International Aerospace Literature

During 1997 the *AIAA Journal* will carry selected abstracts on leading research topics from Russian, Japanese, British, French, German, and Italian aerospace literature. The topics will be chosen and the abstracts reviewed for pertinency by *AIAA Journal* editors. This month features Aircraft Control from Russia and Control Systems, Neural Networks, and Artificial Intelligence from Japan.

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Russian Aerospace Literature
This month: *Aircraft Control*

A96-42554   Optimal control of the elastic structures of flight vehicles (Optimal'noe upravlenie uprugimi konstruktsiyami letatel'nykh apparatov). A. A. GUSEV (Kazanskij Gosudarstvennyj Tekhnicheskij Univ., Kazan, Russia), *Aviatsionnaya Tekhnika* (ISSN 0579-2975), No. 2, 1996, pp. 23–28. In Russian. 7 Refs. Documents available from AIAA Dispatch.

An optimal control synthesis algorithm for the elastic structural elements of a flight vehicle is developed for the case where the measurements of the state of the structural elements are incomplete. The control is represented in terms of distributed and concentrated actions. The optimal control synthesis algorithm proposed here makes it possible to develop efficient computational schemes. An example is presented which involves the synthesis of optimal control for the surface shape of an elastic mirror.

A96-38141   Methods and criteria of simulator versus aircraft similarity evaluation. V. N. SHIHALEYEV and Y. V. MIHEYEV (Penza Simulation Design Co., Russia), *Training—Lowering the cost, maintaining the fidelity; Proceedings of the Conference,* London, UK, 1996 (A96-38130 10-09), London, Royal Aeronautical Society, 1996, pp. 12.1–12.4. Documents available from AIAA Dispatch.

The current practice of flight simulator development is based mainly on the implementation of the design engineering requirements. Human engineering requirements are implemented subjectively, as a rule, taking into account the concrete pilot, and so have qualitative features. Human engineering approach is complex, that is the simulator ergonomics specifications should include the simulator technical specifications and not vice versa. (Author)

A96-35611   Longitudinal flight control in a windshear via H-infinity methods. A. P. KURDJUKOV, B. V. PAVLOV, and V. N. TIMIN (Inst. of Control Sciences, Moscow, Russia), *AIAA, Guidance, Navigation, and Control Conference,* San Diego, CA, 1996, p. 7. 9 Refs. Documents available from AIAA Dispatch.

The design of the control of an aircraft encountering windshear in the landing approach is treated as a problem of minimizing the H-infinity gain between the windshear and two components of the aircraft state space vector: air velocity and the height. The features of application of H-infinity control methods for aircraft control design are examined. A comparison of the derived H-infinity control algorithms (with and without weight functions) to LQG algorithms is given. (Author)

A96-31845   Similarity criteria and some requirements to feel system modelling. L. E. ZAICHIK, V. V. RODCHENKO, and Y. P. YASHIN (TsAGI, Zhukovsky, Russia), *2nd AIAA Test and Evaluation International Aerospace Forum,* London, UK, 1996, TP (A96-31842 08-01), Reston, VA, American Inst. of Aeronautics and Astronautics, 1996, pp. 18–24. 9 Refs. Documents available from AIAA Dispatch.

A methodology of experimental investigations of manipulator and control sensitivity characteristics affecting aircraft controllability is considered. The basic concepts of a theoretical approach to assessing the influence of various manipulator and control sensitivity characteristics on handling qualities are presented. The similarity criteria of controllability are developed for aircraft with different manipulator and control sensitivity characteristics. A method is proposed which allows one to assess the controllability of an aircraft with certain manipulator and control sensitivity characteristics by making a comparison with the respective data obtained for the aircraft with other values of these characteristics. Recommendations are given for modeling the controllability of an aircraft with certain manipulator and control sensitivity characteristics on ground-based and in-flight simulators which may have other values of these characteristics. The requirements on the dynamic characteristics of a manipulator feel system used in ground-based and in-flight simulators are considered. (Author)

A96-27316   The principles of ground-effect aircraft control over an expanded altitude range (Printsipy upravleniya ehkranoplanom v rasshirennom diapazone vysot). L. A. SEVEROV, V. K. PONOMAREV, A. I. PANFEROV, and E. V. KAMINA (Sankt-Peterburgskaya Akademiya Aehrokosmicheskogo Priborostroeniya, St. Petersburg, Russia), *Aviatsionnaya Tekhnika* (ISSN 0579-2975), No. 4, 1995, pp. 19–22. In Russian. Documents available from AIAA Dispatch.

The paper is concerned with the generation of control signals that would ensure the landing of a ground-effect aircraft on the air cushion and its take-off from it. Particular attention is given to the issues of conjugating the segments of the flight trajectory and providing for the required balancing.

A96-17853   A theory for the aeroinertial rotation and spin of aircraft (Teoriya aehroinertsionnogo vrashcheniya i shtopora samoleta). V. F. NATUSHKIN (Moskovskij Aviatsionnyj Inst., Filial 'Voskhod', Leninsk, Russia), *Aviatsionnaya Tekhnika* (ISSN 0579-2975), No. 3, 1995, pp. 14–20. In Russian. 8 Refs. Documents available from AIAA Dispatch.

The aeroinertial rotation and spin theory for aircraft is further extended by introducing the Euler kinematics in nontraditional phase coordinates: three-dimensional angle of attack, aerodynamic bank angle, rotation angle, and their derivatives. Errors are identified in the aeroinertial rotation theory proposed by Phillips (1948). Aircraft control laws are obtained which ensure aircraft stability with respect to steady and quasi-steady aeroinertial rotation and steady spin.

