

**A90-50831 Automation of strength analysis and fracture of composite structures (Avtomatizatsiia raschetov na prochnost' i razrusenie konstruktsii iz kompozitnykh materialov).** R. B. RIKARDS, *Mekhanika Kompozitnykh Materialov* (ISSN 0203-1272), Jan.-Feb. 1990, pp. 69-73. 6 Refs.

The general structure of a set of finite-element software for solving problems in the statics, dynamics, and stability of composite structures is examined. As an example, a solution is presented for the problem of the nonstationary deformation of a shallow cylindrical shell of a carbon composite under pulsed loading. The efficiency of the general-purpose software described here is demonstrated.

**A90-48268 Some applied problems in the mechanics of dimensionally stable composite structures (Nekotorye prikladnye zadachi mekhaniki razmernostabil'nykh konstruktsii iz kompozitov).** V. V. VOROBIEI and N. I. VOITKOV, *Mekhanika Kompozitnykh Materialov* (ISSN 0203-1272), Mar.-Apr. 1990, pp. 292-298. 5 Refs.

The dimensional stability of sandwich-type composite reflectors is examined with reference to the results of experimental and theoretical studies. An alternative transformable reflector structure is proposed which consists of dimensionally stable plates of reinforced composite. The optimum design problem is formulated, with the optimal computational model selected using a finite element code.

**A90-48203 Characteristics of damage accumulation during the loading of brittle composite materials (Osobennosti nakopleniia povrezhdenii pri nagruzhении khrupkikh kompozitsionnykh materialov).** A. M. SHIRIAEV and A. F. SHUROV, *Pis'ma v Zhurnal Tekhnicheskoi Fiziki* (ISSN 0320-0116), Vol. 16, Feb. 12, 1990, pp. 25-28.

Results of an acoustic emission study of the fracture behavior of various brittle composites are reported with emphasis on the newly discovered characteristics of damage accumulation under load. The experimental study was carried out on metal ceramics, porous glasses, glassceramics, and carbon composites. Two distinct types of damage accumulation curves are identified, depending on the initial porosity of the material, as determined by the conditions of hotpressing and annealing. It is also shown that the damage accumulation behavior of the composites tested is characterized by the Kaiser effect.

**A90-46515 An approach to the determination of the linear fracture toughness characteristics with respect to normal tearing cracks in composite materials (Pro odin pidkhd do viznachennia liniinikh kharakteristik trishchinostikosti normal'nogo vidrivu v kompozitsi-inikh materialakh).** M. V. DELIAVS'KII, L. I. ONISHKO, and L. T. BEREZHNIITS'KII, *Fiziko-Khimicheskaiia Mekhanika Materialov* (ISSN 0430-6252), Vol. 26, May-June 1990, pp. 59-65. 7 Refs.

A method is proposed for determining the structural fracture toughness characteristics of orthotropic composite materials using centrally notched rectangular test specimens. Details of the test procedure are reviewed, with particular attention given to the determination of the stressed state of the notched specimen and structural element size, selection of test specimens, determination of the fracture stress, and statistical processing of the experimental data.

**A90-43016 Fluctuations of stresses in elastic composites (Fluktuatsii napriazhenii v uprugikh kompozitakh).** V. Z. PARTON and V. A. BURIACHENKO, *Akademiia Nauk SSSR, Doklady* (ISSN 0002-3264), Vol. 310, No. 5, 1990, pp. 1075-1078. 10 Refs.

The method of Bobeth and Diener (1986) is extended to obtain accurate estimates of all the tensor components of the second moment of the stress and strain field averaged over the component volume for elastic composites with ellipsoidal inclusions. Attention is given to the general case of the anisotropy of the mechanical properties of the components and their geometrical structure. Under the assumption of uniform random stress field in the vicinity of each ellipsoidal inclusion, a method based on perturbation theory shows that the second moment of the stress fields is constant within the inclusion.

