Japanese Aerospace Literature This month: *Large Space Structures*

A92-56099 Space environment resistance of CFRP for use in space infrastructure. SHIGEKAZU HIGUCHI, *Proceedings of the 29th Aircraft Symposium,* Gifu, Japan, Oct. 7–9, 1991, (A92-56001 24-01). Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, pp. 448–452.

Structural materials for use in low earth orbit or geostationary orbit are discussed. Forming conditions of carbon fiber reinforced plastics (CFRP) are presented. Radiation-resistance testing of CFRP composite is discussed.

A92-52084 Antenna pointing control system using a LQG controller for a large antenna reflector. MASAZUMI UEBA, 1992 AIAA/AAS Astrodynamics Conference, Hilton Head Island, SC, Aug. 10–12, 1992, Technical Papers (A92-52051 22-13) Publisher: American Institute of Aeronautics and Astronautics (AIAA Paper 92-4514).

This paper describes an antenna pointing control system using a Linear Quadratic Gaussian (LQG) controller for a 10 m class antenna reflector. The control performances of two regulators are investigated from the viewpoint of pointing accuracy and shape accuracy. The effects of the flexibility of the antenna reflector and the uncertainties of the disturbance torque on those accuracies are clarified. (Author)

A92-47590 Decomposition method for mode shape identification using measured data. YOSHITSUGU YASUI, *JSME International Journal, Series III* (ISSN 0914-8825), Vol. 35, No. 2, June 1992, pp. 279–285.

A mode shape identification procedure which yields mass-weighted orthogonal modes is proposed for application to a vibration test. The orthogonalization is accomplished by eliminating errors existing in the combination of measured forced response equations and an assumed mass matrix. A matrix decomposition technique is utilized for extracting the error coefficients, by which the modification of measured data is performed subject to the theoretical constraints of the forced response equation. The procedure presented herein is formulated for a base excitation test and demonstrated numerically in evaluating the mode participation factors of a component model using a simple plate model. The identified parameters are in good agreement with the exact values, and also, the identified mode shapes satisfy the orthogonality requirement. A comparison with Targoff's method and an evaluation using simulated measurement data with random errors are also presented. (Author)

A92-47588 Active wave control of a flexible beam (Fundamental characteristics of an active-sink system and its verification). NOBUO TANAKA and YOSHIHIRO KIKUSHIMA, *JSME International Journal, Series III* (ISSN 0914-8825), Vol. 35, No. 2, June 1992, pp. 236–244.

This paper deals with the active wave control of a flexible beam. It is the purpose of this paper to realize experimentally the active sink proposed in the previous paper, and to discuss the fundamental characteristics of the active-sink system. First, for the purpose of observing wave flow traveling along the beam, a visualization system is developed. Next, on the basis of the visualization system an experiment is carried out to verify the existence of the active sink. Then, from an analytical point of view, this paper further investigates the characteristics of the active-sink system, showing that an active source also exists in addition to the active sink. It is also found that there are two suppression patterns in active wave control; that is, the progressive-wave type and the standing-wave type. Finally, by introducing both phase distribution and gain of the complex reflection coefficient over a flexible beam, the generation mechanism of these patterns is clarified. (Author)

A92-45402 A new two degrees-of-freedom actuator used for vibration control of large space structures. OSAMU OKAMOTO, TERUOMI NAKAYA, SEIZO SUZUKI, KENJI OGIMOTO, YASUAKI TANIGUCHI, HAJIME SAKAMOTO, GOJI IBA, SOTOMITSU HARA, and MAKOTO HAMADA, *Proceedings of the 29th International Pacific Air and Space Technology Conference and Aircraft Symposium,* Gifu, Japan, Oct. 7–11, 1991, (A92-45376 19-01). Warrendale, PA, Society of Automotive Engineers, Inc., 1991, pp. 315–324. (SAE Paper 912000).