A96-17852   The problem of calculating the reliability of data processing and measuring systems; for the design of aircraft control equipment (K zadache rascheta nadezhnosti informatsionno-izmeritel'nykh sistem). A. E. KONDRAT'EV (KPO SVT, Kazan, Russia) and G. E. POPOVA (Kazanskij Gosudarstvennyj Tekhnicheskij Univ., Kazan, Russia), *Aviatsionnaya Tekhnika* (ISSN 0579-2975), No. 3, 1995, pp. 10–13. In Russian. 3 Refs. Documents available from AIAA Dispatch.

The problem of calculating the reliability characteristics of data processing and measuring systems is examined in the context of ensuring flight safety. In particular, attention is given to the definition of standard requirements for the characteristics of control, data processing, and measuring systems in terms of reliability. The characteristics considered are used in the design of different types of control and measuring equipment, the development of fail-safe systems for newly designed aircraft of various classes, and the development of operating manuals for data processing and measuring systems.

A96-13539   A flight control system for ground-effect aircraft with adaptation properties (Sistema upravleniya poletom ehkranoplana so svojstvami adaptatsii). A. I. BOGOMOLOV and P. K. SEMENOV (Kazanskij Gosudarstvennyj Tekhnicheskij Univ., Kazan, Russia), *Aviatsionnaya Tekhnika* (ISSN 579-2975), No. 2, 1995, pp. 20–26. In Russian. 3 Refs. Documents available from AIAA Dispatch.

A ground-effect aircraft control system is developed using the approach described in previous studies (Bogomolov and Semenov, 1992, 1993). In accordance with this approach, the command signals, generated by the pilot through the operation of levers controlling individual motion parameters, are dynamically transformed in a special digital filter with allowance for the information produced by the autopilot-aircraft system. The control algorithm provides

for a practically ideal tracking of the reference transient processes at all flight regimes, stability of control characteristics in the presence of a large scatter of autopilot and aircraft characteristics, and control resolution in terms of angular and linear motion parameters.

A95-42796   On a flight safety problem—Internal fluid motion in an aircraft. V. V. VYSHINSKIJ and S. A. KRAVCHENKO (TsAGI, Moscow, Russia), *1st AIAA, Aircraft Engineering, Technology, and Operations Congress,* Los Angeles, CA, 1995, p. 12. 11 Refs. Documents available from AIAA Dispatch.

The problem of the unsteady motion of a fluid in an aircraft fuel tank with a free surface is solved in a noninertial coordinate system, within the frameworks of both the shallow water theory equations and the incompressible Euler equations. To solve boundary value problems in both cases, numerical schemes are employed in conjunction with upwind differences. This recourse is stable, without artificial viscosity, and allows solutions with low dissipation to be investigated over long time-intervals.

N95-31728   FBIS report: Science and technology. Central Eurasia. Foreign Broadcast Information Service, Washington, DC. Documents available from AIAA Dispatch.

Translated articles cover the following topics: Use of Radar Set With Synthesized Antenna for Estimating Effectiveness of Active Masking and Simulating Interference Signals; Simulation of Echo Signals Picked From Sea Surface by Grazing Radar Beam at Low Grazing Angle; Methods and Algorithms of Sea Surface Radar Image Processing and Identification; Aircraft Optimum Control Synthesis Based on Group Analysis of Motion Equations; On Issue of Maximizing Aircraft Glide Range Planning; Effect of Amplitude and Phase Noise on Quality of Radar Image Formation; Narrow-Band Infrared ($1.0–1.2\ \mu$) Photodiodes on Stressed Selective Epitaxial GaAs/InGaAs Structures; Selection of Transverse Modes in InGaAsP Lasers with Dielectric Coating on Mirrors; Single-Mode Strip-Geometry lambda = $1.55\ \mu$ Stripe-Geometry InGaAsP/InP Lasers; and Effect of Hydrogen on Cracking of Metals and Testing Them for Indication of Cracking Processes by Acoustic Emission.

A95-23757   The problem of the synthesis of multimode dynamic systems on the basis of the motion stability condition (Zadacha sinteza mnogorezhimnykh dinamicheskikh sistem po usloviyu ustojchivosti dvizheniya). T. K. SIRAZETDINOV (Kazanskij Gosudarstvennyj Tekhnicheskij Univ., Kazan, Russia), *Aviatsionnaya Tekhnika* (ISSN 0579-2975), No. 3, 1994, pp. 36–40. In Russian. 4 Refs. Documents available from AIAA Dispatch.

The various aspects of the modeling and synthesis of multimode technical systems on the basis of the stability condition are examined. The necessary and sufficient conditions are presented for the sign invariance of quadratic forms with coefficients depending on the multimode parameter. The approach adopted here employs Liapunov functions.

A95-23755   An anthropocentric model of pilot actions as the operator in the loop operator-dynamic system (Antropotsentricheskaya model' dejstvij letchika kak operatora v konture 'operator-dinamicheskaya sistema'). V. N. PUGACHEV (Voenno-Vozdushnaya Inzhenernaya Akademiya, Moscow, Russia), *Aviatsionnaya Tekhnika* (ISSN 0579-2975), No. 3, 1994, pp. 24–29. In Russian. 5 Refs. Documents available from AIAA Dispatch.

An anthropocentirc approach is proposed for modeling pilot's actions during flight safety studies at the stage of flight vehicle design. The approach is based on the psychophysical characteristics of human interaction with the controlled plant. The modeling of pilot's actions on the basis of the anthropocentric model makes it possible to carry out computer simulations of flight tests at the flight vehicle design stage.

A95-23754   The problem of ensuring the stability of the safe flight regime of aircraft (K probleme obespecheniya ustojchivosti bezopasnogo rezhima poleta samoleta). G. V. KOLPAKOV (Kazanskij Gosudarstvennyj Tekhnicheskij Univ., Kazan, Russia), *Aviatsionnaya Tekhnika* (ISSN 0579-2975), No. 3, 1994, pp. 18–24. In Russian. 5 Refs. Documents available from AIAA Dispatch.

