Optimal Trajectory Planning under Vague Constraints

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Abstract. An essential feature of the research is the variational approach to optimal control problems developed in fuzzy logic-based framework and applied for trajectory optimization. Trajectory planning in this context is considered as the process of determining control and state trajectories for continuous dynamical systems over a period of time to minimize the objective functional. The talk deals with conditional optimization problems considered under fuzzy constraints in abstract and concrete function spaces.

The goal is to find a control law that will drive the output trajectory in such a way that vague constraints are satisfied in the fuzzy logic sense. The simplest version of trajectory planning problem supposes that there are given sequences of target points and target times, and we are required to be at the given point at the target time [1], [2]. Typically, some deviations from the exact locations are allowed [3]. We start with uncertainty in location restrictions of the type "to be close to the given point at the target time" [4], and then continue with uncertainty in location and time restrictions "to be close to the given point at some time close to the target time".

Taking into account our numerical experience for the case of crisp restrictions [5], [6], we incorporate uncertainty of constraints into the classical setting of the optimal control problem under consideration and adapt numerical schemes for some classes of optimal control problems for dynamical systems modified in this way. We describe an iterative method using the technique of adding and removing interpolation knots [7], [8], according to which the corresponding crisp approximation problem (interpolating or smoothing) must be solved at each step. These approximation problems can be solved by standard numerical methods in the case when an analytical form of solutions is known, and our task is to obtain this form. This means that analytical work constitutes an essential part of the research. We describe the rules for transition from the problem under consideration to crisp approximation problems and study conditions of the convergence of the described iterative technique for some classes of problems.

The proposed approach is illustrated with numerical examples.

Keywords: Optimal Control, Fuzzy Constraints, Trajectory Planning.

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