A new two-degrees-of-freedom actuator called 'superprecision positioning device' (SPD) was developed, which converts rotational motion to translational motion without cams or link mechanisms. Experimental results are presented demonstrating an efficient control of three-dimensional vibrations of a large free-standing flexible frame-type structure by using the SPD as an active damping enhancer.

A92-39274 Some approaches to the optimal adaptive geometries of intelligent truss structures. YOSHISADA MUROTSU and SHAOWEN SHAO, *Proceedings of the 1st Joint U.S./Japan Conference on Adaptive Structures,* Maui, HI, Nov. 13–15, 1990, (A92-39251 16-39). Lancaster, PA, Technomic Publishing Co., Inc., 1991, pp. 743–771.

This paper is concerned with the optimal adaptive geometry of an intelligent truss structure subjected to a given external loading. The optimal geometry is attained by changing the lengths of some active members to obtain the maximum structural strength. The study is carried out by using deterministic, probabilistic and dynamical approaches. The numerical results show that the structural strength is greatly increased by optimizing the geometry of the structure. (Author)

A92-41832 A new control technique based on the LAC/HAC concept for flexible structures. SHINJI HOKAMOTO and NORIHIRO GOTO, *Japan Society for Aeronautical and Space Sciences, Transactions* (ISSN 0549-3811), Vol. 34, No. 106, Feb. 1992, pp. 240–249.

A new control technique based on the LAC/HAC concept is proposed to suppress the vibration of flexible space structures. The new technique employs the mechanism to turn on or off the HAC part of the LAC/HAC system in such a manner as to suppress the spillover effects as quickly as possible. The control system designed by the new technique has global stability and is more effective than a pure LAC system, even when an ordinary LAC/HAC system results in failure because of spillover instability. To show the characteristic features of the new technique and how to implement the system, computer simulation examples are given. The technique is applied to the transversal vibration control of a cantilever beam to show its effectiveness and practicality. (Author)

A92-39282 A ground test equipment with suspension wires for adaptive structures. SABURO MATUNAGA and MICHIHIRO NATORI, *Proceedings of the 1st Joint U.S./Japan Conference on Adaptive Structures,* Maui, HI, Nov. 13–15, 1990, (A92-39251 16-39). Lancaster, PA, Technomic Publishing Co., Inc., 1991, pp. 917–927.

A new concept for the gravity compensation of space structures including especially adaptive structures is proposed. Test equipment using this concept has the ability to actively follow the motion of structure by using movable units and by sensing the inclinations of the suspension wires. The main frame of the test equipment is able to rotate. The rotational degree of freedom is needed in order to simulate the rotational rigid body movement and to avoid the collision between neighboring movable units. Some results of a geometrical analysis and computational simulations to confirm the validity of the rotational degree of freedom are shown, and the outline of the equipment hardware is briefly introduced. (Author)

A92-39279 Active vibration control of a free-free beam by using a tendon mechanism. JUNJI TANI and HIROKI UEDA, *Proceedings of the 1st Joint U.S./Japan Conference on Adaptive Structures,* Maui, HI, Nov. 13–15, 1990, (A92-39251 16-39). Lancaster, PA, Technomic Publishing Co., Inc., 1991, pp. 855–864.

This paper is concerned with an active vibration control of a free-free beam. The beam is reduced to a finite-degree-of-freedom system by the modal analysis, in which the mode function is derived from the transfer matrix method. A control force is produced by a pair of tendons and a DC servo motor attached to the beam. The state of the beam is presumed by the minimum order state observer and the control force is determined by the digital optimum regulator theory. It is found that the active tendon control method is effective to suppress the vibration of the free-free beam. (Author)

A92-39276 Application of fuzzy control to tracking for docking operation of an adaptive space structure. YUJI MATSUZAKI, HIROTO HOSODA, and YOSHIYASU HAYAKAWA, *Proceedings of the 1st Joint U.S./Japan Conference on Adaptive Structures,* Maui, HI, Nov. 13–15, 1990, (A92-39251 16-39). Lancaster, PA, Technomic Publishing Co., Inc., 1991, pp. 792–803.