A method for analyzing flight safety is proposed which is based on the properties of safety indices, concepts of motion stability theory, and method of Liapunov functions. Algorithms for the avoidance and prevention of hazardous flight regimes are presented which can be used in aircraft control. The approach is illustrated for the case of safe aircraft landing.

A95-21172   Distributed estimation systems with a random structure (Raspredelennye sistemy otsenivaniya so sluchajnoj strukturoj). A. S. BURYJ (Voennaya Akademiya, Moscow, Russia), *Avtomatika i Telemekhanika* (ISSN 0005-2310), No. 12, 1994, pp. 70–75. In Russian. 6 Refs. Documents available from AIAA Dispatch.

Attention is given to multiple-stage distributed estimation systems with a randomly changing structure, with the change representing a Markovian process. Recursive Bayes algorithms are proposed for determining the a posteriori probabilities of the system structure change and for estimating the state vector of a plant. Experimental results are presented, with particular reference to smoothing filters in the form of power polynomials.

A95-16949   Control of an aircraft landing in windshear. V. S. PATSKO, N. D. BOTKIN (Russian Academy of Sciences, Inst. of Mathematics and Mechanics, Yekaterinburg, Russia), V. M. KEIN (Civil Aviation Academy, St. Petersburg, Russia), V. L. TUROVA, and M. A. ZARKH (Russian Academy of Sciences, Inst. of Mathematics and Mechanics, Yekaterinburg, Russia), *Journal of*

Optimization Theory and Applications (ISSN 0022-3239), Vol. 83, No. 2, 1994, pp. 237–267. 27 Refs. Documents available from AIAA Dispatch.

The landing problem for midsize transport aircraft is considered. The aircraft dynamics is described using a sufficiently complete nonlinear system taking the time lag of servomechanics into account. The landing process from the altitude of 400 m up to the time when the runway threshold is reached is considered. Numerical differential game (DG) algorithms are used for the feedback control synthesis. The complete system is linearized with respect to the nominal motion along the descending glide path and decomposed into a vertical motion subsystem and a lateral motion subsystem. DGs with a terminal performance index are formulated for both subsystems. The numerical solution for these games gives the minimax feedback control for the linear models. Control laws are applied to the original nonlinear system and tested by simulating the motion of the nonlinear system under various wind disturbances.

A94-28448   Locally optimal control of a flight vehicle with final state optimization (Lokal'no-optimal'noe upravlenie letatel'nym apparatom s optimizatsiej konechnogo sostoyaniya). V. I. SMAGIN (Tomskij Gosudarstvennyj Univ., Tomsk, Russia), *Aviatsionnaya Tekhnika* (ISSN 0579-2975), No. 4, 1993, pp. 74–76. In Russian. 4 Refs. Documents available from AIAA Dispatch.

The problem of transferring a flight vehicle descending in an atmosphere to a horizontal gliding flight at a specified altitude, with maximum flight velocity at the final moment of time, is solved by using locally optimal tracking of a moving point and numerical optimization of the terminal guidance criterion. The control law is formulated in the form of a nonlinear state feedback.

A94-28433   Parameter identification of multidimensional systems in indirect measurements with errors (Parametricheskaya identifikatsiya mnogomernykh sistem pri kosvennykh izmereniyakh s oshibkami). L. G. AMBARTSUMOV (Kazanskij Gosuradstvennyj Tekhnicheskij Univ., Kazan, Russia), *Aviatsionnaya Tekhnika* (ISSN 0579-2975), No. 4, 1993, pp. 10–15. In Russian. 5 Refs. Documents available from AIAA Dispatch.

An algorithm is developed for the parameter identification of multidimensional linear dynamic systems with discrete time in the case of indirect measurements with additive errors. The validity of the algorithms is demonstrated theoretically and by a numerical example involving parametric identification of an aircraft in longitudinal perturbed motion in a turbulent atmosphere. The relative estimation error is calculated.

A94-25713   Dynamics of adaptive circuits for damping the rotational motions of aircraft (Dinamika adaptivnykh konturov dempfirovaniya vrashchatel'nykh dvizhenij samoleta). P. D. KRUT'KO, A. A. MALAKHOV, and V. G. CHERNYSHOV (Moscow State Technical Univ., Russia), *Moskovskij Gosudarstvennyj Tekhnicheskij Universitet, Vestnik, Seriia Priborostroenie* (ISSN 0236-3933), Vol. 1993, No. 2, 1993, pp. 65–73. 3 Refs. Documents available from AIAA Dispatch.

The dynamics of a system with an adaptive damping algorithm are investigated as a function of the parameters of the servomotor and of the angular velocity derivative signal formation circuit in the feedback loop. With the yaw channel used as an example, a system stability condition is obtained for an infinite increase in the circuit gain coefficient. A procedure is presented for selecting the algorithm parameters in such a way as to ensure the required stability and quality of control. Mathematical modeling results are presented.

A94-25712   Synthesis of a digital yaw-channel stabilization system for an unmanned flight vehicle using the modal control method (Sintez tsifrovoj sistemy stabilizatsii bespilotnogo letatel'nogo apparata v kanale ryskaniya metodom modal'nogo upravieniya). M. E. TRET'YAKOV (Moscow State Technical Univ., Russia), *Moskovskij Gosudarstvennyj Tekhnicheskij Universitet, Vestnik, Seriia Priborostroenie* (ISSN 0236-3933), Vol. 1993, No. 2, 1993, pp. 34–41. 3 Refs. Documents available from AIAA Dispatch.

The use of the modal control method for the synthesis of a digital yaw-channel stabilization system for a pilotless flight vehicle is described with reference to a specific example. Simple analytical expressions are obtained for the feedback gain coefficients of the digital stabilization system and for the perturbation identifier parameters which facilitate the synthesis of control systems of this kind.

