NANJING UNIVERSITY OF AERONAUTICS AND ASTRONAUTICS

南京航空航天大學

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论文摘要集

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序

南京航空航天大学研究生学术论坛的前身是南京航空航天大学研究生学术会议。研究生学术会议是由研究生院、校团委、校科协联合主办，南京航空航天大学研究生会承办，面向广大研究生的学术交流盛会，旨在营造浓厚的校园学术氛围，不断提高研究生的学术素养，增强研究生学术交流意识，培养良好的学术道德和科学精神。研究生学术会议自1999年开办以来，已成功举办了十届，以其鲜明的学术特色和严谨的学术风格赢得了全校广大师生的密切关注和积极参与，会议期间组织的主会场、各学院分会场、学术沙龙、“科创之星”、“科创新秀”评选以及和其他合作院校的学术交流活动，已成为我校提高研究生学术水平，增进学术交流的重要平台，并在省内乃至全国具有了一定的影响。

第十一届研究生学术论坛的召开恰逢我校建校57周年校庆。论坛以“引领科技，创新思维”为主题，在继承往届传统的同时，在形式和内容上均做了精心的策划，力争为广大研究生同学提供更大的自我展示舞台，提供更多的学术交流机会。学术论坛期间，将举办开幕式、2009年度研究生“科创之星、科创新秀”评选活动、多场专家报告会、“科学·人生”院长论坛、研究生学术沙龙系列活动、“科创之星（新秀）”论坛和闭幕式，各学院分论坛也将组织开展丰富多彩的学术交流活动。

第十一届研究生学术论坛也特别得到了中国一航611所的大力支持和赞助，并冠名“枭龙杯”；同时也得到了南京理工大学研究生会等著名兄弟高校研究生会的鼎立合作，切实反映了我校研究生学术论坛创新、开放、务实、多赢的论坛精神。

为反映我校广大研究生同学的优秀研究成果，我们选取了2009年度“科创之星”、“科创新秀”参评学生的学术论文摘要结集成册，以期对大家的研究工作有参考和促进作用。由于作者和编者水平有限，疏漏和错误之处在所难免，恳请读者批评指正。

南京航空航天大学研究生会

二〇〇九年十一月

目 录

季红丽 B0701128

Multimodal vibration control using a synchronized switch based on a displacement switching threshold

Hongli Ji, Jinhao Qiu, Adrien Badel, Yuansheng Chen, and Kongjun Zhu

Abstract: A new semi-active method for multi-mode vibration control using the nonlinear synchronized switch damping (SSD) approach based on a displacement switching threshold is proposed in this paper. Several extensions of the SSD approach, including SSDI (SSD on inductance), SSDV (SSD on a voltage source), enhanced SSDV, and adaptive SSDV, have been developed to improve the control of the single-mode vibration, but the weakness of the SSD approach for multi-modal vibration control has not been solved. In all these extensions of the SSD approach, the switch is controlled by the same algorithm, that is, it reverses the voltage of the piezoelectric element at all extrema of displacement. This switching algorithm is effective in single-mode control, but it leads to over-frequent switching in multi-mode control. In the method proposed in this study, an improved switching algorithm based on a displacement threshold, which prevents the switch in the shunt circuit from over-frequent on-and-off actions and accordingly increases the converted energy to improve the control performance, is proposed. The switching algorithm is applied to an SSDI system and used in the vibration damping of a beam with two excited modes. Compared to the classical SSDI approach, the control performance of the first mode is improved from 3.7 to 18.2 dB, but that of the second mode is slightly worse, having changed from 3.46 to 2.6.

Semi-active Vibration Control of a Composite Beam Using Adaptive SSDV Approach

Hongli Ji, Jinhao Qiu, Adrien Badel, and Kongjun Zhu

Abstract: In this paper an improved semi-active control method is proposed and applied to the vibration control of a composite beam. This method is an improved version of the previously developed SSDV (Synchronized Switch Damping on Voltage) approach. In the SSDV, a voltage source is connected to the shunting branch, in series with the inductor, which can magnify the inverted voltage and hence improve the control performance. Optimization of the voltage source is an important issue in all the SSDV techniques. In the proposed approach, called adaptive SSDV, the voltage coefficient that control the damping effectiveness is adjusted adaptively. An improved switching algorithm, which prevents the switch from over-frequent on-and-off and accordingly improve the control performance, is also proposed. Compared with previous SSDV techniques, this adaptive SSDV is the most stable, is independent of the excitation level and is more flexible because the voltage coefficient is adjusted adaptively to achieve optimal control performances. The adaptive SSDV has been applied to the vibration control of a composite beam and its control results were compared with those of previously developed SSDV techniques. The effectiveness of new switching algorithm was also verified by comparing it with the conventional switch. An experimental setup of semi-active control system for the cantilever composite beam was established, and control experiments were carried out using different SSDV methods.

