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論　　文　　要　　旨

Thesis Abstract

2018 年 09 月　14 日

※報告番号	甲第２２６号	氏　名 (Name)	NGUYEN MANH LINH

主論文題名　（Title）

Discrete-Time Control Design for Tracking Control Of Piezo-Actuated Positioning Systems

内容の要旨　（Abstract）

Recently, the micro-positioning has become an important development target for meeting the requirements of the precision industry, such as in the semiconductor manufacturing process, biotechnology processes and opto-electronics systems. Since the piezoelectric actuator (PEA) has many advantages, such as high displacement resolution (sub nanometer), large actuating force, fast response time, tiny size, electric controllable, PEA as well as PEA-driven positioning systems has been extensively used in the fields of micro/nano positioning and being the most commercialized and understood technology in the smart actuator market. However, PEAs also exhibit undesired serious disadvantages such as hysteresis, creep and vibration behaviors, which have shown to be able to significantly degrade the performance of the controlled system.

In this study, precise tracking control of piezo-actuated positioning systems, which is composed by a PEA and a positioning mechanism (PM), is considered due to its important role and popularity in practical applications. In this case, the performance of system is mainly affected by hysteresis phenomenon. Hence, the goal of this study is to propose control algorithms which have ability to handle the difficulties caused by the nonlinear behavior and achieve excellent tracking performance. In advanced, all the control designs are conducted in discrete-time domain. As a result, the control algorithm can easily be implemented in digital controllers.

To achieve the above goals, various advanced control schemes have been proposed in this study. A pseudo model predictive control is presented in Chapter 2. In Chapter 3, the conventional discrete-time sliding mode control and integral sliding mode control design is introduced in the first two sections. Then, a novel discrete-time prescribed performance sliding mode control is proposed to improve the response in transient-state while remains the tracking performance in steady-state. In Chapter 4, the discrete-time fractional order-based controllers are discussed. A new method to approximate the fractional order integral is proposed first. Then, this proposed approximation is applied to a discrete-time fractional order PID controller along with an on-line particle swarm optimization to get the best performance. At last, the discrete-time fractional order integral sliding mode control is investigated. Fuzzy tuning is chosen to improve the system performance by adjusting all parameters of the controller simultaneously. The validity and effectiveness of all proposed methods are confirmed by experiments.

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In this study, precise tracking control of piezo-actuated positioning systems, which is composed by a PEA and a positioning mechanism (PM), is considered due to its important role and popularity in practical applications. In this case, the performance of system is mainly affected by hysteresis phenomenon. Hence, the goal of this study is to propose a control algorithm which has ability to handle the difficulties caused by the nonlinear behavior and achieve excellent tracking performance. In advanced, all the control designs are conducted in discrete-time domain. As a result, the control algorithm can easily be implemented in digital controllers.

In order to achieve the above goals, various advanced control schemes have been proposed and presented in this study. In details, a pseudo model predictive control which mimics the behavior of its conventional counterpart is presented in Chapter 2. In Chapter 3, the conventional discrete-time sliding mode control and integral sliding mode control design is introduced in the first two sections. Then, a novel discrete-time prescribed performance sliding mode control is proposed to improve the response in transient-state while remains the tracking performance in steady-state. In Chapter 4, the discrete-time fractional order-based controllers are discussed. A new method to approximate the fractional order integral is proposed first. Then, this proposed approximation is applied to a discrete-time fractional order PID controller along with an on-line particle swarm optimization to get the best performance. At last, the discrete-time fractional order integral sliding mode control is investigated. Fuzzy tuning is chosen as an effective tool to improve the system performance by adjusting all parameters of the controller simultaneously. The validity and effectiveness of all proposed methods are confirmed by experiments.

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