A94-24895   Applications of a quasi-stationary autopilot in a nonstationary aircraft-autopilot system (Oblasti primeneniya kvazistatsionarnogo avtopilota v nestatsionarnoj sisteme samolet-avtopilot). B. N. OKOEMOV, S. E. NIKITIN, and V. M. PETROV, *Moskovskij Gosudarstvennyj Tekhnicheskij Universitet, Vestnik, Seriya Priborostroenie* (ISSN 0236-3933), No. 4, 1991, pp. 120–126. In Russian. 2 Refs. Documents available from AIAA Dispatch.

A method for estimating the stationarity of autopilot parameters is proposed which is based on the sensitivity theory. Calculations of the final approach of an aircraft using the signals of angle-measuring radio instruments are presented as an example.

A94-24894   Structural schemes of a specialized digital navigation device with fail-safe redundancy for aviation flight control and navigation systems (Skhemy postroeniya spetsializirovannogo tsifrovogo navigatsionnogo ustrojstva odnokratnogo rezervirovaniya dlya aviatsionnykh pilotazhno-navigatsionnykh kompleksov). B. N. OKOEMOV, S. E. NIKITIN, and V. M. PETROV, *Moskovskij Gosudarstvennyj Tekhnicheskij Universitet, Vestnik, Seriya Priborostroenie* (ISSN 0236-3933), No. 4, 1991, pp. 112–120. In Russian. 3 Refs. Documents available from AIAA Dispatch.

Various fail-safe redundancy schemes for the digital navigation devices of flight control and navigation systems are examined. The redundancy schemes considered are evaluated in terms of their contribution to the efficiency of the system with respect to the reliability criterion.

A94-22544 Su-25 attack aircraft. K. TRUBETSKOJ, *Military Parade*, Feb. 1994, pp. 38–41. In English and Russian. Documents available from AIAA Dispatch.

An account is given of the performance characteristics and representative weaponry of the Su-25 ground-attack aircraft, which is of very simple, low-maintenance design for primitive field conditions; if aviation kerosene is unavailable, diesel fuel will be accepted by its engines. Attention is given to the enhanced capabilities of the latest variant of this aircraft, the Su-25 TK, whose sophisticated target-acquisition electronics are optimized for antitank operations.

A94-18552 High maneuverability—Theory and practice (Wright Brothers Lecture). G. I. ZAJGANOV (TsAGI, Zhukovski, Russia), *AIAA/USAF/NASA/OAI 4th Symposium on Multidisciplinary Analysis and Optimization*, Cleveland, OH, 1992, p. 11. 6 Refs. Documents available from AIAA Dispatch.

The dynamics and aerodynamics problems of a present-day maneuverable aircraft at high angles of attack are discussed on the basis of the development of the MiG-29 and Su-27 aircraft. The flight efficiency at high angles of attack and, in particular, a short-duration dynamic flight of the aircraft at high angles of attack are considered. The peculiarities and conditions of a flight regime known as 'Pugatchov's cobra' are described. (Author)

A93-52944 Solution of the boundary value problem in flight dynamics by the opposite motion method (Reshenie kraevoj zadachi dinamiki poleta metodom vstrechnykh dvizhenij). E. A. KRAMARENKO and O. G. KOVRIZHKIN, *Aviatsionnaya Tekhnika* (ISSN 0579-2975). 2 Refs. Documents available from AIAA Dispatch.

A nonoptimization approach is proposed for solving the boundary value problem of guiding a flight vehicle to a specified terminal state on the basis of six phase coordinates. Control synthesis is carried out in steps using piecewise constant functions. The method is recommended for the generation of automatic control signals in guiding a flight vehicle to a specified point on the basis of six phase coordinates in relatively simple maneuvers.

A93-52941 Stabilization of the dynamic characteristics of the two-channel automatic control system of aircraft (Stabilizatsiya dinamicheskikh khrakteristik dvukhkanal'noj sistemy avtomaticheskogo upravleniya samoleta). A. I. BOGOMOLOV and P. K. SEMENOV, *Aviatsionnaya Tekhnika* (ISSN 0579-2975). 5 Refs. Documents available from AIAA Dispatch.

A method is proposed for ensuring the stability of the transient process characteristics in the automatic pilot-aircraft system with considerable crosstalk coupling between the control channels. The approach proposed here is an extension of the method proposed in an earlier study (Bogomolov and Semenov,

1992) for single-channel systems. The efficiency of the method is illustrated by an example.

A93-52694 Computerized teaching of pilots to spatial orientation flight tasks. V. A. PONOMARENKO, A. A. VORONA, D. V. GANDER, and V. M. USOV (Russian Air Force Inst. of Aerospace Medicine, Moscow, Russia), *AIAA Flight Simulation Technologies Conference*, Monterey, CA, 1993, TP (A93-52651 23-09). 5 Refs. Documents available from AIAA Dispatch.

The paper discusses components of a computer-based training program for pilots of military aircraft, teaching mental and physical readiness to flight tasks requiring spatial orientation during aircraft maneuvers. The computer simulating system emphasizes the formation of the knowledge of spatial and temporal characteristics of the aircraft acrobatic maneuver; the development of an orientation basis for decision making; training of spatial and temporal perceptions of the aircraft movement on the trajectory; training of the distribution of indicators; the development of anticipated mental tasks; the formation of tactical thinking as a basis of making decisions on optimal maneuver choice under different situation parameters; and the formation of physical readiness to the recovery maneuver of the aircraft under different situations.

A93-52673 Semi-full-scale dynamic simulation complex on the basis of centrifuge. V. M. VASILETS (Inst. of Aviation and Space Medicine, Moscow, Russia) and O. A. YAKIMENKO (Military Air Force Engineering Academy, Moscow, Russia), *AIAA Flight Simulation Technologies Conference*, Monterey, CA, 1993, TP (A93-52651 23-09). Documents available from AIAA Dispatch.