基于TMS320F2812的悬臂梁振动半主动控制

季宏丽，裘进浩，赵永春，朱孔军

摘 要：基于压电元件的主动振动控制不仅需要复杂的信号处理系统,而且需要庞大的能量供给系统;被动控制中电感和电阻参数对环境变化适应能力差,而且低频控制时需要很大的电感,不容易实现。为了克服主被动控制存在的缺点,提出了一种基于同步开关阻尼技术的半主动振动控制的新方法。利用TMS320F2812处理器,通过合理的开关控制算法,使埋入复合材料悬臂梁约束端的压电元件上的电压极性在适当的时候进行翻转,使其电压始终与应变反相,从而达到振动控制的效果。实验结果表明,该方法可以使悬臂梁一阶振动模态减小3.164 1 dB。

基于压电元件的半主动振动控制研究

季宏丽，裘进浩，赵永春，朱孔军

摘 要：为了克服主Ö被动控制中存在的缺点,提出了一种基于同步开关阻尼技术的半主动振动控制新方法。基于该方法的控制系统简单,只要一些电子元器件就可以实现振动控制,且控制效果好、鲁棒性高。采用此方法能有效对悬臂复合梁进行了振动控制。由于半主动控制方法的控制效果主要取决于电路品质因子以及开关切换的延时时间,因此通过探讨这两个参数对控制效果的影响,推导了基于开关切换延时的半主动振动控制的阻尼公式,搭建了悬臂复合梁振动半主动实验平台,对理论分析结果进行了实验验证。

Modelling, Simulation and Optimization of High Efficiency Piezoelectric Energy Harvester

Hongli Ji, Yong Ma, Hao Jiang, Hui Shen, Jinhao Qiu and Kongjun Zhu

Abstract:In this paper we show that by applying a switching power converter the power transformation efficiency of a piezoelectric energy harvester can be enhanced by more than 400%. This switching power converter is derived from the Buck-Boost Converter, and in this work it is optimized by using a control circuitry of low power consumption. The whole circuitry has been modeled and simulated in the Pspice software. The simulation results show that after optimization the output power of the proposed energy harvester has been enhanced by 3.4 times.

一种不用声学传感器的结构噪声主动控制新方法

季宏丽，裘进浩，沈星，松田和也

摘 要：在本文中，提出了一种不需要声学传感器的噪声主动控制的新方法。在该控制系统中，将嵌入在CFRP复合材料板中的压电材料作为传感器和执行器。因为压电传感器只能测量出结构的振动，为了获取结构产生的噪声信号，需要从嵌入式压电器件的输出信号估算噪声的声压信号。为此，本文中设计了一种通过神经网络从压电元件的电压信号来估算声音信号的系统。实验结果表明，估测得到的噪声声压和用麦克风直接测得的声压完全吻合。此外，本文中采用了基于Filter-X LMS算法的自适应滤波控制器，对透过复合材料板的噪声进行了主动控制。在实验中，用麦克风来检验此控制方法的效果，但是它的输出不用于反馈控制中。实验结果表明，不用声学传感器的噪声控制系统和传统的控制方式一样取得了较好的噪声控制效果，但比振动控制时取得的控制效果要好的多。尽管采用同样的压电元件配置，振动控制系统中直接用压电器件的输出电压作为反馈信号，而在新的噪声控制系统中则以估算的声压信号作为反馈信号。

Semi-active vibration control of a composite beam by adaptive synchronized switching on voltage sources based on LMS algorithm

