Perception
Department of Cybernetics, Faculty of Electrical Engineering
Czech Technical University in Prague

Master's Thesis Review

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Title: Trajectory Determination and Control for Autonomous Racing
Author: Burak Aydin
Supervisor: Doc. Ing. Martin Hromčík, Ph.D.
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The thesis presents a method for estimating a centreline of a path delineated by traffic cones, a race track of student formula competition. A lateral deviation from the centreline is estimated. The algorithm assumes the traffic cone position is given. The second part of the thesis proposes an MPC (Model Predictive Controller) to track the centreline in a lane keeping assistant fashion.

The thesis comprises 7 chapters. The first chapter provides a motivation, introduces a reader into the autonomous driving and racing, formulates the problem, and briefly reviews related literature. The second chapter presents the proposed centreline estimation algorithm. Chapter 3 summarizes kinematic and dynamic models of a vehicle. Chapter 4 describes the MPC controller. Chapter 5 presents the MPC controller tracking the estimated centreline. Chapter 6 shows simulations and Chapter 7 concludes the thesis.

To name positive points of the thesis, I would emphasise that the problem is practical and really occurs in the autonomous student formula system design. The author proved certain level of competence in implementing and testing the MPC controller in simulations. Some of the technical issues that needs to be resolved are well discussed. The proposed algorithm probably works to some extent.

On the other hand, the thesis suffers from several weaknesses.

1. The proposed centreline estimation algorithm is not presented clearly. The input to the algorithm (cone positions, vehicle positions) is assumed perfect, without any uncertainty or noise, which is naive especially when the cones are said to be localized by stereo-vision. Despite the unrealistic assumptions, it is unclear if data are fed to the algorithm sequentially or at once. The output of the algorithm is also unclear – Is it a continuous curve or a discrete set of waypoints? The pseudocode in Alg. 1 is not legible and would have required a major revision, since it is by far not reproducible.

2. Estimation of path curvature in Sec. 2.5 suggests that the discrete waypoints are taken. Nevertheless a scale on which the curvature is estimated is not revealed. The path cannot be always represented explicitly by function graph $\big(x, f(x)\big)$. This might be the reason of a large discrepancy between the ground-truth and the parabolic estimate in Fig. 2.14.

3. The experiments are not enough convincing generally in the thesis, both for the centreline estimation and for the MPC controller testing. An algorithm correctness needs to be proven, either mathematically or by a set of experiments that spans many possible cases of the input. Only a single instance in a simple track (an open arc) is shown in Fig. 6.1. The example of the deviation from the centreline in Fig. 6.2 is trivial. Set of more complex scenarios with various tracks with a possible ambiguity where the path goes should have been generated and the algorithm tested on it. The MPC controller is again shown on a single instance as well in Fig. 6.10. It is unclear why the curves in Fig. 6.9 are so wavy while the reference path seems to be perfectly smooth.

4. The thesis does not read well. There are many undefined references and symbols, unfinished sentences and typos. Symbols in the text are often not matching symbols depicted in figures which is particularly confusing.

In summary, I suggest assessing the thesis by

D – satisfactory.

Ing. Jan Čech, Ph.D.