

Template paper for the Robotics: Science and Systems Conference

Author Names Omitted for Anonymous Review. Paper-ID [add your ID here]

Abstract—MPC online control problem enhanced in CasADi, a framework written by Andersson et al. [1].

I. INTRODUCTION

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II. PROPOSED APPROACH

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A. Vehicle model

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B. Spatial formulation

The race track, assumed planar, is modelled through the parametric 2D curve

$$\mathcal{C}(\alpha) = \{\mathbf{x}(\alpha) = [x(\alpha), y(\alpha)]^T \in \mathbb{R}^2 : \alpha \in [\alpha_0, \alpha_f]\} \quad (1)$$

that identifies the road centerline, and the 1D curve $\mathcal{W}(\alpha)$ that specifies the track width. With reference to Figure 1b, the *curve parameter* α uniquely selects a point $\mathbf{F} = \mathbf{x}(\alpha)$ that defines the origin of the *Frenet-Serret frame* $\mathcal{F} = \{\mathbf{F}, (\mathbf{t}, \mathbf{p})\}$ whose unit vectors are, respectively, the tangent \mathbf{t} and the normal \mathbf{p} of the curve \mathcal{C} in the point \mathbf{F} . The vehicle reference system $\mathcal{V} = \{\mathbf{G}, (\mathbf{i}, \mathbf{j})\}$ can be expressed in terms of the moving frame \mathcal{F} with a *lateral displacement* e_p along the track normal direction \mathbf{p} and the *heading error* e_ψ . In order to maintain \mathcal{F} side-by-side with \mathcal{V} , the Frenet-Serret system has to proceed together with the vehicle: this leads to a relation between vehicle and Frenet-Serret velocities that ultimately imposes a bound between time and α increments.

The final formulation of the vehicle model dynamics, extended with lateral displacement, heading error and transposed in spatial domain is

$$\begin{cases} u_{,\alpha} = \frac{\|\hat{\mathbf{x}}_{,\alpha}\|}{s_p} \left[\frac{1}{m} (F_{x_1} - F_{y_1} \delta + F_{x_2} - X_a) + vr \right] \\ v_{,\alpha} = \frac{\|\hat{\mathbf{x}}_{,\alpha}\|}{s_p} \left[\frac{1}{m} (F_{x_1} \delta + F_{y_1} + F_{y_2}) - ur \right] \\ r_{,\alpha} = \frac{\|\hat{\mathbf{x}}_{,\alpha}\|}{s_p} \left[\frac{1}{I_{zz}} (F_{x_1} a_1 \delta + F_{y_1} a_1 - F_{y_2} a_2) \right] \\ e_{p,\alpha} = \frac{\|\hat{\mathbf{x}}_{,\alpha}\|}{s_p} [u \sin e_\psi + v \cos e_\psi] \\ e_{\psi,\alpha} = \|\hat{\mathbf{x}}_{,\alpha}\| \left(\frac{r}{s_p} - k \right), \end{cases} \quad (2)$$

where the notation $u_{,\alpha} = \frac{du}{d\alpha}$ has been used to shorten derivative notations.

C. Offset-free MPC

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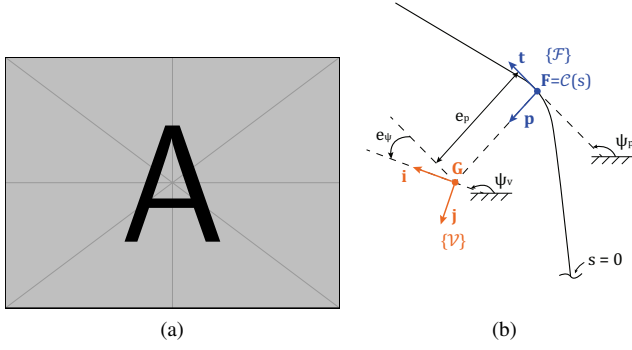


Fig. 1. (a) Something, maybe a vehicle model schematic; (b) vehicle pose respect to the Frenet-Serret reference system identified on the track curve.

III. PRELIMINARY RESULTS

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IV. CONCLUSION

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REFERENCES

- [1] Joel A.E. Andersson, Joris Gillis, Greg Horn, James B. Rawlings, and Moritz Diehl. CasADi: a software framework for nonlinear optimization and optimal control. *Math. Program. Comput.*, 11(1):1–36, mar 2019. ISSN 18672957. doi: 10.1007/s12532-018-0139-4. URL <https://link.springer.com/article/10.1007/s12532-018-0139-4>.