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Adaptive State Estimation of UAV Information Physical System Under Network Attack

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Abstract: with the idea of information physics system put forward, governments, enterprises and scientific research institutions have joined the research and construction of information physics system. The construction and development of information physics system is bound to be restricted by the security and privacy of information physical system, which provides theoretical reference for clearing the current security threats of information physical system and providing theoretical reference for the security and privacy protection of information physical system. UAV is an intelligent information physics system which relies on ground communication and flight control system to realize autonomous flight. The concept of IT system was first proposed by NASA in 1992. As a new intelligent system, UAV has emerged and is widely used. It is a complex system of computing, network and physical entity integration and deep cooperation. Thus, the real-time perception, dynamic control and information service of large physical system and information system can be achieved.

Key words: Network attack, UAV Information Physics System, Adaptive state estimation

Introduction

Information physics system is a multi-dimensional and complex system which integrates computing, network and physical environment. Through a series of computing units and physical objects highly integrated and interactive in the network environment, the information physical system can improve the system's ability in information processing, real-time communication, remote precise control and component autonomous coordination, and is a hybrid autonomous system with multi-dimensional and heterogeneous space-time. At present, a recursive state estimator based on the minimization of adaptive variance is proposed to solve the problem of security state estimation of UAV information physical system under network attack. By modeling malicious attacks against control input and sensor data as unknown interference terms in state and measurement equation, a recursive estimator of unknown interference decoupling state is established to realize the decoupling of unknown interference in filtering error. The adaptive adjustment factor is designed to minimize the upper limit of estimation error. The gain feedback matrix of measurement is solved by using the minimum variance estimation criterion. At the same time, the event triggering mechanism is introduced to save communication resources while maintaining a certain estimation of accuracy. In addition, the sufficient conditions for the boundedness of the filter error index are given.

1, Overview of information physics system

(1) Definition of information physics system

The idea of an information physics system was first proposed by the natural Fund Committee of the United States. The concept has been widely concerned by the world once it is put forward. Scholars from all over the world have studied it from different levels, such as theoretical methods, system design and operation environment. The

information physics system has a high complexity, and has developed different technologies of many disciplines. Therefore, researchers in different fields have different understanding of the IT system. Lee thinks that the information physics system is a close integration of a series of computing processes and physical process components. It monitors the operation of physical entities through the computing core, and physical entities realize the perception and control of the environment by means of network and computing components. Bahetti and others think that the information physical system is a highly reliable system which is closely combined with various computing elements and physical elements in the system and coordinated under the action of dynamic uncertain events. From the aspect of computing science and information storage processing, says believes that the information physical system integrates computing, communication and storage capabilities, can run in real time, reliably, safely, stably and efficiently, and is a networked computer system which can monitor all entities in the physical world. From the perspective of embedded system and equipment development, branicky and Krogh point out that "cyber" is the integration of computing, communication and control technology involving physical process and biological characteristics. The essence of the information physics system is the intelligent machine human system integrating reliable computing, communication and control capabilities. Ma Wenfang believes that the information physics system is a controllable, credible and scalable network physical equipment system with deep fusion of computing, communication and control capabilities on the basis of environmental awareness. It can realize deep fusion and real-time interaction through feedback cycle of mutual influence between computing process and physical process to increase or expand new functions to ensure safety, reliability, and reliability to detect or control a physical entity in an efficient and real-time manner. Wang Zhongjie and others pointed out that the information physics system emphasizes the interaction of "cyber physical", involving the integration of massive heterogeneous data in the future network environment, real-time and reliable processing and communication of uncertain information signals, organic coordination and adaptive control of dynamic resources and capabilities, which is highly autonomous perception, independent judgment, independent adjustment and autonomy, The next generation intelligent system can realize the interconnection and cooperation between virtual world and real physical world.

2, The architecture of information physics system

Information physics system usually has three important characteristics:

Coupling with environment: each information physical system is closely coupled with the environment (i.e. physical process). Any change of environmental behavior will cause the change of the behavior of information physical system, and vice versa. The medical equipment information physics system such as ICD (implanted cardia defibrator) is a typical case.

Various functions and performance: Information Physics system is usually composed of different entities with different function performance. The sensor embedded in the physical process is used as monitoring purpose, and its performance is limited, while the entity that manages the sensor has strong function and performance. For example, a health monitoring system with strong availability is composed of many small medical sensors, but the base station that manages these sensors is usually a handheld computer. The diversity of function and performance is the potential bottleneck in the data processing, communication and storage in the workflow of information physics system.