This paper describes an application of fuzzy logic control to an experimental simulation of tracking of space structures. The test was made using a two-dimensional truss-type structure with variable geometries constructed for rendezvous and docking test. The bending-deformation modules of the structure were controlled by the signal from the optical tracking sensor while the docking target was moving vertically at a constant speed between two specified points. Based on triangle-shaped membership functions and partition with three terms, two fuzzy inference approaches were applied together with the center of area method to defuzzification. This preliminary test suggests that the application of fuzzy logic control will be effective in rendezvous and docking of the space structures. (Author)

A92-39271 Shape control experiments with a functional model for large optical reflectors. MASAKI TABATA, NOBORU ITOH, KEIZO MIYAWAKI, ATSUSHI SATORI, MASANORI IYE, YASUMASA YAMASHITA, TAKESHI NOGUCHI, and WATARU TANAKA, *Proceedings of the 1st Joint U.S./Japan Conference on Adaptive Structures,* Maui, HI, Nov. 13–15, 1990, (A92-39251 16-39). Lancaster, PA, Technomic Publishing Co., Inc., 1991, pp. 615–630.

Quasi-static shape control experiments of an optical reflector were performed to ascertain the capability of active optics system for future large astronomical telescopes. The experimental apparatus consists of a 62 cm-diameter thin spherical mirror, high precision force controlled actuators, optical wavefront aberration sensors, and an elevation angle driver. Using the experimental apparatus, the mirror figure control in range of the visible light wavelength was performed for correction of lower spatial frequency modes. The control algorithm, experimental results and error evaluation are reported in this paper. Through the various experiments, basic performance of the apparatus and the control algorithm are confirmed to be adaptable to the active mirror support system of telescopes in the next generation. (Author)

A92-39267 On damping enhancement of LSS coupled with the antenna pointing system. M. TANAKA, K. HIRAKO, S. UENO, T. KIDA, and I. YAMAGUCHI, *Proceedings of the 1st Joint U.S./Japan Conference on Adaptive Structures,* Maui, HI, Nov. 13–15, 1990, (A92-39251 16-39). Lancaster, PA, Technomic Publishing Co., Inc., 1991, pp. 510–524.

Results of an experimental study tracing the dynamical interaction between the antenna pointing system (APS) and the structural vibration of large space structures (LSS) are presented. The important role of the damping enhancement of the structure is considered and demonstrated. From many case-runs for various parameter values of APS control gain, the numerical analytical results correspond to the results of the experiment with sufficient accuracy. By increasing the proportional gain, K sub P, excellent pointing performance is attained. The system becomes unstable for excessively large K sub P because of the dynamical interaction with the structural vibration. The damping enhancement of the structure by the proof-mass actuator can recover system stability.

A92-39264 Criteria-oriented configuration control of adaptive structure and its modular neural network representation. YASUYUKI SEGUCHI, MASAO TANAKA, and KAZUYUKI HANAHARA, *Proceedings of the 1st Joint U.S./Japan Conference on Adaptive Structures,* Maui, HI, Nov. 13–15, 1990, (A92-39251 16-39). Lancaster, PA, Technomic Publishing Co., Inc., 1991, pp. 402–421.

