

A MODEL-FREE ADAPTIVE CONTROL APPROACH FOR FREEWAY TRAFFIC DENSITY VIA RAMP METERING

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ABSTRACT. *By introducing a new dynamical linearization technology, this paper presents a model-free adaptive control approach for density control of freeway traffic flow via ramp metering, which is consisted with a control input learning law and a parameter updating law. The design and analysis of the presented method just depends on the I/O data of the freeway traffic system without requiring any other priori of the control system. Furthermore, the control input learning law is extended to a higher-order form by incorporating more control information of previous sampling instants for improving the control performance. Both convergence analysis and simulation results illustrate the validity of the presented methods.*

Keywords: Non-parametric dynamical linearization, Model-free adaptive control, Density control, Macroscopic traffic flow, Ramp metering

1. Introduction. Ramp metering has been recognized as one of the most effective ways for combating freeway congestion (Papageorgiou & Kotsialos, 2002). A common objective of ramp control is to regulate the amount of traffic entering a freeway from entry ramps during certain time periods, so that the flow on the freeway does not exceed its capacity.

From the viewpoint of system control, ramp metering is a typical regulating problem and numerous control methods have been exploited, e.g. linearization based control (Chang & Li, 2002), optimal control theory (Alessandri et al, 1998; Papageorgiou et al, 1990; Zhang & Recker, 1999), prediction adaptive control (Ji, 1996), function approximation based on neural network (Zhang et al, 2001), fuzzy adaptive control (Akiyama & Okushima, 2006), ALINEA controller (Papageorgiou et al, 1991), etc.

In fact, the freeway traffic flow system is of nonlinearities, coupling, and uncertain and an accurate model is hardly available in practice. However, the model-based control methods (Chang & Li, 2002; Alessandri et al, 1998; Papageorgiou et al, 1990; Zhang & Recker, 1999) are difficult to design and construct for nonlinear processes because they need the exact model knowledge of the control system. Although the adaptive control (Ji, 1996) can address the constant or slow time-varying parameter uncertainties, it still requires some knowledge of control system such as linearly parameterization structure. As for neural network control (Zhang et al, 2001), and fuzzy control (Akiyama & Okushima, 2006), we also need to know some knowledge of the control system to establish a proper estimate model. ALINEA (Papageorgiou et al, 1991) is a feedback regulator and has been