**A90-45115 Composite materials in large-scale optics (Kompozitsionnye materialy v krupnogabaritnoi optike).** V. V. APOLLONOV, G. I. BABAIANTS, M. V. GARTMAN, V. M. GOLOMAZOV, I. D. LOKTIONOV et al., *Pis'ma v Zhurnal Tekhnicheskoi Fiziki* (ISSN 0320-0116), Vol. 16, Jan. 26, 1990, pp. 83-86. 5 Refs.

Recent developments in the use of composite materials for lightweight large-scale optics are reviewed. In particular, attention is given to the construction of large-scale optical elements made of composite materials based on the carbon-silicon-silicon carbide composition with an efficient thermal stabilization and good optical characteristics. The advantages of using honeycomb structures are noted in particular.

**A90-42910 Behavior of a two-component medium under impulsive loading (O povedenii dvukhkomponentnoi sredy pri impul'snom nagruzhении).** V. S. ZARUBIN and G. N. KUVYRKIN, *Prikladnaia Mekhanika* (ISSN 0032-8243), Vol. 26, Jan. 1990, pp. 91-98. 15 Refs.

The paper is concerned with materials representing a mixture of two components with different thermophysical and mechanical properties. Based on the thermodynamics of irreversible processes, a closed system of governing equations is obtained, with allowance made for changes in the internal parameters of each component. The propagation characteristics of waves of different types are examined.

**A90-36094 The boundary layer method in the fracture mechanics of periodic composites (Metod pogranichnogo sloia v mekhanike razruseniia kompozitov periodicheskoi struktury).** A. L. KALAMKAROV, B. A. KUDRIAVTSEV, and V. Z. PARTON, *Prikladnaia Matematika i Mekhanika* (ISSN 0032-8235), Vol. 54, Mar.-Apr. 1990, pp. 322-328.

The problem of a rectilinear crack in a composite with a bi-periodic structure is analyzed for the case where the crack size is significantly larger than the periodicity cell size. For the analysis of the stress field in the vicinity of a microcrack, a boundary layer method is proposed which is based on the asymptotic averaging of periodic structures with allowance for additional solutions of the boundary layer type. These solutions make it possible to allow for the edge effect in the vicinity of the crack boundary.

**A90-30393 A study of local fields in the vicinity of a macrocrack in a composite with a periodic structure (K issledovaniu lokal'nykh polei v okrestnosti makrotreshchiny v kompozitsionnom materiale periodicheskoi struktury).** V. Z. PARTON, A. L. KALAMKAROV, and V. G. BORISKOVSII, *Fiziko-Khimicheskaiia Mekhanika Materialov* (ISSN 0430-6252), Vol. 26, Jan.-Feb. 1990, pp. 3-9. 10 Refs.

A new numerical-analytical approach is proposed for studying the local structure of the stress-strain state near a macrocrack in a strongly inhomogeneous composite with a periodic structure. The approach is based on the asymptotic averaging of periodic structures with allowance for additional boundary layer solutions that model local effects arising near the crack. The problem of a tearing macrocrack in a two-phase layered composite is analyzed as an example. Local stressfield distributions near the crack tip are obtained, and an analysis is made of the dependence of the stress intensity factors on the composite component characteristics.

**A90-27308 Deformation of composite beams under transverse impact (Deformirovanie kompozitnykh balok pri poperechnom udare).** S. I. SNISARENKO, *Problemy Prochnosti* (ISSN 0556-171X), Feb. 1990, pp. 114-119. Refs.

The contact force for carbon composite beams loaded in transverse impact is determined experimentally and analytically. The problem is stated and solved using the finite element method and the Timoshenko shear theory. The principal finite element equation is integrated by the Runge-Kutta method. An analysis of the experimental and analytical results indicates that the form, magnitude, and duration of the contact force depend on the elastic and strength characteristics of the contact surface and are largely determined by the natural frequency spectrum. Maximum nonstationary flexural and shear deformations are observed in beams whose first eigenfrequency half-periods are comparable with the impact duration.

## Japanese Aerospace Literature This month: Neural Networks

**A91-47069 Neural processing-type displacement sensor employing multimode waveguide.** SHIGEKI AISAWA, KAZUHIRO NOGUCHI, and TAKAO MATSUMOTO, *IEEE Photonics Technology Letters* (ISSN 1041-1135), Vol. 3, April 1991, pp. 394-396. 8 Refs.