The paper considers a structure and fundamental characteristics of semifull-scale imitative dynamic simulation complex (IDSC) on the basis of centrifuge. Capacities of the complex are illustrated graphically with some results made of different experimental works on investigation, optimization, and ergonomic justification of performances of the closed loop 'pilot-control system-aircraft-environment' with different composition of antistress facilities, different configuration of controls, and action of different flight factors. It must be emphasized that the represented results have a rather particular character, because they pursue an aim only to show IDSC capacities for imitative modeling of the investigation, design, and test of the flying-machine's specific tasks. (Author (revised))

A93-52660 Hybrid complex of the aircraft intellectualized control systems simulation at the stage of their research projecting. A. I. YAKOVLEV and V. M. VASILETS (International Academy of Engineering, Moscow, Russia), *AIAA Flight Simulation Technologies Conference*, Monterey, CA, 1993, TP (A93-52651 23-09). 3 Refs. Documents available from AIAA Dispatch.

The paper examines the problem of simulating aircraft intelligent control systems at the initial development state, with emphasis on the flight factors affecting pilots and operators. Consideration is given to the primary elements of an intelligent control system of flight vehicles, the set of indices for the man-machine system analyses, and the selection tasks for the 'best' man-machine system. The tasks optimization scheme of the 'best' selection system is formulated taking into account the features of human participation. A simulation example of spacecraft intelligent control system is described, and block diagrams of the control system and its elements are presented.

Japanese Aerospace Literature
This month: *Control Systems, Neural Networks, and Artificial Intelligence*

A96-33010   Flutter test signal analysis with wavelets and neural networks. C. M. PEI (Northwestern Polytechnical Univ., Xian, China), *Proceedings of the 33rd Aircraft Symposium*, Hiroshima, Japan, 1995 (A96-32875 08-31), Tokyo, Japan Society for Aeronautical and Space Sciences, 1995, pp. 657–660. 8 Refs. Documents available from AIAA Dispatch.

Digital signal processing (DSP) has been crucial to modern aircraft flutter testing. This paper provides some basic ideas for introducing two novel DSP techniques, i.e., wavelet transform and neural networks, to flutter testing data analysis. (Author)

A96-25147   A MULTINEURO computer system by using high performance digital neuro processor. T. SAITO, Y. BABA (Toshiba Corp., Fuchu Works, Japan), K. NAKAGAWA (Toshiba Corp., Tokyo, Japan), Y. FUWA, and Y. SHIMOKAWA (Toshiba Corp., Heavy Apparatus Engineering Lab., Tokyo, Japan), *Toshiba's Selected Papers on Science & Technology* (ISSN 0916-1465) Vol. 8, No. 1, 1996, pp. 34–39. 8 Refs. Documents available from AIAA Dispatch.

We have developed an accelerator device 'MULTINEURO-A' which incorporates multiple processors (one master node and plural slave nodes) dedicated to neural network high-speed computing realized on an engineering work station. Nodes are connected by two data paths, a broadcast bus and a ring bus. Processing speed is in proportion to the number of processors. It is built in two boards (master and slave) having 64 VLSI processors that offer 1.5 billion connections per seconds. It processes forward/backward calculations of multilayer perceptron type neural networks, feedback type neural networks such as Hopfield model, and any other types by programming for parallel processing. (Author)

N96-11616   Critical element study on autonomous position control of articulated-arm type manipulator. K. OKA, S. KAKUDATE, M. NAKAHIRA, E. TADA, K. OBARA, K. TAGUCHI, N. KANAMORI, M. KONDOH, K. SHIBANUMA, and M. SEKI, Japan Atomic Energy Research Inst., Tokyo (Japan). Documents available from AIAA Dispatch.

An articulated-arm type manipulator can be operated effectively in a restricted space due to its flexibility and it can be attractive for a wide range of in-vessel maintenance such as viewing, inspection and limiter handling in fusion experimental reactors. In case of the in-vessel maintenance using a flexible manipulator, it is quite essential to develop an autonomous control method for compensating a deflection of manipulator so as to minimize the maintenance time with high precision. For this purpose, a new position control method using a combination of neural network predictor with a rigid inverse kinematics is being developed. The key features of this method are to simplify a kinematics modeling of flexible manipulator, to enable quick position compensation in stead of ordinary large matrix compensation, and to be applicable to a wide variety of manipulator characteristics. A sub-scaled model of flexible manipulator with 4 joints has been fabricated for a benchmark experiments of the autonomous position control. Comparing analytical simulation with experiments using the flexible manipulator, it has been demonstrated that the new position control method gives significant improvement in control performance with high precision in order of a figure. In addition, further optimization can be possible by adding other non-linear predictors such as radial basis function and fuzzy modeling. This paper describes the details of a sub-scaled flexible manipulator and a neural network position control system as well as results of analytical simulation and benchmark experiments.

A95-34018   Superior generalization capability of hardware-learning algorithm developed for self-learning neuron-MOS neural networks. S. KONDO, T. SHIBATA, and T. OHMI (Tohoku Univ., Sendai, Japan), *Japanese Journal of Applied Physics, Part 1* (ISSN 0021-4922), Vol. 34, No. 2B, 1995, pp. 1066–1069. 12 Refs. Documents available from AIAA Dispatch.

We have investigated the learning performance of the hardware backpropagation (HBP) algorithm, a hardware-oriented learning algorithm developed for the self-learning architecture of neural networks constructed using neuron MOS (metal-oxide-semiconductor) transistors. The solution to finding a mirror symmetry axis in a 4×4 binary pixel array was tested by computer simulation based on the HBP algorithm. Despite the inherent restrictions imposed on the hardware-learning algorithm, HBP exhibits equivalent learning performance to that of the original backpropagation (BP) algorithm when all the pertinent parameters are optimized. Very importantly, we have found that HBP has a superior generalization capability over BP; namely, HBP exhibits higher performance in solving problems that the network has not yet learned.

A95-34015   Stand-alone hardware-based learning system. T. CLARKSON (King's College, London, UK) and C. K. NG (City Polytechnic of Hong Kong, Hong Kong), *Japanese Journal of Applied Physics, Part 1* (ISSN 0021-4922), Vol. 34, No. 2B, 1995, pp. 1050–1055. 11 Refs. Documents available from AIAA Dispatch.

