# Japanese Aerospace Literature This month: *Neural Networks*

**A93-51130 Technique for optimum design of truss structures by neural network.** JUHACHI ODA and TAKAYUKI MIZUKAMI. *Japan Society of Mechanical Engineers, Transactions A* (ISSN 0387-5008), Vol. 59, No. 557, Jan. 1993, pp. 273–278.

This paper describes an application of a mutual combination-type neural network to the optimum design problems of truss structures. The optimum design problems of truss structures are changed to some combinatorial optimization problems. The Hopfield model and the quadratic energy function are used to solve the design problems. The method is able to obtain feasible solutions for several optimum design problems. The effectiveness of this method is demonstrated by two examples of the minimum weight and maximum stiffness design problems of truss structures.

**A93-50774 Fuzzy neural position controller for servomotor.** NIGUEL STREFEZZA and YASUHIKO DOTE, Muroran Inst. of Technology, Japan. In: *WNN 92; Proceedings of the 3rd Workshop on Neural Networks:* Academic/Industrial/NASA/Defense, Auburn Univ., AL, Feb. 10–12, 1992 and South Shore Harbour, TX, Nov. 4–6, 1992 (A93-50726 21-63). San Diego, CA/Bellingham, WA, Society for Computer Simulation/Society of Photo-Optical Instrumentation Engineers, 1993, pp. 490–495. Documents Available from Aeroplus Dispatch.

Fuzzy control and neural-network control are complementary, in that while the former resembles a following language concerning what a person says, the latter resembles following data describing what a person does. An account is given of a servomotor's neurofuzzy position controller, which yields much higher control performance than a linear controller for highly nonlinear systems. The proposed controller is robust.

**A93-50736 A fast algorithm with a guarantee to learn—Binary synaptic weights algorithm on neural networks.** FIGEN ULGEN, and NORIO AKAMATSU, Tokushima Univ., Japan. In: *WNN 92; Proceedings of the 3rd Workshop on Neural Networks:* Academic/Industrial/NASA/Defense, Auburn Univ., AL, Feb. 10–12, 1992 and South Shore Harbour, TX, Nov. 4–6, 1992 (A93-50726 21-63), San Diego, CA/Bellingham, WA, Society for Computer Simulation/Society of Photo-Optical Instrumentation Engineers, 1993, pp. 101–106. Documents Available from Aeroplus Dispatch.

The binary synaptic weights (BSW) algorithm for neural networks learn efficiently due to its freedom from local minima-trapping; its binary character, moreover, allows hardware implementation. Satisfactory performance has been obtained from the BSW algorithm in pattern recognition tasks. Application-specific programming information is reflected in synaptic weights; these can be modified to furnish adaptabiliy in a variety of applications. BSW applications encompass hybrid systems and dynamical systems control methods.

**A93-50733 Complexity term to activate connections in recurrent neural networks.** RYOTARO KAMIMURA, Tokai Univ., Hiratsuka, Japan. In: *WNN 92; Proceedings of the 3rd Workshop on Neural Networks:* Academic/Industrial/NASA/Defense, Auburn Univ., AL, Feb. 10–12, 1992 and South Shore Harbour, TX, Nov. 4–6, 1992 (A93-50726 21-63). San Diego, CA/Bellingham, WA, Society for Computer Simulation/Society of Photo-Optical Instrumentation Engineers, 1993, pp. 61–76. Documents Available from Aeroplus Dispatch.

The present method activates connections among units in fully recurrent neural networks, and especially those among hidden units, by adding the Rumelhart complexity term to a standard error function; this facilitates rapid convergence. By making visible and hidden connections and large and as biased as possible, the network can learn skew connection matrices in which small values are pushed toward zero, while large values are pushed toward larger values still. It is experimentally confirmed that clear hidden unit patterns are obtainable by these means.

**A93-50720 An improved synthesis method for multilayered neural networks using qualitative knowledge.** HIROSHI NARAZAKI, Kobe Steel, Ltd., Electronics Research Lab., Japan and ANCA L. RALESCU, Tokyo Inst. of Technology, Yokohama, Japan and Cincinnati Univ., OH. *IEEE Transactions on Fuzzy Systems* (ISSN 1063-6706), Vol. 1, No. 2, May 1993, pp. 125–137.