Hongli Ji, Jinhao Qiu, Adrien Badel, Yuansheng Chen, and Kongjun Zhu

Abstract:In this paper, an adaptive semi-active SSDV (Synchronized Switch Damping on Voltage) method based on the LMS algorithm is proposed and applied to the vibration control of a composite beam. In the SSDV method, the value of voltage source in the switching circuit is critical to its control performance. In the adaptive approach proposed in this study, the voltage source is adjusted adaptively using the LMS algorithm. Two cases of the adjustment are considered. In the first case, as an improvement to the enhanced SSDV, the voltage coefficient is adjusted by the LMS algorithm. In the second case, as an improvement to the classical SSDV, the voltage value is adjusted directly. The new adaptive approach is compared with the derivative-based adaptive SSDV proposed in the former study in the control of the first mode of a composite beam. The control results show that adaptive adjustment of voltage value and adaptive adjustment of voltage coefficient are equally effective in the vibration control of the composite beam and that LMS-based approach is slightly better than the derivative-based approach.

An improved system of active noise isolation using an self-sensing actuator and neural network

Hongli Ji, Jinhao Qiu, Kongjun Zhu, and Kazuya Matsuta

Abstract:This paper presents an improved active noise isolation method, consisting of a self-sensing actuator, a neural network identifier and an adaptive feedback controller using a FIR filter and the Filtered-X LMS algorithm, in which no acoustical sensors were necessary to suppress the noise transmission through a plate structure. The structure is a composite plate with an embedded piezoelectric patch. Based on the self-sensing technique, the same piezoelectric element functions as both a sensor and an actuator. A bridge circuit was used to separate the sensor signal from the actuator signal on the piezoelectric patch and the obtained signal was used in the identification of sound pressure of a point in the space. A neural network was used instead of the Rayleigh's integral formula for the identification of sound pressure as used in the former study. The results show that the proposed control approach using both self-sensing actuator (SSA) and neural network identifier exhibited better noise control performance than that using Rayleigh's integral formula. It also exhibited similar noise control performance as the traditional control system using a microphone though the new system used only one piezoelectric patch for both sensor and actuator.

Multi-mode vibration control using nonlinear synchronized switching damping based on the maximization of converted energy

Hongli Ji, Jinhao Qiu, Adrien Badel, and Kongjun Zhu

Abstract:In this paper, a new switch control strategy based on an energy threshold is proposed for the synchronized switch damping techniques in multimode control. This strategy is derived from the total converted energy of a synchronized switch damping (SSD) system in a given time window. Using the new strategy the voltage is inverted only at those extrema where the effective distance, which is proportional to the converted energy between two neighboring extrema, exceeds the threshold. The new switch control strategy is used in both the synchronized switch damping on inductor (SSDI) technique and the synchronized switch damping on voltage source (SSDV) technique, which are applied to the two-mode control of a composite beam. Their control performances are compared with those of the single-mode control and those of classical SSDI and SSDV techniques in two-mode control. The experimental results show that voltage inversion is prevented at some of the displacement extrema to increase the total converted energy, and exhibit better global damping effect than classical SSDI and classical SSDV, respectively. In single mode, the best control performance is achieved when the voltage is inverted at every extremum. But in multimodal control, total converted energy is increased and the control performance is improved when some extrema are skipped.

Vibration control of a composite beam using self-sensing semi-active approach

Hongli Ji, Jinhao Qiu, Kongjun Zhu

Abstract:Structural vibration control has been an active research for the past twenty years because their potential application in aerospace structures, civil structures, naval structures, et al. Semi-active vibration control methods based on piezoelectric actuators and Synchronized Switch Damping on Inductance (SSDI) techniques have attracted the attention of many researchers recently due to their advantages over passive and active methods. In the SSDI method, a switched shunt circuit is connected to the piezoelectric patch to shift the phase and amplify the magnitude of the voltage on the piezoelectric patch. The most important issue in SSDI method is to control the switching actions synchronously with the maximum vibration displacement or maximum strain. Hence, usually a displacement sensor is used to measure the vibration displacement or a collocated piezoelectric sensor is needed to measure the strain of the structure near the piezoelectric actuator. To avoid using a separate sensor, a self-sensing SSDI approach is proposed and applied to the vibration control of a composite beam. In the self-sensing technique, the same piezoelectric element functions as both a sensor and an actuator so that the total number of required piezoelectric elements can be reduced. Furthermore, in order to present the shunt circuit from over-frequent on-and-off actions, a simple switch control algorithm is proposed. The results of control experiments show that the self-sensing SSDI approach gives better control performance than the traditional SSDI using a separate piezoelectric element as a sensor when they are combined with a classical switch, and the same control performance when they are combined with the improved switch.