The probabilistic Random Access Memory (pRAM) is a biologically-inspired model of a neuron. The pRAM behavior is described in this paper in relation to binary and real-valued input vectors. The pRAM is hardware-realizable, as is its reinforcement training algorithm. The pRAM model may be applied to a wide range of artificial neural network applications, many of which are classification tasks. The application presented here is a control problem where an inverted pendulum, mounted on a cart, is to be balanced. The solution to this problem using the pRAM-256, a VLSI pRAM controller, is shown. (Author)

A95-12801   LAC/HAC system with a variable feedback gain for flexible space structures; low authority control/high authority control. S. HOKAMOTO (Saga Univ., Saga, Japan) and N. GOTO (Kyushu Univ., Fukuoka, Japan), *JSME International Journal, Series C* (ISSN 1340-8062), Vol. 37, No. 3, 1994, pp. 431–435. 6 Refs. Documents available from AIAA Dispatch.

This paper proposes a new control technique, based on the low authority control/high authority control (LAC/HAC) concept, to suppress the vibration of flexible space structures. The control system designed by the new control technique has a mechanism to adjust the HAC feedback gain between zero and one in such a manner as to enhance the effectiveness of control and to obtain global stability even when the magnitude of the LAC gain is not suitable. The paper first describes the theoretical mechanism of the new control technique and proposes a numerical method for determining the HAC feedback gain based on a neural network system. Then it shows the characteristic features of the new technique by computer simulation examples. The computer simulation shows that the new technique is quite effective in suppressing the spillover effects, and quite feasible for implementation. (Author)

A95-12509   Data processing of a rendez-vous docking sensor using neural networks. K.-I. TANAKA and M. SHIMIZU (Mitsubishi Electric Corp., Central Research Lab., Amagasaki, Japan), *Proceedings of the 18th International Symposium on Space Technology and Science*, Kagoshima, Japan, 1992, Vol. 1 (A95-12376 01-12), Tokyo, Japan, AGNE Publishing, Inc., 1992, pp. 909–914. Documents available from AIAA Dispatch.

Real-time performance is important for an information processing system of an autonomous space robot. In this paper, we present a method of real-time data processing using a neural network model. This method is quite suitable for an onboard computer of the spacecraft because it significantly reduces computational expense. We demonstrate the effectiveness of the method by applying it to the data processing of a rendezvous docking sensor. (Author)

A95-10565   Intelligent scheduler with distributed decision makers for managing OTV Network operations. S. NAKASUKA, H. KATO, and T. NINOMIYA (Tokyo Univ., Japan), *Japan Society for Aeronautical and Space Sciences, Transactions* (ISSN 0549-3811), Vol. 37, No. 116, 1994, pp. 113–124. 11 Refs. Documents available from AIAA Dispatch.

A novel architecture is proposed for scheduling of various operations of the OTV Network, which has been proposed as the next-generation space transportation system based on reusable OTVs and fuel stations. The proposed scheduling architecture consists of several decision making agents named 'intelligent managers,' each of which performs certain decision making tasks by using some heuristic rules or by using other agents as internal simulators where knowledge is insufficient. Dynamic scheduling, i.e., dynamic selection of scheduling rules, is employed to compensate for the drawbacks of decision making with fixed heuristic rules, and back-propagation type Neural Network is employed to obtain knowledge as to a these rule selections. Computer simulations indicate that using this architecture, satisfactory, though suboptimal, schedules can be obtained which well suppress delay from mission due dates and fuel consumption within a manageable computational time. (Author)

A94-28759   A design of a self-learning robust scheduled autopilot. T. TANAKA, Y. AIZAWA, and H. EGUCHI (Japan Defense Agency, 3rd Research Center, Tachikawa), *Proceedings of the 30th Aircraft Symposium*, Tsukuba, Japan, 1992 (A94-28718 09-01), Tokyo, Japan Society for Aeronautical and Space Sciences, 1992, pp. 266–269. 6 Refs. Documents available from AIAA Dispatch.

A robust scheduled controller was designed for the MIMO plant which depends on time-varying variables. A neural network is used to emulate the scheduling function generated automatically through self-learning by a back-propagation algorithm. This scheduling method allows for controller dynamic which changes between the selected operating conditions and can produce an effective controller/plant combination to produce robust stability and robust performance. A design is developed based on multiple models that describes the plant with time-invariant models at different operating conditions and membership functions. As an example, a scheduled autopilot for the F-8 aircraft is descibed applying H-infinity control theories.

N94-24623   Design of central control system for Large Helical Device (LHD). K. YAMAZAKI, H. KANEKO, S. YAMAGUCHI, K. Y. WATANABE, Y. TANIGUCHI, O. MOTOJIMA, ET AL., National Inst. for Fusion Science, Nagoya (Japan). Documents available from AIAA Dispatch.

The world's largest superconducting fusion machine Large Helical Device (LHD), is under construction in Japan, aiming at steady state operations. Its basic control system consists of UNIX computers, FDDI/Ethernet LAN's, VME multiprocessors, and VxWorks real-time operating system. For flexible and reliable operations of the LHD machine, a cooperative distributed system with more than 30 pieces of experimental equipment is controlled by the central computer and the main timing system, and is supervised by the main protective interlock system. Intelligent control systems, such as applications of fuzzy logic and neural networks, are to be adopted for flexible feedback control of plasma configurations besides the classical PID control scheme. Design studies of the control system and related research and development programs with coil-plasma simulation systems are now being performed. The construction of

the LHD Control Building on a new site will begin in 1995 after finishing the construction of the LHD Experimental Building, and the hardware construction of the LHD central control equipment will be started in 1996. A first plasma production by means of this control system is expected in 1997.

