A Control-Theoretic Framework for Recommendation Systems with Data-Driven Approximation

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We present a novel eclectic framework for recommendation calculation. This framework unites the control-theoretic view with the classical data analysis-based paradigm as follows: the problem is considered as a control problem with a very complex state space taking all of the information at our disposal into account. In particular, we forgo the classical Markovian assumption that dynamics depend exclusively on the current item. Furthermore, we allow for non-stationary dynamics. From a purely abstract mathematical point of view, both structural concessions may be remedied by state space augmentation, i.e., considering histories of states rather than single states, and adding time as an additional state space dimension. As this leaves us with an infinite state space, we need a suitable finitization to tackle the problem computationally. This is achieved by linear function approximation in a Galerkin-style similar to that of FEM methods. As the course of our discussion will show, this enables to reduce computational complexity to an arbitrarily small degree.

Classical data analysis figures in the construction of sensible approximation architectures. Due to the inherently non-physical nature of the underlying state space concept, there is no natural topology and thus no natural notion of continuity that would allow for generalizations of locally observed function values. We propose an approach that is based upon endowing the state space with a content-related, i.e., semantic-aware metric. This metric gives rise to a (hopefully) sensible notion of a continuous function and thus enables construction of suitable approximation spaces.