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# Solving optimal control problems with loss control regions using OptimalControl.jl

*Tuesday, October 29, 2024 11:30 AM (30 minutes)*

In this presentation, we address optimal control problems involving *loss control regions*. In this context, the state space is partitioned into disjoint sets referred to as regions, which are classified into two types: *control regions* and *loss control regions*. When the state belongs to a control region, the control is permanent (i.e., the control value can be modified at any time). On the other hand, when the state belongs to a loss control region, the control must remain constant, equal to the last assigned value before the state enters the loss control region, and this value is kept until the state exits this region [1].

The objective of this presentation is twofold:

**(i)** First, we introduce a direct method that is based on a regularization technique and the consideration of additional states and controls. This allows to transform the initial problem with discontinuous dynamics to a (classical) optimal control problem with smooth dynamics. Furthermore, thanks to OptimalControl.jl [4], we are able to obtain the optimal solution of the regularized problem and also extract the adjoint vectors.

**(ii)** Second, based on first-order necessary optimality conditions in a loss control framework (see [1] and [3]), we develop a shooting method that includes new conditions such as the jumps of adjoint vectors at each crossing times and the averaged Hamiltonian gradient condition. This approach relies on the direct method that provides a good initialization of adjoint vectors, crossing times, and adjoint vector jumps, which allows to solve the initial problem.

Finally, we demonstrate the effectiveness of this numerical approach through various illustrative examples (for detailed documentation, we refer to LossControl.jl).

**References**

[1]: T. Bayen, A. Bouali, L. Bourdin & O. Cots, "Loss control regions in optimal control problems," Journal of Differential Equations, 2024, vol. **405**, p. 359-397.

[2]: Bayen, T., Bouali, A., & Bourdin, L. "The Hybrid Maximum Principle for Optimal Control Problems with Spatially Heterogeneous Dynamics is a Consequence of a Pontryagin Maximum Principle for $L^1_{square}$local Solutions," SIAM Journal on Control and Optimization, 2024, vol. **62**, no 4, p. 2412-2432.

[3]: T. Bayen, A. Bouali, & L. Bourdin, "Optimal control problems with non-control regions: necessary optimality conditions," IFAC-PapersOnLine, vol. 55, no. 16, pp. 68-73, 2022.

[4]: J.-B. Caillau, O. Cots, J. Gergaud, P. Martinon, & S. Sed, "OptimalControl.jl: a Julia package to model and solve optimal control problems with ODE's," DOI: 10.5281/zenodo.13336563

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