Vibration control of a composite beam by an adaptive semi-active method based on LMS algorithm

Hongli Ji, Jinhao Qiu, Kongjun Zhu

Abstract:In this paper, an adaptive semi-active SSDV (Synchronized Switch Damping on Voltage) method based on the LMS algorithm is proposed and applied to the vibration control of a composite beam. In the SSDV method, the value of voltage source in the switching circuit is critical to its control performance. In the adaptive approach proposed in this study, the voltage coefficient is adjusted adaptively using the LMS algorithm. The new adaptive approach is compared with the derivative-based adaptive SSDV proposed in the former study in the control of the first mode of a composite beam. The control results show that adaptive adjustment of voltage coefficient is effective in the vibration control of the composite beam and that LMS-based approach is slightly better than the derivative-based approach.

Multimodal vibration control using a synchronized switch based on a displacement switching threshold

Hongli Ji, Jinhao Qiu, Yuansheng Chen, and Kongjun Zhu

Abstract:A new semi-active method using the nonlinear synchronized switch damping (SSD) approach based on a displacement switching threshold was proposed in this paper for multimode vibration control. In the method proposed in this study, an improved switching algorithm based on a displacement threshold, which prevents the switch in the shunt circuit from over-frequent on-and-off and accordingly increase the converted energy to improve the control performance, is proposed. The switching algorithm is applied to a SSDI system and used in the vibration damping of a beam with two excited modes. Compared to the classical SSDI, the control performance of the new method is improved from 3.7 dB to 18.2 dB.

Semi-active vibration control of a composite beam using an adaptive SSDV approach

Hongli Ji, Jinhao Qiu, Adrien Badel, and Kongjun Zhu

Abstract:In this paper an improved semi-active control method is proposed and applied to the vibration control of a composite beam. This method is an improved version of the previously developed SSDV (Synchronized Switch Damping on Voltage) approach. In the SSDV, a voltage source is connected to the shunting branch, in series with the inductor, which can magnify the inverted voltage and hence improve the control performance. Optimization of the voltage source is an important issue in all the SSDV techniques. In the proposed approach, called adaptive SSDV, the voltage coefficient that control the damping effectiveness is adjusted adaptively. Compared with previous SSDV techniques, this adaptive SSDV is the most stable, is independent of the excitation level and is more flexible because the voltage coefficient is adjusted adaptively to achieve optimal control performances. The adaptive SSDV has been applied to the vibration control of a composite beam and its control results were compared with those of previously developed SSDV techniques. An experimental setup of semi-active control system for the cantilever composite beam was established, and control experiments were carried out using different SSDV methods.

Piezoelectric Vibration Damping by an Enhanced Semi-Passive Method

Hongli Ji, Adrien Badel, Jinhao Qiu, Elie Lefeuvre, Claude Richard, Daniel Guyomar

Abstract:In this paper an improved semi-active control method is proposed and applied to the vibration control of a composite beam. This method is an improved version of the previously developed SSDV (Synchronized Switch Damping on Voltage) approach. In the SSDV, a voltage source is connected to the shunting branch, in series with the inductor, which can magnify the inverted voltage and hence improve the control performance. Optimization of the voltage source is an important issue in all the SSDV techniques. In the proposed approach, called adaptive SSDV, the voltage coefficient that control the damping effectiveness is adjusted adaptively. Compared with previous SSDV techniques, this adaptive SSDV is the most stable, is independent of the excitation level and is more flexible because the voltage coefficient is adjusted adaptively to achieve optimal control performances. The adaptive SSDV has been applied to the vibration control of a composite beam and its control results were compared with those of previously developed SSDV techniques. An experimental setup of semi-active control system for the cantilever composite beam was established, and control experiments were carried out using different SSDV methods.

