Automatic Tracking and Control System

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Abstract

The rapid evolution of smart systems, characterized by increased autonomy, interconnectivity, and adaptability to the operating environment, requires the development of advanced tracking and control strategies capable of ensuring high performance, robustness, and energy efficiency. In this context, automatic tracking and control systems represent a key component for the optimal operation of smart applications in domains such as robotics, aerospace engineering, cyber-physical systems, and intelligent infrastructures.

This paper presents an automatic tracking and control system dedicated to smart systems, based on a general architectural model, a dedicated mathematical model for tracking and control, and a performance optimization analysis. The proposed approach aims to provide a unified, flexible, and scalable framework applicable to a wide range of dynamic smart systems.

From an architectural perspective, the system is designed in a modular manner and comprises the following main components: the data acquisition and preprocessing subsystem, the state estimation subsystem, the decision-making module, and the control subsystem. The acquisition subsystem integrates heterogeneous sensors specific to smart systems, ensuring the collection of relevant information regarding both the system state and the surrounding environment. The state estimation module employs advanced filtering techniques to reduce uncertainties and to obtain accurate estimates of the system state variables. The decision-making module enables the dynamic adaptation of control strategies according to tracking objectives and operating conditions, while the control subsystem generates the necessary control commands to achieve the desired tracking performance.

The mathematical model of the tracking and control system is formulated using a state-space representation, considering the nonlinear dynamics inherent to smart systems. Tracking is defined as a minimization problem of the error between the actual system state and the imposed reference trajectory. Accordingly, error functions and performance criteria are introduced to evaluate tracking accuracy, stability, and robustness. Mathematical formulation explicitly incorporates the effects of external disturbances and parametric uncertainties, which are commonly encountered in smart system applications.

The optimization analysis of the automatic tracking and control system is carried out by defining an objective function that combines performance criteria such as tracking error, control effort, and energy consumption. The optimization of controller parameters aims to achieve an optimal trade-off between tracking precision and overall system efficiency. Various operating scenarios are analyzed, highlighting the impact of different optimization strategies on the dynamic behavior of the smart system.

The results of the analysis demonstrate that the proposed architectural framework and the associated mathematical model enable a significant improvement in tracking and control performance, while ensuring adaptability and robustness under variable operating conditions. The conclusions emphasize the relevance of the proposed solution for the future development of smart systems, providing a solid theoretical foundation for practical implementations and for further extensions based on artificial intelligence and intelligent control techniques.

Keywords

Smart systems, automatic tracking, automatic control, architectural model, mathematical model, optimization.