A novel neural processing-type displacement sensor, consisting of a multimode waveguide and a neural network, is demonstrated. This sensor detects displacement using changes in the interference output image of the waveguide. The interference image is directly processed by a three-layer perceptron neural network. Environmental change, such as the intensity fluctuation, and change of the temperature can be followed by training the neural network. Experimental results show that the sensor has a resolution of 1 micron.

**A91-43684 Lateral inhibitory action in an optical neural network using an internal-light-coupled optical device array.** WATARU KAWAKAMI, KEN-ICHI KITAYAMA, YOSHINORI NAKANO, MASAHIRO IKEDA, *Optics Letters* (ISSN 0146-9592), Vol. 16, July 1, 1991, pp. 1028-1030. 7 Refs.

A novel configuration of an optical lateral inhibitory neural network using a two-dimensional internal-light-coupled optical device (ILCOD) array is proposed. It is experimentally certified with a test ILCOD structured with seven units in a two-dimensional hexagonal arrangement that the optical coupling between the units causes turn-off of the light emission of the unit in a specific position, which results in lateral inhibitory action of a neural network.

**A92-13570 A neural network applied to crack type recognition.** T. OGI, M. NOTAKE, Y. YABE, and M. KITAHARA, *Review of progress in quantitative nondestructive evaluation*, Vol. 9A (A92-13526 03-38), New York, Plenum Press, 1990, pp. 689-696. 4 Refs.

A quantitative nondestructive evaluation system is developed from which the analytical solutions are extracted by means of artificial intelligence. A waveform obtained from the analytical solutions provides quantitative data regarding crack parameters, and a neural network is applied as one of two inference functions in the system. The utility of the neural network is demonstrated with a prototype that concerns the problems of a main crack with a subcrack near the tip.

**A91-41056 Characteristics of floating gate device as analogue memory for neural networks.** O. FUJITA, Y. AMEMIYA, and A. IWATA, *Electronics Letters* (ISSN 0013-5194), Vol. 27, May 23, 1991, pp. 924-926. 5 Refs.

An effective controlling circuit for a floating-gate MOSFET analog memory used in neural networks is described. It is possible to charge or discharge the floating gate storage with high resolution of more than 1 percent of full scale. The experimental results are described and discussed. An improved device structure is proposed for simplifying the controlling circuit.

**A91-41040 Digital neuron model using digital phase-locked loop.** MANABU TOKUNAGA, IWA O SASASE, and SHINSAKU MORI, *IEICE Transactions on Communications, Electronics, Information and Systems* (ISSN 0917-1673), Vol. E74, March 1991, pp. 615-621. 7 Refs.

A new type of digital neuron model is proposed by using a multiinput, multilevel-quantized digital phase-locked loop, where the input is represented by the phase-modulated signal. It is shown that this model has the characteristics of the neuron: spatial summation, temporal summation and thresholding. The model is applied to pattern recognition and to Hopfield-type associative memory in order to verify that the network of this model can operate properly. In the pattern recognition, the perceptron convergence procedure (delta rule) is used, and the possibility of learning by modifying the connection weights is confirmed. In associative memory, the network can learn five digit patterns of fundamental memories, and can also recall the correct pattern for the noisy input pattern.

**A91-41030 Neural networks for visual pattern recognition.** KUNIKO FUKUSHIMA, *IEICE Transactions on Communications, Electronics, Information and Systems* (ISSN 0917-1673), Vol. E74, Jan. 1991, pp. 179-190. 16 Refs.

Modeling neural networks is useful for understanding the mechanism of the brain, and also for obtaining design principles for new information processors. With this approach, various models of visual pattern recognition have been developed, e.g., a multilayered network for curvature extraction, a self-organizing network called a cognitron, a model called a neocognitron for deformation-invariant pattern-recognition, and a model of selective attention. It has been demonstrated by computer simulation that, using ideas obtained from the models, pattern-recognition systems of an ability much greater than conventional systems can be designed.