We propose an improved synthesis method for the multilayered neural network (NN) as function approximator. Our method offers a 'translation mechanism' that maps the qualitative knowledge into a multilayered NN structure. Qualitative knowledge is expressed in the form of 'representative points' which can be linguistically described as 'When $x$ is around $x(i)$ then $y$ is around $y(i)$'. We provide synthesis equations for the translation mechanism. After the direct synthesis of the initial NN, the NN is tuned by back-propagation (BP) using the training data. The direct synthesis decreases the burden on BP and contributes to improved learning efficiency, accuracy, and stability. Further, we demonstrate that our translation mechanism is also useful for incremental modeling, i.e., increasing the number of neurons, or representative points, based on the results of BP. (Author (revised)).

**A93-47847 Non-parametric texture extraction using neural network (utilizing spatial information).** KIYONARI SUNPYOHONG FUKUE, HARUHISA SHIMODA, and TOSHIBUMI SAKATA, Tokai Univ., Tokyo, Japan. In: *IGARSS '92; Proceedings of the 12th Annual International Geoscience and Remote Sensing Symposium*, Houston, TX, May 26–29, 1992. Vol. 2 (A93-47551 20-43), New York, Institute of Electrical and Electronics Engineers, Inc., 1992, pp. 1084–1086.

A method using a neural network is applied for the use of spatial information. The neural network model has a three-layered architecture, and the training method for the network is the backpropagation algorithm. A cooccurrence matrix generated from original image data is used for the input pattern to the neural network. To evaluate this method, image classification of SPOT HRV panchromatic image data acquired over both a cityscape and a sand area is performed. These images cannot be separated with the pixelwise maximum likelihood method based on spectral information. The classification accuracy obtained using the neural network was better than 80 percent.

**A93-45810 A neural network for feedforward controlled smart structures.** SCOTT D. SNYDER and NOBUO TANAKA, Mechanical Engineering Lab., Tsukuba, Japan. *Journal of Intelligent Material Systems and Structures*, (ISSN 1045-389X), Vol. 4, No. 3, July 1993, pp. 373–378.

A neural network and adaptive algorithm suitable for driving non-linear feedforward control systems used with 'smart' structures to actively control sound and vibration is presented. The neural network/algorithm combination can be viewed as an extension to the commonly used transversal filter/filtered-$x$ LMS algorithm combination, in that the neural network is essentially a transversal filter with a non-linear hidden layer placed between the input delay chain and output accumulator. The algorithm accommodates the transfer function and time delay between the control signal output and error signal input. The arrangement is shown in simulation to be capable of suppressing a primary disturbance, which is a non-linear function of the reference signal fed to the control filter, and of suppressing harmonics introduced into a system by a control actuator exhibiting non-linear performance characteristics. The results are compared to those similarly obtained using a linear adaptive control arrangement, which is incapable of providing attenuation in either case.

**A93-45809 ER fluid applications to vibration control devices and an adaptive neural-net controller (electrorheological).** SHIN MORISHITA, Yokohama National Univ., Japan and TAMAKI URA, Tokyo Univ., Japan. *Journal of Intelligent Material Systems and Structures*, (ISSN 1045-389X), Vol. 4, No. 3, July 1993, pp. 366–372. Documents Available from Aeroplus Dispatch.

Four applications of electrorheological (ER) fluid to vibration control actuators and an adaptive neural-net control system suitable for the controller of ER actuators are described: a shock absorber system for automobiles, a squeeze film damper bearing for rotational machines, a dynamic damper for multidegree-of-freedom structures, and a vibration isolator. An adaptive neural-net control system composed of a forward model network for structural identification and a controller network is introduced for the control system of these ER actuators. As an example study of intelligent vibration control systems, an experiment was performed in which the ER dynamic damper was attached to a beam structure and controlled by the present neural-net controller so that the vibration in several modes of the beam was reduced with a single dynamic damper.