The adaptive truss structure has the capability to perform specified tasks smartly and/or to meet the environment by changing its geometrical and mechanical properties actively. It is a kinematically redundant system in nature and the criteria-oriented approach is the conventional in order to resolve the redundancy. This article discusses a new neural network approach to this criteria-oriented configuration control. The basic idea is proposed based on the multi-layered neural network and the error back-propagation scheme. Then, the modular neural network representation is discussed to reduce the learning transaction in practical level, since the scale of the total neural network becomes very large due to the hugeness and the complexity of the problem. Simulations studies are carried out based on a transputer-based multi-processor system and the feasibility is examined. (Author)

A92-39257 Optimal configuration control of an intelligent truss structure. Y. MUROTSU, K. SENDA, and K. HISAJI, *Proceedings of the 1st Joint U.S./Japan Conference on Adaptive Structures,* Maui, HI, Nov. 13–15, 1990, (A92-39251 16-39). Lancaster, PA, Technomic Publishing Co., Inc., 1991, pp. 157–175.

This paper is concerned with the optimal configuration and the configuration control of the intelligent truss structures composed of a truss type mechanism. First, the problem to find the optimal configuration is solved by minimizing the performance index corresponding to the demanded task. The computational effort is huge, and the method can only be used for finding the optimal configuration. Next, two efficient methods are proposed for the configuration control under the relaxed conditions of optimality. The validity of the proposed methods is demonstrated through numerical simulations. (Author)

A92-34559 Optimal locations of actuators for statistical static shape control of large space structure—A comparison of approaches. JUNJIRO ONODA and YOJI HANAWA, 33rd AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, Dallas, TX, Apr. 13–15, 1992, Technical Papers, Pt. 5, (A92-34522 13-39). Washington, DC, American Institute of Aeronautics and Astronautics, 1992, pp. 2788–2795.

This paper compares the use of the genetic algorithm (GA) and an improved version of the simulated annealing (SA) method for the optimization of actuator placement for the static-distortion correction of trusses. The improved simulated annealing (ISA) method is reviewed which is essentially a combination of GA and SA. These approaches are used to solve typical design problems, and the results are compared to those from the exhaustive single-point substitution algorithm, the worst-out-best-in algorithm, and the SA algorithm. The optimal actuator placement problem involves the statistical static shape correction of a tetrahedral truss structure with three rings. The GA approaches and the ISA approach lead to better results than the other techniques and give groups of optimized solutions with good values for mean value and variance of the solutions.

A91-44780 Active wave control of a flexible beam—Proposition of the active sink method. NOBUO TANAKA and YOSHIHIRO KIKUSHIMA, *JSME International Journal, Series III* (ISSN 0914-8825), Vol. 34, June 1991, pp. 159–167.

This paper deals with the flexural wave control of a flexible beam with an infinite number of vibration modes. It is the purpose of this paper to present a new vibration control method, the active sink method, which makes it possible to suppress all vibration modes of the flexible beam. Unlike a conventional vibration control method which attempts to suppress several vibration modes already excited, the active sink method seeks to keep all the vibration modes in active. First, this paper presents the principle of the active sink method and shows a means of realizing its system. Next, in order to describe the principle of the active sink method mathematically, transfer matrices of a beam using a progressive wave solution to the wave equation are obtained. Then, the optimal conditions for the active sink system are derived, and the fundamental characteristics of the system are discussed. Finally, from the viewpoint of vibration intensity analysis, the validity of the active sink method is clarified. (Author)

A92-39256 Simultaneous optimum design of structural and control system. TAKUZO IWATSUBO, SHOZO KAWAMURA, KAZUHIKO ADACHI, and MASAO IKEDA, *Proceedings of the 1st Joint U.S./Japan Conference on Adaptive Structures,* Maui, HI, Nov. 13–15, 1990, (A92-39251 16-39). Lancaster, PA, Technomic Publishing Co., Inc., 1991, pp. 117–140.

Recently, the simultaneous optimum design of a structural and control systems has attracted special interest. This paper describes one approach to calculate the large number of elements of structure model in the simultaneous optimum design. To formulate the structural configuration, the gradients of the characteristic values and shape of the structure are taken as the structural design variables. In this way, the number of the structural design variables is constant in spite of the increase of number of elements. The locations of the sensors and actuators are taken as the control variables. These design variables are optimized under the condition of minimizing a objective function composed of the kinetic and control energies. (Author)

A92-29519 A feature of the mission-function control. HIRONORI FUJII, *Japan Society for Aeronautical and Space Sciences Journal* (ISSN 0021-4663), Vol. 40, No. 457, 1992, pp. 103–110.