**A91-36167 Artificial neural network circuits with Josephson devices.** Y. HARADA, and E. GOTO, (Proceedings of the 1990 Applied Superconductivity Conference, Snowmass, CO, Sept. 24-28, 1990, A91-36027 15-33) *IEEE Transactions on Magnetics* (ISSN 0018-9464), Vol. 27, pt. 4, March 1991, pp. 2863-2866. 5 Refs.

A novel approach to Josephson devices for computer applications is described. With an artificial neural network scheme, Josephson devices will be expected to develop a new paradigm for future computer systems. Circuit configurations for a neuron with Josephson devices are described. A combination of a variable bias source and Josephson devices is proposed for a synapse circuit. The bias source signal is steered by the Josephson device input signal and becomes the synapse output signal. These output signals are summed up at the specific resistor or inductor to produce the weighted sum of Josephson devices input signals. According to the error signal, the bias source value is corrected. This corresponds to the learning procedure. Because Josephson devices are threshold logic circuits themselves, they are used as soma circuits. The cell structure of the artificial neural network is discussed.

**A91-35223 Possibility of neural networks controller for robot manipulators.** TETSURO YABUTA and TAKAYUKI YAMADA, *Proceedings of the 1990 IEEE International Conference on Robotics and Automation*, Vol. 3, Cincinnati, OH, May 13-18, 1990, (A91-35126 14-63), Los Alamitos, CA, IEEE Computer Society Press, 1990, pp. 1686-1691. 17 Refs.

NN (neural network) controller characteristics are clarified by comparison with the adaptive control theory. The authors explain the classification of the NN controller architecture and the dynamic NN structure. A comparison between the NN controller and the adaptive controller shows that the framework of a linear two-layer NN controller is the same as that of the adaptive controller, and that the nonlinear three-layer NN (PDP, or parallel distributed processing type) is a nonlinear extension of the adaptive control. The stability characteristics of the NN control system, which shows the robustness effect of the generalized delta rule, the plant and the NN mapping function, are treated. Finally, NN controller experiments are demonstrated using a force control servomechanism. Experimental results suggest that the nonlinear sigmoid function of the NN can compensate for the nonlinear plant effect.

**A91-36494 Dynamic optical neurochip using variable-sensitivity photodiodes.** J. OHTA, Y. NITTA, and K. KYUMA, *Optics Letters* (ISSN 0146-9592), Vol. 16, May 15, 1991, pp. 744-746. 9 Refs.

A novel type of a dynamic optical neurochip that uses sensitivity-variable photodiodes (VSPDs) as variable interconnection weight elements is proposed and analyzed. The chip consists of the line-shaped light-emitting diode array and the VSPD matrix array. A monolithic integration of these arrays is presented. This dynamic chip has advantages such as less optical cross talk, higher processing speed, and realization of analog synaptic weights. Experimental results of the VSPD array using metal-semiconductor-metal structure are shown. The results of the computer simulation using this chip as a learning element show that the unwanted effect of the optical cross talk on the recognition rate can be alleviated by the learning capability of the chip. The theoretical maximum density is about 2000 neurons/sq cm for the backpropagation model.

**A91-34823 A signal processing using scale-space filtering and neural network.** SHIGEKI DOI, MINORU MATSUDA, and EIJI SHIMIZU, *Osaka City University, Faculty of Engineering, Memoirs* (ISSN 0078-6659), Vol. 31, Dec. 1990, pp. 23-31. 5 Refs.

This paper presents the signal processing method applying the symbolizing method and the neural network to the scale-space filtered signal, and also discusses the availability of this method. In this method, the scale-space filtering that is one of the method of the multi-scale description is used for abstraction for the character of the signal, and the symbolizing method and the neural network are used for the recognition of the character. From simulating and experimental results, it is shown that the symbolizing method and the neural network are effective for recognizing the fingerprint derived from the scale-space filtering.

**A91-34388 Optoelectronic associative memory using an advanced optical neurochip.** YOSHIKUNO NITTA, JUN OHTA, KAZUMASA MITSUNAGA, SYUICHI TAI, and KAZUO KYUMA, *Applied Optics* (ISSN 0003-6935), Vol. 30, April 10, 1991, pp. 1328-1330. 10 Refs.

