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Advanced controller design for AUV based on adaptive dynamic programming

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Abstract. The main purpose to introduce model based controller in proposed control technique is to provide better and fast learning of the floating dynamics by means of fuzzy logic controller and also cancelling effect of nonlinear terms of the system. An iterative adaptive dynamic programming algorithm is proposed to deal with the optimal trajectory-tracking control problems for autonomous underwater vehicle (AUV). The optimal tracking control problem is converted into an optimal regulation problem by system transformation. Then the optimal regulation problem is solved by the policy iteration adaptive dynamic programming algorithm. Finally, simulation example is given to show the performance of the iterative adaptive dynamic programming algorithm.

Keywords: complex systems; fuzzy models; delay-dependent robust stability criterion; parallel distributed compensation

1. Introduction

A great number of systems consist of interdependent subsystems which serve particular functions, share resources, and are governed by a set of interrelated goals and constraints. Many approaches have been used to investigate the stability and stabilization of complex systems (Lin *et al*. 2017, Mansour *et al*. 2017, Santhakumar and Asokan 2013, Shariatmadar and Razavi 2014, Son *et al*. 2016, Trinh and Aldeen, 1995, Tsai *et al*. 2015, Xiang *et al*. 2015, Yao and Yang 2016, Zandi *et al*. 2018, Zhang 2015, Zhang *et al*. 2011). Because of the potential technical superiority, autonomous underwater vehicle(AUV) has been widely used in commercial, scientific and military applications, such as offshore oil and obviating torpedoes. In these applications, high precision is usually a very important factor. There are a lot of control methods for AUVs available in the literature. A representative few will be discussed here. A self-adaptive fuzzy PID controller is proposed by Khodayari and Balochian (2015) based on nonlinear MIMO structure for an AUV. A

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$$+\sum_{j=1}^{J}\sum_{i=1}^{r_j}\sum_{k=1}^{G_j} h_{ij}(t)x_j^T(t-\tau_{kj})\{\alpha_j^{-1}G_j\overline{A}_{ikj}^T P_j P_j \overline{A}_{ikj} + \rho_j G_j \overline{H}_{qj}^T\overline{H}_{qj} - R_{kj}\}x_j(t-\tau_{kj})$$

$$=\sum_{j=1}^{J}\sum_{i=1}^{r_j}\sum_{f=1}^{r_j} h_{ij}(t)h_{fj}(t)x_j^T(t)[(A_{ij}-B_{ij}K_{fj})^T\sum_{k=1}^{G_j}\tau_{kj}P_j + P_j\sum_{k=1}^{G_j}\tau_{kj}(A_{ij}-B_{ij}K_{fj})$$

$$+\kappa_j\sum_{k=1}^{G_j}\tau_{kj}^2 H_{qj}^T H_{qj} + \varpi_j + \theta_j]x_j(t)$$

$$+\sum_{j=1}^{J}\sum_{i=1}^{r_j}\sum_{k=1}^{G_j} h_{ij}(t)x_j^T(t-\tau_{kj})\{\alpha_j^{-1}G_j\overline{A}_{ikj}^T P_j P_j \overline{A}_{ikj} + \rho_j G_j \overline{H}_{qj}^T\overline{H}_{qj} - R_{kj}\}x_j(t-\tau_{kj})$$

$$=\sum_{j=1}^{J}\sum_{i=1}^{r_j}\sum_{f=1}^{r_j} h_{ij}(t)h_{fj}(t)x_j^T(t)Q_{ifj}x_j(t) + \sum_{j=1}^{J}\sum_{i=1}^{r_j} h_{ij}(t)\sum_{k=1}^{G_j} x_j^T(t-\tau_{kj})\Psi_{ikj}x_j(t-\tau_{kj}).$$

Based on the Eq. (4.14a) and Eq. (4.14b), we have $\dot{V} < 0$ and the proof is thereby completed.