**A93-44747 Superconducting implementation of neural networks using fluxon pulses.** Y. MIZUGAKI, K.NAKAJIMA, Y. SAWADA, and T.YAMASHITA, Tohoku Univ., Sendai, Japan. *IEEE Transactions on Applied Superconductivity*, (ISSN 1051-8223), Vol. 3, No. 1, pt. 4, March 1993, pp. 2765–2768, (*1992 Applied Superconductivity Conference, Chicago*, IL, Aug. 23–28, 1992, *Proceedings*, Pt. 3, A93-44612 18-33). (Author)

The authors fabricated neural-based superconducting integrated circuits by using Nb/AlO(x)/Nb Josephson junctions, and demonstrated the operation of a 2-bit neural-based analog-to-digital (A/D) converter. Fluxon pulses were used as neural impulses, and a Josephson junction was used as a threshold element. The conductance values of resistors by which Josephson transmission lines are connected represent fixed synaptic strengths. The preliminary experimental result suggests that variable critical currents of dc-SQUIDs (superconducting quantum interference devices) may provide synapses with variable strength.

**A93-43724 Dynamic system identification using neural networks.** TAKAYUKI YAMADA and TETSURO YABUTA, NTT, Telecommunication Field Systems Research and Development Center, Tokai, Japan. *IEEE Transactions on Systems, Man, and Cybernetics* (ISSN 0018-9472), Vol. 23, No. 1, Jan.–Feb. 1993, pp. 204–211. (Author (revised))

A neural network direct controller is proposed as a servolevel controller and its characteristics such as stability are confirmed. A practical neural network design method for the identification of both the direct transfer function and inverse transfer function of the object plant is proposed. A nonlinear plant simulator as a practical application of the direct transfer function identifier using a neural network is also proposed. Simulated and experimental results for a second-order plant show that these identifications can be satisfactorily achieved. They also confirm that neural-network identifiers can represent nonlinear plant characteristics very well. The characteristics of a neural network direct controller with a feedback control loop is also proposed and confirmed which uses the learning results of the inverse transfer function identifier.

**N93-22210 The 3-D image recognition based on fuzzy neural network technology.** KAORU HIROTA, KENICHI YAMAUCHI, JUN MURAKAMI, and KEI TANAKA, Hosei Univ., Tokyo Japan, Dept. of Instrument and Control Engineering. In NASA. Johnson Space Center, *Proceedings of the Third International Workshop on Neural Networks and Fuzzy Logic*, Vol. 2, pp. 249–256 (SEE N93-22206 08-63).

Three dimensional stereoscopic image recognition system based on fuzzy- neural network technology was developed. The system consists of three parts; preprocessing part, feature extraction part, and matching part. Two CCD color camera image are fed to the preprocessing part, where several operations including RGB-HSV transformation are done. A multi-layer perception is used for the line detection in the feature extraction part. Then fuzzy matching technique is introduced in the matching part. The system is realized on SUN spark station and special image input hardware system. An experimental result on bottle images is also presented. (Author (revised)).

**A93-20951 Study on image data compression by using neural network.** ZHONG ZHENG, MASAYUKI NAKAJIMA, and TAKESHI AGUI, Tokyo Inst. of Technology, Yokohama, Japan. In: *Visual communications and image processing '92; Proceedings of the Meeting*, Boston, MA, Nov. 18–20, 1992 (A93-20944 06-35), Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1992, pp. 1425–1433. (Author)

Properties of the neural network employed in image data compression are studied, and a method for increasing the compression capability is proposed. Since the multiple gray level image has a large quantity of data, the poor mapping capacity of the neural network is the main problem causing the poor data compression capability. In order to increase the compression capability, in the proposed method, first an image is divided into subimages, that is blocks. Then these blocks are divided into several classes. Several independent neural networks are assigned adaptively to these blocks according to their classes. Since the mapping capacity is proportional to the number of the neural networks, and no data quantity increases, the compression capability is increased efficiently by our method. The computer simulation results show that the SNR of the reconstructed images was increased by about 1 to about 2 dB by our method. Especially the visual image quality has increased.