A feature of the mission-function (MF) control is studied. The MF control is a control algorithm compatible with the fundamentals of mechanics of flexible structures and employs the mission function. The mission function is a Liapunov function which includes such mechanical information of the system as the Hamiltonian and also a generalized energy to improve the performance of the controller. This paper presents the necessary conditions for the MF control in a general form. Another purpose of the paper is to present a feature belonging to the MF control, namely, that application of the control algorithm reduces to the design of an optimal regulator for the flexible structural system. Two examples for application of the MF control are shown through the use of the numerical simulation. (Author)

A92-27672 Adaptive structures research at ISAS—1984–1990. KORYO MIURA, *Journal of Intelligent Material Systems and Structures* (ISSN 1045-389X), Vol. 3, Jan. 1992, pp. 54–74.

This article reviews the research and development on adaptive structures and intelligent structural systems done by the structures and structural dynamic group at the Institute of Space and Astronautical Science (ISAS) from 1984 to 1990. Activity is closely linked to the practical needs for actively controlled structures on board scientific satellites and interplanetary vehicles which ISAS launches annually. The subjects described are: the proposal of novel structural concepts such as the variable geometry truss, the adaptive structure and the tension truss antenna; the proposal of vibration control schemes for flexible structures and the shape control scheme for precision antenna reflectors; and the study on construction of large space structures by assembling adaptive structures. (Author)

A92-14731 A modular approach to build a large space antenna. JIN MITSUGI and TETSUO YASAKA, *42nd IAF, International Astronautical Congress,* Montreal, Canada, Oct. 5–11, 1991. 11 p.

Large deployable mesh antenna composed of independently manufactured and tested modules is presented and its feasibility for a 10-m aperture, C-band application is examined from the surface accuracy point of view. The required accuracy of a module under possible imperfection between modules is derived. The tensions in the mesh surface to achieve the module accuracy is elicited by modeling the mesh with an equivalent cable network. Results gives a mesh surface that could be considered as flat among the shaping cable network. (Author)

A92-14730 Scale model development of assembling type space antenna. YOSHIAKI SUZUKI, TETSUO TAKAHASHI, MASATO TANAKA, TAKASHI IIDA, SEIJI YOKOTA, KAZUO OHSHIMA, *42nd IAF, International Astronautical Congress,* Montreal, Canada, Oct. 5–11, 1991. 8 p.

This paper describes the development of assembling type antenna scale models which are designed to be constructed by using manipulator arm. The assembling type antenna has possible advantages to achieve high accuracy in reflector surface construction and is appropriate for the high frequency application, comparing deployable type antenna. After some trade-off studies, two types of antennas which have unique coupling mechanisms were selected. Using these smart mechanisms, construction using manipulator instead of using dangerous extra vehicular operation became possible. (Author)

A91-44781 Digital active vibration control of a cantilever beam with piezoelectric actuators. JUNJI TANI, SEIJI CHONAN, YU-ZHOU LIU, FUMIAKI TAKAHASHI, KIKUHO OHTOMO et al., *JSME International Journal, Series III* (ISSN 0914-8825), Vol. 34, June 1991, pp. 168–175.

A digital optimal regulator technique is introduced to the problem of vibration control of a cantilever beam. A pair of piezoelectric cells is adhered to the upper and lower surfaces of the beam and used as the actuator. Influences of the mass and the rigidity of the actuator are taken into account in the analysis, and the equations of motion for the beam-control system are derived by applying the transfer matrix method. Simulated transient response of the beam is compared with the experimental result. It is found that the effect of vibration suppression is obtained by means of the present technique which compensates for the delay arising from the computation time. (Author)