Novel approach of self-sensing actuation for active vibration control

Hongli Ji, Jinhao Qiu, Jun Cheng, Yipeng Wu, and Kongjun Zhu

Abstract:In a self-sensing actuator, the same piezoelectric element functions as both a sensor and an actuator. Due to their advantages of reducing the number of needed piezoelectric elements and true collocation of sensors and actuators, self-sensing actuators have attracted the attention of many researchers and many studies have been reported. Since the actuator signal and the sensor signal are mixed together in a self-sensing actuator, usually a bridge circuit is used to separate the two signals. It has been found that the two signals cannot be separately ideally because the bridge is difficult to balance and the actuator signal is much larger than the sensor signal. In this study, the influence of the local strain on the output signal of a piezoelectric sensor is investigated and a new method using neural network is proposed to identify the global vibration strain. The identified signal is used as feedback signal for an adaptive control system and the effectiveness in suppressing the beam vibration is verified in the experiment.

Application of a Negative Capacitance Circuit in Synchronized Switch Damping Techniques for Vibration Suppression

Hongli Ji, Jinhao Qiu, and Jun Cheng

Abstract:In the SSD techniques, the voltage on the piezoelectric element is switched synchronously with the vibration to be controlled using an inductive shunt circuit. The inherent capacitance and the inductance in the shunt circuit comprise an electrically resonant circuit. In this study a negative capacitance is used in the shunt circuit instead of an inductance in the traditional SSD technique. The voltage on the piezoelectric element can be effectively inverted though the equivalent circuit is capacitive and no resonance occurs. The principle of the new SSD system is investigated and the effectiveness of the new method is confirmed by the experimental results.

王方磊 B0801111

Nonnegative doubly periodic solutions for nonlinear telegraph system

F. Wang, Y. An

Abstract: This paper deals with the nonnegative doubly periodic solutions for nonlinear telegraph system

$$\begin{cases} u_t - u_{xx} + c_1 u_t + a_{11}(t,x)u + a_{12}(t,x)v = b_1(t,x) f(t,x,u,v), \\ v_t - v_{xx} + c_2 v_t + a_{21}(t,x)u + a_{22}(t,x)v = b_2(t,x) g(t,x,u,v), \end{cases}$$

with periodic boundary condition

$$\begin{cases} u(t+2\pi, x) = u(t, x-2\pi) = u(t,x), \\ v(t+2\pi, x) = v(t, x-2\pi) = v(t,x). \end{cases}$$

We show the existence and multiplicity results when the nonlinearities are are superlinear or sublinear on by using the fixed point theorem in cones..

Existence and multiplicity results of positive doubly periodic solutions for nonlinear telegraph system

F. Wang, Y. An

Abstract: In this paper, the existence of positive doubly periodic solutions for nonlinear telegraph system is discussed using the method of upper and lower solutions.

Nonnegative doubly periodic solutions for nonlinear telegraph system with twin-parameters

F. Wang, W,L, Y. An

Abstract: In this paper, by using Krasnosel' skii fixed-point theorem and under suitable conditions, we present the existence and multiplicity of nonnegative doubly periodic solutions for the following system:

$$\begin{cases} u_t - u_{xx} - c_1 u_t - a_{11}(t,x)u + a_{12}(t,x)v = b_1(t,x) f(t,x,u,v), \\ v_t - v_{xx} + c_2 v_t + a_{21}(t,x)u + a_{22}(t,x)v = b_2(t,x) g(t,x,u,v), \end{cases}$$

We derive two explicit intervals of $b_1(t,x)$ and $b_2(t,x)$ such that for any $b_1(t,x)$ and $b_2(t,x)$ in the two intervals respectively, the existence of at least one solution for the system is guaranteed, and the existence of at least two solutions for $b_1(t,x)$ and $b_2(t,x)$ in appropriate intervals is also discussed.

A generalized quasilinearization method for telegraph system

F. Wang, Y. An

Abstract: In this note, we build a maximum principle for the doubly periodic solutions of telegraph system. And the generalized quasilinearization technique is applied to obtain a monotone sequence of iterates converging uniformly and quadratically to a solution of a coupled telegraph system with doubly periodic boundary condition.

