Template paper for the Robotics: Science and Systems Conference

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***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

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

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 $\boldsymbol{F} = \boldsymbol{x}(\alpha)$ that defines the origin of the *Frenet-Serret frame* $\mathcal{F} = \{\boldsymbol{F}, (\boldsymbol{t}, \boldsymbol{p})\}$ whose unit vectors are, respectively, the tangent $\boldsymbol{t}$ and the normal $\boldsymbol{p}$ of the curve $\mathcal{C}$ in the point $\boldsymbol{F}$. The vehicle reference system $\mathcal{V} = \{\boldsymbol{G}, (\boldsymbol{i}, \boldsymbol{j})\}$ can be expressed in terms of the moving frame $\mathcal{F}$ with a *lateral displacement* e_p along the track normal direction $\boldsymbol{p}$ 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

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

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

C. Offset-free MPC

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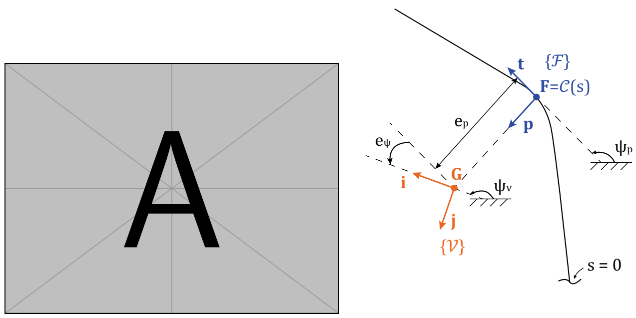

(a) (b)

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.