**A93-20883 An application of a neural network to CFRP elastic coefficient design.** GOICHI BEN and YASUKAZU NISHI. Japan Society of Mechanical Engineers, Transactions A (ISSN 0387-5008), Vol. 58, April 1992, pp. 539–543. In Japanese. (Author)

Since a fiber volume fraction and a fiber orientation angle have an important effect on elastic coefficients and strengths of CFRP, they are main design variables of unidirectional and angle-ply CFRP. However, it is hard to determine the correct values of these variables in the case of designing CFRP plates having specific values of elastic coefficients and strengths. This decision becomes, so to speak, an inverse problem. This paper presents an application of a neural network to the design of elastic coefficients of CFRP and gives the unique solution of this inverse problem by use of the neural network.

**A93-19702 Massively parallel architectures for large scale neural network simulations.** YOSHIJI FUJIMOTO, Sharp Corp., Information Systems Labs., Yamatokoriyama, Japan; NAOYUKI FUKUDA, Sharp Corp., Integrated Circuits Group, Tenri, Japan; and TOSHIO AKABANE, Sharp Corp., Corporate Research and Development Group, Tenri, Japan. *IEEE Transactions on Neural Networks*, (ISSN 1045-9227), Vol. 3, No. 6, Nov. 1992, pp. 876–888.

A toroidal lattice architecture and a planar lattice architecture are proposed as massively parallel architectures for large scale neural network simulations. The processor connections of these architectures are configured in toroidal lattice and complete planar lattice structures that are most efficient for implementation using wafer scale integration. The performance of the architectures is nearly proportional to the number of processors. Implementations of the toroidal and planar lattice architecture are described.

**A93-18650 Neural network for crack-depth determination from ultrasonic scattering data.** M. KITAHARA, Tokai Univ., Shimizu, Japan, J. D. ACHENBACH, Q. C. GUO, and M. L. PETERSON, Northwestern Univ., Evanston, IL; and M. NOTAKE, and M. TAKADOYA, Mitsubishi Research Inst., Tokyo, Japan. In: *Review of progress in quantitative nondestructive evaluation.* Vol. 11A; *Proceedings of the 18th Annual Review*, Brunswick, ME, July 28–Aug. 2, 1991 (A93-18576 05-38). New York, Plenum Press, 1992, pp. 701–708.

The depth of a surface-breaking crack in a steel plate is presently determined from ultrasonic backscattering by means of a neural network that is trained by the use of a feedforward three-layered network, in conjunction with a back-propagation algorithm for error corrections. The computed backscattered field furnishes synthetic data for network training. The training data have been calculated for cracks with specified increments of the crack length. (O.C.).

**A93-15635 Programmable MOS charge-mode neural circuits.** Z. TANG, O. ISHIZUKA, and H. MATSUMOTO, Miyazaki Univ., Japan. *Electronics Letters* (ISSN 0013-5194), Vol. 28, No. 22, Oct. 22, 1992, pp. 2059–2060. Research supported by Asahi Glass Foundation.

The charge-redistribution principle is employed in this technique for developing programmable MOS charge-mode circuits for analog VLSI neural systems. Known principles of circuit technology are studied in the analog domain that are analogous to nervous systems, and a dynamic technique is derived for implementing programmable synapses. The charge-mode circuits are effective and permit the design of all-MOS analog neural networks for VLSI implementations.

**A93-12602 Continuous complex-valued back-propagation learning.** A. HIROSE, Tokyo Univ., Japan. *Electronics Letters* (ISSN 0013-5194), Vol. 28, No. 20, Sept. 24, 1992, pp. 1854, 1855. (Author)

A novel back-propagation learning method is proposed for fully complex-valued layered neural networks. Nonlinearity suitable for realizing smooth and unified complex learning is introduced. A gradient descent method is also analyzed and optimized so that the variations of independent elements of the output complex vectors are related directly to the fragmentary changes of weighting matrix elements. The learning process is presented and demonstrated.