An optical associative memory using the optical neurochip is demonstrated. The efficiency and the uniformity of the device characteristics were improved and the optical crosstalk was reduced in order to increase the recognition rate of the associative memory.

**A91-34366 Remote image classification through multimode optical fiber using a neural network.** SHIGEKI AISAWA, KAZUHIRO NOGUCHI, and TAKAO MATSUMOTO, *Optics Letters* (ISSN 0146-9592), Vol. 16, May 1, 1991, pp. 645-647. 8 Refs.

A novel method for classifying two-dimensional images through a multimode fiber using a neural network is proposed. An image-recognition experiment with 10 alphabetic characteristics is performed.

**A91-33948 A self-learning neural network chip with 125 neurons and 10 K self-organization synapses.** YUTAKA ARIMA, KOICHIRO MASHIKO, KEISUKE OKADA, TSUYOSHI YAMADA, ATSUSHI MAEDA et al., *IEEE Journal of Solid-State Circuits* (ISSN 0018-9200), Vol. 26, April 1991, pp. 607-611. 7 Refs.

A learning neural network LSI chip is described. The chip integrates 125 neuron units and 10K synapse units with the 1.0-micron double-poly-Si, double-metal CMOS technology. Most of this integration has been realized by using a mixed design architecture of digital and analog circuits. The fully feedback connection network LSI can memorize at least 15 patterns with 50-microsec learning time for each pattern. Under the condition that each test vector keeps a Hamming distance of 6 from memorized pattern, a correct association rate of 98 percent is obtained. The relaxation time is 1 to 2 microsecs. This chip consumes less than 1.5 W.

**A91-26849 Learning temporal waveforms in neural networks.** KIICHI URAHAMA, *Institute of Electronics, Information and Communication Engineers, Transactions* (ISSN 0913-574X), Vol. E73, Dec. 1990, pp. 1925-1931. 7 Refs.

An approach is described to synthesis and recognition of temporal patterns by using neural networks. A neural network is trained to produce prescribed waveforms with the steepest descent method which optimizes analog dynamics of neural networks described by differential equations. First, a technique is developed for calculating error sensitivities with respect to network parameters by the adjoint network approach. Next, an upper bound on timesteps is established to ensure the stability of the numerical solutions of the differential equations of networks. The effectiveness of these techniques are verified by several examples of learning of transient or oscillating waveforms with simple networks. In addition, the complexity of the waveform which can be synthesized by a simple class of neural networks is discussed.

**A90-27929 Optical limits for spatial interconnection networks using 2-D optical array devices.** TOSHIKAZU SAKANO, KAZUHIRO NOGUCHI, and TAKAO MATSUMOTO, *Applied Optics* (ISSN 0003-6935), Vol. 29, March 10, 1990, pp. 1094-1100. 16 Refs.

An optical spatial interconnection network consisting of a two-dimensional source array, a lens array, and a detector array is suitable for use as the interconnection device in multiprocessor systems and neural networks. This paper describes the theoretical limits on the maximum channel numbers of these networks derived from optical restrictions. These results yield optimum design parameters for an interconnection network.

**A91-20948 A new global organization method and supervised learning of multilayer neural networks.** JINHUI CHAO, WIJAK RATANASWAN, and SHIGEO TSUJII, (Institute of Electronics, Information and Communication Engineers, Autumn National Convention, Hiroshima, Japan, Oct. 1-4, 1990) *Institute of Electronics, Information and Communication Engineers, Transactions* (ISSN 0913-574X), Vol. E73, Nov. 1990, pp. 1796-1799. 10 Refs.

This note presents a new global optimization method and derives a learning schema based on the method for multilayer artificial neural networks. The schema consists of (1) 'pasting' the admissible region in  $R \exp n$  to an  $n$ -D torus  $T \exp n$  and smoothly connecting the potential function at the boundary; (2) global searching along the flow of a nonvanishing vector field on the compact smooth manifold  $T \exp n$ . This flow is featured by the ability of automatically passing through distinct local minima one after another along the negative/positive gradient field. It has also a unit norm everywhere on the  $T \exp n$ , so the searching speed will not slow down in the neighborhood of critical points.