Existence of Nontrivial Solution for a Nonlocal Elliptic Equation with Nonlinear Boundary Condition

F. Wang, Y. An,

Abstract: In this paper, we establish two different existence results of solutions for a nonlocal elliptic equations with nonlinear boundary condition. The first one is based on Galerkin method, and gives a priori estimate. The second one is based on Mountain Pass Lemma

Three positive doubly periodic solutions of a nonlinear telegraph system

F. Wang, Y. An

Abstract:This paper studies existence of at least three positive doubly periodic solutions of a coupled nonlinear telegraph system with doubly periodic boundary conditions. First, by using the Green function and maximum principle, existence of solutions of a nonlinear telegraph system is equivalent to existence of fixed points of an operator. By imposing growth conditions on the nonlinearities, existence of at least three fixed points in cone is obtained by using the Leggett-Williams fixed point theorem to cones in ordered Banach spaces. In other words, there exist at least three positive doubly periodic solutions of nonlinear telegraph system.

On positive solution of nonlinear telegraph semipositone system

F. Wang1, Y. An and P. Wang

Abstract:In this paper, we shall deal with the superlinear semipositone problem of a nonlinear telegraph system and establish the existence of positive doubly periodic solutions for the system. The proofs are based on a fixed-point theorem in cones.

邱雷 B0801129

On Development of a Multi-Channel PZT Array Scanning System and Its Evaluating Application on UAV Wing Box

Qiu Lei

Abstract:Piezoelectric sensor (PZT) based structural health monitoring (SHM) methods can efficiently estimate the health condition of aircraft structures. To monitor large-scale structures, dense PZT arrays are usually needed. How to scan different PZT actuator-sensor channels in the PZT array to achieve a real time and stable SHM task is an important issue in the application of these methods. In this paper, an integrated multi-channel PZT array scanning system (ISS) is developed for the purpose of SHM. A type of gain programmable charge amplifier and a low crosstalk scanning module are discussed. An integrated software system which is based on the LabVIEW software platform is developed to manage the hardware, and perform signal processing and damage estimation. To validate the functions of this system, an evaluation is performed on a carbon fiber composite wing box of an unmanned aerial vehicle (UAV). The application results show the promising performance of this system.

Design and experimental research of a PZT network based structural health monitoring scanning system

Qiu Lei

Abstract:The active Lamb wave and piezoelectric transducer (PZT) based structural health monitoring (SHM) technology is a kind of ef-ficient approach to estimate the health state of aircraft structures. In practical applications, PZT networks are needed to monitor large scale structures. Scanning many of the different PZT actuator-sensor channels within these PZT networks to achieve on-line SHM task is important. Based on a PXI (PCI eXtensions for Instrumentation) platform, an active Lamb wave and PZT network based integrated multi-channel scanning system (PXI-ISS) is developed for the purpose of practical applications of SHM, which is compact, and portable and can scan large numbers of actuator-sensor channels and perform damage assessing automatically. A PXI based 4 channels gain-programmable charge amplifier, an external scanning module with 276 actuator-sensor channels and integrated SHM software are proposed and discussed in detail. The experimental research on a carbon fiber composite wing box of an unmanned aerial vehicle (UAV) for verifying the functions of the PXI-ISS is mainly discussed, including the design of PZTs layer, the method of excitation frequency selection, functional test of damage imaging, stability test of the PXI-ISS and the load-ing effect on signals. The experimental results have verified the stability and damage functions of this system.

基于Shannon复数小波的复合材料结构时间反转聚焦多损伤成像方法

邱 雷

摘 要：研究了一种基于压电传感器阵列和主动Lamb波的结构损伤成像方法，有助于克服Lamb波在板结构中，特别是在复合材料板结构中存在的频散、多种模式及模式转换的现象给结构健康监测带来的困难。分析了结构多损伤散射信号的时间反转聚焦原理，在此基础上提出了一种基于Shannon复数小波和时间反转聚焦的信号合成成像方法。该方法中，确定Lamb波响应信号的到达时刻是信号能够准确聚焦的关键因素之一。提出了利用Shannon复数小波变换计算Lamb波响应信号到达时刻的方法。在碳纤维复合材料板结构上对整套信号合成成像方法进行了验证。研究结果表明，该方法能够有效地对同一个监测区域中的多个损伤进行成像定位。相对于30cm×30cm的监测区域，定位误差不超过2cmm。该方法有助于结构健康监测技术的工程应用。