N94-14241 Detecting land cover changes in Chiang-Mai area in Thailand. T. HOSOMURA and P. K. M. M. PALLEWATTA, *Science and Technology Agency, Asia-Pacific ISY Conference*, Vol. 2, pp. 164–172 (SEE N94-14209 02-43). Documents available from AIAA Dispatch.

Remote sensing techniques can be effectively used as a tool to monitor land cover change. Global coverage, high spatial resolution, and high revisit capabilities of modern remote sensing satellites provide large amounts of data daily. Land cover changes in Chiang-Mai area in Thailand are analyzed. The study has been carried out using two multitemporal images of MOS-1 (Marine Observation Satellite-1) MESSR (Multispectral Electronic Self-Scanning Radiometer) data. The analysis is done using difference images and classification results. The classification has been carried out using a neural network classifier, whose structure has been obtained by using a special technique developed. (Author)

A93-16149 Object recognition based on aspect vision using two-dimensional space spectrum analysis and neural network. M. IZUMI (Osaka Prefecture Univ., Sakai, Japan), S. KATO (Matsushita Electric Industrial Co., Ltd., Tokyo, Japan), H. KAWAKAMI, and K. FUKUNAGA (Osaka Prefecture Univ., Sakai, Japan), *Osaka Prefecture University, Bulletin, Series A—Engineering and Natural Sciences* (ISSN 0474-7844), 4 Refs. Documents available from AIAA Dispatch.

In this paper, we propose a method for object recognition using two-dimensional space spectrum analysis and neural network on the basis of aspect vision approach. To avoid mismatching caused by rotation and translation, we use two-dimensional space spectrum as training data of multilayer feedforward neural network, as well as edge images from the viewpoints partitioned uniformly. The multilayer feedforward neural network works as the matching processor of the aspect graph and its two-dimensional space spectrum, and recognizes the objects in the scene taken from unlearned viewpoints. With the experiments, we show the effectiveness of recognition of some kinds of chairs. (Author)

A92-51591 Associative memory in a cyclic neural network. J. SUN and T. NAGATA (Kyushu Univ., Fukuoka, Japan), *Kyushu University, Faculty of Engineering, Memoirs* (ISSN 0023-6160), Vol. 52, No. 1, 1992, pp. 85–94. 10 Refs. Documents available from AIAA Dispatch.

Pattern orthogonalization extension or high correlation is introduced in the cyclic neural network. The pattern orthogonalization extension by the power product sets of the original patterns can change nonorthogonal patterns to orthogonal or near-orthogonal vectors, which are easy to be stored. The storage capacity and the storage effectiveness of the cyclic neural network are shown to be higher than those of a two-layer BAM network due to the pattern orthogonalization extension. (Author)

A92-49607 Optical learning neural network using Selfoc microlens array. Y. HAYASAKI, I. TOHYAMA, T. YATAGAI (Tsukuba Univ., Japan), M. MORI, and S. ISHIHARA, (Electrotechnical Lab. Tsukuba, Japan), *Japanese Journal of Applied Physics, Part 1* (ISSN 0021-4922), Vol. 31, No. 5B, 1992, pp. 1689–1693. 10 Refs. Documents available from AIAA Dispatch.

The study proposes an optical network system with learning capabilities and a two-dimensional architecture. This architecture is implemented by a multiple imaging system of Selfoc microlens arrays, which makes it possible to develop a compact optical neural network system. Synaptic weights of neurons are memorized in a Pockels readout optical modulator and the system obtains the learning capabilities. Experimental verification of multiple imaging and learning is presented. In the experiments, the neural network system stores the three patterns by an orthogonal learning method. The performance of the optical neural network system is evaluated in terms of a point spread function of the Selfoc microlens.

A92-38050 Stimulated electronic transition concept for an erasable optical memory. S. ALBIN, J. D. SATIRA, D. L. LIVINGSTON (Old Dominion Univ., Norfolk, VA), and T. A. SHULL (NASA Langley Research Center, Hampton, VA), *Japanese Journal of Applied Physics, Part 1* (ISSN 0021-4922), Vol. 31, No. 2B, 1992, pp. 715–719. 13 Refs. Documents available from AIAA Dispatch.

A new concept for an erasable optical memory is demonstrated using stimulated electronic transition (SET). Large bandgap semiconductors are suitable materials for the SET medium. The properties of MgS:Eu,Sm and SrS:Eu,Sm as possible media for the SET process are investigated. Quantum storage is achieved in the form of charges in deep levels in the medium and stimulated radiative recombination is used as the reading process. Unlike magneto-optic (M-O) and phase change (PC) processes, optical writing, reading and erasing are achieved without localized heating. The SET process will have an inherently faster data transfer rate and a higher storage density, and the medium will be more durable than the M-O and PC media. A possible application of the SET process in neural networks is also discussed. (Author)

A92-37975 Pattern formation of synaptic connection in a generalized Hebb-type learning model. Y. USAMI (Kanagawa Univ., Yokohama, Japan), *Physical Society of Japan, Journal* (ISSN 0031-9015), Vol. 61, No. 2, 1992, pp. 735–743. 23 Refs. Documents available from AIAA Dispatch.

The similarity between the learning process of a neural network and its pattern formation is analyzed by introducing a potential function of synaptic-connection weight into the Hebb-type learning equation. The equation assumes

that the synapse connection weight has force term describing an arbitrary potential function that can have double stable points. The learning model is utilized in a computer simulation which demonstrates that the system can maintain learned patterns when the patterns are no longer being presented. The model is found to reflect the observation of a critical period in the brain's nerve system. The simulation of this property suggests that the synaptic behavior of pattern formation in the present learning model represents a neural logic similar to that of the human brain.