**A91-20368 CMOS layout design of the hysteresis McCulloch-Pitts neuron.** T. KUROKAWA, K. C. LEE, Y. B. CHO, and Y. TAKEFUJI, *Electronics Letters* (ISSN 0013-5194), Vol. 26, Dec. 6, 1990, pp. 2093-2095. 12 Refs.

Digital CMOS layout design of the hysteresis McCulloch-Pitts neuron is presented. Based on simulation results using the hysteresis McCulloch-Pitts binary neuron model, a 6-bit fixed point 2's complement arithmetic was adopted for the calculation of the input  $U$  of each neuron. Each neuron needs 204 transistors and requires a  $399 \lambda \times 368 \lambda$  layout area using the MOSIS scalable CMOS/bulk (SCMOS) VLSI technology with 2 micron rule of P-well, double-level metal.

**A91-19500 Large suppression of spurious states in neural networks of nonlinear analog neurons.** T. FUKAI, and M. SHIINO, *Physical Review A* (ISSN 1050-2947), Vol. 42, Dec. 15, 1990, pp. 7459-7466. 19 Refs.

An upper bound for the density of the metastable states of neural networks consisting of analog neurons with graded response is calculated exactly in the limit of infinitely many number of neurons. It is found that the density of the metastable states that are uncorrelated to any memory patterns is remarkably suppressed compared with the case of deterministic neural networks of formal neurons. The result gives a theoretical explanation for the belief that the neural networks of nonlinear analog neurons are very effective in computation. The critical storage capacity is obtained as a function of the analog gain, which should correspond to the 'temperature' in stochastic Ising-spin neural networks, exhibiting a small increase compared with the case of the stochastic neural networks.

**A91-18667 Optical neurochip based on a three-layered feed-forward model.** J. OHTA, K. KOJIMA, Y. NITTA, S. TAI, and K. KYUMA, *Optics Letters* (ISSN 0146-9592), Vol. 15, Dec. 1, 1990, pp. 1362-1364. 12 Refs.

A GaAs/AlGaAs optical neurochip based on a three-layered feed-forward model is reported. The optical neurochip consists of a light-emitting diode array with 66 elements, a fixed interconnection matrix, and a photodiode array with 110 elements. The interconnection matrix is determined by the backpropagation learning rule with three quantized levels. There are 35, 29, and 26 neurons, respectively, in the input, hidden, and output layers. The excitatory and inhibitory synapses are integrated on one chip. By using the chip and external electronics, the recognition of 10 characters with  $5 \times 7$  bits has been achieved.

**A91-14871 Mathematical foundations of neurocomputing.** SHUN-ICHI AMARI, *Proceedings of the IEEE*, (ISSN 0018-9219), Vol. 78, Sept. 1990, pp. 1443-1463. 74 Refs.

An attempt is made to establish a mathematical theory that shows the intrinsic mechanisms, capabilities, and limitations of information processing by various architectures of neural networks. A method of statistically analyzing one-layer neural networks is given, covering the stability of associative mapping and mapping by totally random networks. A fundamental problem of statistical neurodynamics is considered in a way that is different from the spin-glass approach. A dynamic analysis of associative memory models and a general theory of neural learning, in which the learning potential function plays a role are given. An advanced theory of learning and self-organization is proposed, covering backpropagation and its generalizations as well as the formation of topological maps and neural representations of information.

**A90-52178 Neural-network model of induction processes in the way of thinking by using random excitation patterns of neural elements.** MASAHIRO AGU and KAZUO YAMANAKA, *Japanese Journal of Applied Physics, Part 1* (ISSN 0021-4922), Vol. 29, May 1990, pp. 993-995. 7 Refs.

A probabilistic neural network model of the induction process of a hypothesis drawn from a datum is proposed on the basis of the Bayes rule. The hypothesis and the datum are assumed to be represented by the excitation patterns of neurons. The patterns representing the hypothesis are improved successively as information is accumulated. This process is interpreted as an evolutionary brain process. The most plausible hypothesis consistent with the data relates to spontaneously occurring excitation patterns of neurons. The model is applied to the estimation of a prototype pattern.