**A93-11965 An adaptive control for CARMA systems using linear neural networks.** KEIGO WATANABE, Saga Univ., Japan; TOSHIO FUKUDA, Nagoya Univ., Japan; SPYROS G. TZAFESTAS, Athens National Technical Univ., Greece. *International Journal of Control* (ISSN 0020-7179), Vol. 56, No. 2, Aug. 1992, pp. 483–497.(Author)

A neural network controller is described for controlling unknown, linear, discrete-time CARMA systems with single-input single-output. A linear two-layered neural network is used to model the inverse dynamics of the unknown plant on-line; it is learned by the delta rule, in which the difference between the actual control input to the plant, which is generated from the neural controller, and the input estimated from the inverse-dynamics model by using an actual plant output is minimized. A similar neural network is also used to estimate the unknown noise sequence so that the proposed neural network controller can treat a noisy output, where the regular dynamics are modelled on-line by using the actual plant output. Some simulation examples are finally presented to illustrate the features of the present neural controller.

**A93-11962 Self-organizing control using fuzzy neural networks.** T. YAMAGUCHI and T. TAKAGI, Lab. for International Fuzzy Engineering Research, Yokohama, Japan; and T. MITA, Chiba Univ., Japan. *International Journal of Control* (ISSN 0020-7179), Vol. 56, No. 2, Aug. 1992, pp. 415–439.

A fuzzy associative memory system, called the fuzzy associative memory organizing units system (FAMOUS), for achieving self-organizing control based on fuzzy rules is proposed. FAMOUS simulates the knowledge representation and inference process by employing fuzzy notation and by association in neural networks. FAMOUS's learning algorithm uses training steps to generate operation skills by modifying the expert knowledge that is initially built-in. A set of fuzzy if-then rules is used for controlling variable parameter processes. The control knowledge is represented as pairs consisting of a 'condition' in the if- part and an 'operation (controller)' in the then-part. FAMOUS can highly refine knowledge by using neural network learning algorithms. Ways to obtain the class of stabilizers are discussed in order to verify that the entire controller stabilizes the parameter variance process. The method is applied to the control of a small helicopter, and its usefulness in designing the controller is shown.

**A92-52646 Position and size representations by neural networks.** KAZUTOSHI GOUHARA, Chubu University, Kasugai, Japan; KATSUJI IMAI, Toyota Motor Corp., Electrical and Electronics Production Div., Japan; and YOSHIKI UCHIKAWA, Nagoya Univ., Japa). Control and Computers (ISSN 0315-8934), Vol. 20, No. 1, 1992, pp. 1–5. (Author)

In applying the back-propagation (BP) model to visual pattern recognition, two neural networks are proposed which respectively represent the position and the size of the target pattern in the two-dimensional input visual field. It was proved that both of the proposed neural networks have the generalization capability to various shapes of unlearning target patterns. It was discovered that some of the hidden layer units respond selectively to the position and the size of the target pattern in the input visual field, independent of the shape of the target pattern. Computer simulations were carried out in recognizing handwritten characters, and demonstrated that those two neural networks work out satisfactorily for practical use. It was possible to detect the position and the size of the target pattern on the noisy input visual field.

**A92-52512 Dynamics of fully complex-valued neural networks.** A. HIROSE, Tokyo, University, Japan. *Electronics Letters* (ISSN 0013-5194), Vol. 28, No. 16, July 30, 1992, pp. 1492–1494. (Author)

A novel neural network that processes input vectors and attractors fully in complex space using complex weights is proposed. Real and imaginary data are treated consistently with an equivalent significance in nondegenerate complex space. This network can be applied for ill-posed problems concerning realistic physical fields and continuous motion controls. The dynamics are presented and demonstrated.

**A92-51591 Associative memory in a cyclic neural network.** JIFENG SUN and TADASHI NAGATA, Kyushu University, Fukuoka, Japan. *Kyushu University, Faculty of Engineering, Memoirs* (ISSN 0023-6160), Vol. 52, No. 1, March 1992, pp. 85–94. (Author)

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.