基于FBG的机翼盒段结构健康监测系统功能验证研究

邱 雷

摘 要：光纤布拉格光栅（FBG）传感器由于其抗电磁干扰、重量轻、可多路复用等优点，在结构健康监测领域有着广泛的应用前景。国内在航空结构的健康监测领域研究中，对FBG传感器的应用研究都是集中在实验室小尺寸试件上进行的，本文在某型无人机大型碳纤维复合材料机翼盒段实验件上布置了34个FBG传感器组成FBG健康监测系统，在机翼盒段的强度测试中对其进行了在静态扭转和弯曲载荷下的在线实时的应变分布监测，并将其与传统的应变片测得的数据进行对比，得到了好的吻合性。本文还针对FBG的该应用，对其粘结剂的选取和标定方法进行了讨论。

基于Lamb波主动结构健康监测系统的研制

邱 雷

摘 要：基于压电传感器和Lamb波的主动诊断技术是结构健康监测方法中行之有效的热门研究方法，它能实现对金属和复合材料结构中的微小损伤进行在线实时的监测。该文基于上述方法，研制了一台通用的结构健康监测系统。针对该方法在实际工程应用中的需求，详细讨论了系统整体软硬件的实现、运行效率和抗串扰能力。最后在某型无人机机翼盒段上完成了该系统地面应用的功能验证实验。

On development of PZT array based structural health monitoring scanning system and its experimental research on UAV wing box

Qiu Lei

Abstract:The active Lamb wave and piezoelectric sensor (PZT) based structural health monitoring (SHM) technologies are efficient methods to estimate the health state of aircraft structures. In real applications, PZT networks are needed to monitor large scale structures. The scanning of many different PZT actuator-sensor channels among these PZT networks is impor-tant to achieve a real time SHM task. In this paper, an active Lamb wave and PZT network based integrated multi-channel scanning system (ISS) for SHM purpose is developed, which can scan large numbers of actuator-sensor channels and estimate damage automatically. Its hardware and software realizations are introduced in detail in this paper, including the archi-tecture of whole system, the development of a computer bus based charge amplifier for re-sponse signal amplifying and a low crosstalk scanning module for multi-channel switching, techniques of software realization for enhancing its running efficiency. Experimental research is performed on a carbon fiber composite wing box of an unmanned aerial vehicle (UAV) to validate the functions of the ISS. In the experimental, frequency selection, damage monitoring, stability test of response signals under loading condition are main discussed. The experimental results show good performance of the developed ISS.

压电光纤综合结构健康监测系统的研究及验证

邱 雷

摘 要：本文以某型无人机机翼盒段试验件为对象，进行了压电－光纤综合结构健康监系统的研究。研究中自主研发了国内首台集成压电多通道扫查系统，可实现多达552个激励-传感通道的损伤自动扫查，并同光纤光栅解调系统组合，自行开发了集成健康监测系统软件，构成了压电－光纤综合结构健康监测系统。基于该系统进行了大型碳纤维复合材料盒段试验件弯扭强度实验过程中的结构健康监测功能验证研究，监测结构尺寸达4×1.2×0.265m，监测对象包括结构的应变场分布及抽钉失效。研究中，系统监测了全盒段上下壁板共34点的应变场分布情况，应变场监测准确；监测系统不仅实现了对结构抽钉的缺失实现了准确监测，而且可以分辨所试验结构的4种抽钉缺失程度。

大型飞机的发展对结构健康监测的需求与挑战

邱 雷

摘 要：本文分析了大型飞机的发展对结构健康监测技术的需求，综述了国内外飞行器结构健康监测技术的发展情况，分析了当前所应重点研究和解决的关键技术问题，介绍了当前研究中具有应用前景的相关新方法。飞行器结构健康监测技术是确保飞行器结构先进、机构新颖、飞行安全、易维护并满足高性能飞行指标的高新技术之一，其发展和应用对于研发我国具有自主知识产权的高性能军民用飞机具有重要意义。

基于Lamb 波相控阵和图像增强方法的损伤监测

邱 雷

摘 要：利用Lamb波和超声相控阵理论对结构进行损伤监测。选择合适的低频窄带激励信号，产生单一模式Lamb波，结合超声相控阵技术对结构进行多方位监测。针对原始损伤图像不完美的问题，研究基于点运算的对比度增强方法，改善图像质量，提高图像的可识别度和分辨率。在复合材料板结构和铝板结构中针对不同损伤类型的实验研究证明，运用图像增强技术后的损伤图像表征清晰、识别度高。