Network: unlike the traditional independent embedded system, the information physical system needs a communication channel to provide services (usually in the form of cooperation between the parts) whether embedded in the physical process or not. For example, in intelligent vehicle systems, sensors that perceive the state of the car communicate with the car radio, which enables the radio to automatically increase the volume with the increase of vehicle speed, and prevent the interference of the increased noise.

Perceived executive layer:

The perceptual executive layer includes sensors, actuators, RFID (radio frequency identification) tags, RFID readers, mobile intelligent terminals and other physical devices, which are mainly responsible for sensing and acquiring physical environment data and executing system control commands. Through the interaction between embedded sensors

and actuators distributed on physical equipment and physical environment, large-scale distributed data acquisition and state identification are carried out for material attribute, environment status and other data. The upper data processing results are obtained through data communication layer, and feedback to the actuator, and operation is carried out according to control commands to adapt to the changes of system and physical environment.

Data transmission layer:

The data transmission layer is supported by real-time communication and information interaction by the next generation network. It mainly transmits data through existing networks such as Internet, private network, LAN and communication network to realize data interaction. At the same time, the data transmission layer should have the ability of intelligent processing and management of massive information.

Application control layer:

The Application control layer is the core part of the interaction of information physics system. After the information obtained from the data transmission layer is abstracted, the executive control command is generated by the judgment of preset rules and high-level control semantic specifications. The executive control command is fed back to the underlying physical unit of the perceptive execution layer through the data transmission layer, and the relevant operations are performed by the actuator. The application control layer also combines the information physics system with the professional application of the industry to realize the application solution collection of wide-ranging intelligence, such as intelligent transportation and intelligent grid.

3, Adaptive state estimation of UAV information physical system under network attack

In order to solve the problem of adaptive recursive state estimation of UAV information physical system under various network attacks, the random attack for control input is modeled as unknown interference in state equation, and malicious data implantation attack for sensor data is modeled as unknown interference in measurement equation. The problem is transformed into an equivalent state estimation problem for stochastic uncertain systems with double unknown interference.

The problem of decoupling the sensor measurement attack signal and control input attack signal in the state filtering error is solved by using the recursive filter and adaptive adjustment factor. The minimum upper bound of the covariance of the filtering error is obtained. The minimum variance estimation criterion is used to solve the gain feedback matrix of measurement, and the state estimation in the sense of minimizing the adaptive variance is realized.

4, Security measures of information physical system

(1) Perceived executive layer security measures

The perceptive execution layer of information physical system mainly involves the physical security of each node infrastructure, the acquisition of sensing data and the execution of control commands. It is the foundation of information physical system security to ensure the security of sensors, actuators, RFID devices, image capture devices and other equipment. The following are some security measures to perceive the security threat of the executive layer:

The identity of the node is managed and protected. This will extend the authentication time to a certain extent. In practical application, the security and efficiency of the system can be weighed and a more balanced node authentication strategy can be formulated.

Through biometric and near-field communication, the security of node sensing data is better protected.

Strengthen legislation, and make clear illegal behaviors and their costs for behaviors that threaten users or system security by using information physical system.

The paper also discusses the key and password technology, privacy protection technology, secure routing technology, security data fusion technology and security location technology. (2) Data transmission layer security

measures

The security measures of data transmission layer are mainly to ensure communication data security in the system, including the integrity, confidentiality and consistency of data. The security mechanism of data transmission layer can make use of point-to-point encryption mechanism and end-to-end encryption mechanism.

The point-to-point encryption mechanism ensures the security of data in the hop by hop transmission process, but because each node can get clear text data, it requires high reliability of nodes. The security mechanism includes node authentication, hop by hop encryption and cross network authentication.

The end-to-end encryption mechanism mainly realizes the end-to-end data confidentiality, and can provide flexible security policies with different security levels. But the end-to-end encryption method cannot hide the data source and purpose, and there is a security hidden danger exploited by the attacker. The security mechanism includes end-to-end authentication, key negotiation and key management.

(3) Application of control layer safety measures

Application control layer is the core part of decision-making of information physical system. The massive data in the system requires that the application control layer has strong data intelligent processing ability, and must protect the security of data and user privacy data. The security measures for the application control layer of information physics system include:

Strengthen the access control strategy of the system;

Strengthen the authentication mechanism and encryption mechanism of different application scenarios;

Improve the mechanism of network forensics and strengthen the ability of network forensics;

At the same time, it establishes a unified and efficient security management platform for the information physical system without affecting the application.

Concluding remarks

In a word, the information physics system is a very promising research field in exploration, and the research on its system has just begun at home and abroad. The existing science and technology are combined with computer technology, network technology, control technology, communication technology and physics, life science, sociology and other related fields to improve the theory of information physics system and to study the real-time, security, autonomy and high-performance of the information physics system.

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