A92-32428 A new optical neuron device for all-optical neural networks. K. AKIYAMA, A. TAKIMOTO, M. MIYAUCHI, Y. KURATOMI, J. ASAYAMA, and H. OGAWA (Matsushita Electric Industrial Co., Ltd., Central Research Lab., Moriguchi, Japan), (*Japan Society of Applied Physics, International Conference on Solid State Devices and Materials*, Yokohama, Japan, 1991), *Japanese Journal of Applied Physics, Part 1* (ISSN 0021-4922), Vol. 30, Dec. 1991, pp. 3887–3892. 9 Refs. Documents available from AIAA Dispatch.

A new optical neuron device has been developed. The device can perform both summation and thresholding operations in optics, and consists of a PIN a Si:H photoreceptor, aluminum neuron electrodes and a ferroelectric liquid crystal light modulator. The a-Si:H photoreceptor shows characteristics of an ideal quantum efficiency and a good linearity. The optical neuron device exhibits a response time of about 30 μ for incident light power of 9 μW and a contrast ratio of 300:1. Using this neuron device, a lenslet array and a memory mask, an all-optical neural network has been constructed. The network demonstrates an associate memory function on purely optical parallel processing without any help from electric computation. (Author)

A92-31574 Configuration control of the truss-type parallel manipulator by the modular neural network model. M. TANAKA, K. HANAHARA, and Y. SEGUCHI (Osaka Univ., Toyonaka, Japan), *JSME International Journal, Series III* (ISSN 0914-8825), Vol. 35, March 1992, pp. 89–95. 21 Refs. Documents available from AIAA Dispatch.

A new control method for the truss-type parallel manipulator is proposed by a neural network approach. The proposed method solves the inverse kinematic problem involving kinematic redundance with the multilayered neural network model. This neural network model is prepared to provide the kinematic relation of the manipulator as well as the criterion function for the configuration and/or motion control. A concept of the modular neural network is employed to cope with the immensity of the network, in which a neural network module is constructed separately for each kinematic module. This modular neural network approach enables the network system for the configuration control to be adopted for various combinations of truss modules. Some simulation studies demonstrate the effectiveness and the potential capability of the proposed method. (Author)

A92-30060 Neural network pruning by fusing hidden layer units. K. KAMEYAMA and Y. KOSUGI (Tokyo Inst. of Technology, Yokohama, Japan), *IEICE Transactions* (ISSN 0917-1673), Vol. E74, Dec. 1991, pp. 4198–4204. 7 Refs. Documents available from AIAA Dispatch.

Neural network pruning is a technique to obtain a fully functional subset of a redundant network for the efficiency of computation. A new method to prune a redundant three-layered neural network by means of neural element 'fusion' is introduced. In contrast to conventional pruning techniques that remove unimportant portions of the network, this method fuses a pair of hidden layer units so that features accumulated in both units are preserved as possible. The pair of hidden layer units to be fused is chosen by evaluating a firing similarity. This similarity measure also informs when the pruning should be stopped. The fusing method was compared with well-known 'unit removing' methods on computer simulations. The results show that the fusing method considerably reduces the error increase due to the pruning, even in subminimal networks where conventional methods are ineffective. This enables reduction of the total cost of computation to reach the minimal network configuration. (Author)

A92-23693 AI technology and application development on the Shuttle project. D. SHANKAR (IBM Corp., Houston, TX), *i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space*, Kobe, Japan, 1990 (A92-23653 08-12). Tokyo, REN Associates, Inc., 1990, pp. 185–188. 18 Refs. Documents available from AIAA Dispatch.

Projects related to artificial intelligence (AI) are reviewed that are designed to support Space Shuttle activities including applications concepts and technological developments. Specific descriptions are given of performance tests for flight software and hardware to analyze relevant applications. Reference is given to launch-abort analysis, shuttle hardware diagnostics, mission-data determination, Shuttle/Spacelab interface diagnostics, cold start initialization, and software code reviews. AI technological developments include a real-time embedded expert system, knowledge acquisition, neural networks for improving productivity, automated program composition, software reengineering and AI coprocessors. Some of the AI expert systems are in use as production systems, and the areas for AI applications are growing.

A92-23686 Modular neural networks for motion control of the truss-type redundant robot arm. K. HANAHARA, M. TANAKA, and Y. SEGUCHI (Osaka Univ., Toyonaka, Japan), *i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space*, Kobe, Japan, 1990 (A92-23653 08-12). Tokyo, REN Associates, Inc., 1990, pp. 153–156. 10 Refs. Documents available from AIAA Dispatch.

To utilize kinematical redundancy effectively, this study proposes a neural-network approach for the criteria-oriented motion control of the truss-type redundant robot arm. A multilayered network and back propagation are the basic

elements. The modular constitution is employed to build the resultant network for motion control, and it reduces the necessary transactions during the preparation stage of the network and the motion-control stage. This also enables flexible construction of the motion-control network in accordance with the various configurations of the arm system. A simulation study is carried out with the transputer-based multiprocessor system which demonstrates the feasibility of the proposed approach. (Author)

A92-23685   Reasoning about sensor signals using artificial neural networks. A. B. DOBRZENIECKI and L. M. LIDSKY (MIT, Cambridge, MA), i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, 1990 (A92-23653 08-12). Tokyo, REN Associates, Inc., 1990, pp. 149–152. 15 Refs. Documents available from AIAA Dispatch.

Artificial intelligence techniques encourage reasoning at a high level about the operation, status and predicted behavior of complex physical systems such as process plants or space installations. To be effective and complete, such reasoning also requires high-level analysis and abstraction of sensor signals. However, current processing of sensor signals has not reached this level. A system based on neural network architectures that provides a flexible, adaptive and dynamic method for reasoning about signals emanating from sensors is presented. The usage of the system involves dynamically specifying the patterns or waveforms to detect in the output of a sensor, given centain noise and adaptability parameters; detection of the patterns is scale-invariant. The system operates in the time domain and exploits various characteristics of the sensors used for measuring pressure, temperature, electrical load, etc. The analysis of sensor signals using neural networks thus provides a partial link between the symbolic reasoning methods of AI and the numerical methods of signal processing. (Author)