**A91-12076 Opto-electronic implementation of a large-scale neural network using multiplexing techniques.** JUN OHTA, MASAYA OITA, SHUICHI TAI, KUNIIHIKO HARA, and KAZUO KYUMA, (7th International Conference on Integrated Optics and Optical Fiber Communication, Kobe, Japan, July 18-21, 1989) *Institute of Electronics, Information and Communication Engineers, Transactions* (ISSN 0913-574X), Vol. E73, Jan. 1990, pp. 41-45. 8 Refs.

Two kinds of architectures for implementing large-scale optoelectronic neural networks are proposed. These architectures are based on time- and frequency-division multiplexing (TDM and FDM) techniques, respectively, in which both the neuron state vector and the interconnection matrix are divided in the time and frequency domains. The computer simulations, which were carried out for the Hopfield associative memories in the neuron number of 400 and the memory number of 20, have shown their usefulness, providing almost the same recognition rate as the conventional architectures. Using the TDM technique, moreover, an optoelectronic implementation of the Hopfield associative memory was experimentally demonstrated. The experimental results showed that the number of the neurons was effectively increased.

**A91-11657 Experimental demonstration of optical three-layer neural network.** NOBUYUKI KASAMA, YOSHIO HAYASAKI, TOYOHIKO YATAGAI, MASAHIKO MORI, and SATOSHI ISHIHARA, (International Commission for Optics, Japan Society of Applied Physics, and Optoelectronic Industry and Technology Development Association, International Topical Meeting on Optical Computing, Kobe, Japan, Apr. 8-12, 1990) *Japanese Journal of Applied Physics, Part 2* (ISSN 0021-4922), Vol. 29, Aug. 1990, pp. L1565-L1568. 8 Refs.

An optical three-layer neural network using a microchannel plate spatial light modulator is demonstrated. The back-propagation learning algorithm is used to calculate optimum weight matrices. Experimental results on learning of exclusive OR operation are presented.

**A91-11614 Multimatched filtering using a microlens array for an optical-neural pattern recognition system.** MASAHIRO AGU, ATSUSHI AKIBA, TERUHISA MOCHIZUKI, and SHUN-ICHI KAMEMARU, *Applied Optics* (ISSN 0003-6935), Vol. 29, Oct. 1, 1990, pp. 4087-4091. 18 Refs.

In the optical-neural recognition system proposed for flexible parallel information processing, a planar microlens array is used to form simultaneously many identical Fourier transforms of an input pattern; from each transform the feature extraction of the input pattern is performed in parallel through optical correlations with memorized standard spatial filters. In this paper, it is experimentally shown that the multimatched filtering system, as the optical feature extracting part of the proposed system, can be composed of a planar array of graded index microlenses of 1.05-mm diameter and 2.6-mm focal length.

**A91-10793 An optoelectronic synaptic connection circuit with variable analog and nonvolatile weights.** HIROO YONEZU, TOSHIHIKO HIMENO, KOHJI KANAMORI, KANGSA PAK, and YASUSHI TAKANO, (International Commission for Optics, Japan Society of Applied Physics, and Optoelectronic Industry and Technology Development Association, International Topical Meeting on Optical Computing - OC'90, Kobe, Japan, Apr. 8-12, 1990) *Japanese Journal of Applied Physics, Part 2* (ISSN 0021-4922), Vol. 29, July 1990, pp. L1314-L1316. 8 Refs.

An artificial synaptic connection circuit was constructed using an optical interconnection and a nonvolatile memory device. Nonvolatile analog synaptic weights were realized, which were varied electrically and operated at a low current level. The possibility of a remarkable reduction of the number of electric wires was verified, which could lead to a realization of a large scale one-chip OEIC using a conventional wiring technique in Si LSIs.

**A91-12998 Character recognition using a dynamic optoelectronic neural network with unipolar binary weights.** MASAYA OITA, MASAOKU TAKAHASHI, SHUICHI TAI, and KAZUO KYUMA, *Optics Letters* (ISSN 0146-9592), Vol. 15, Nov. 1, 1990, pp. 1227-1229. 13 Refs.

A novel type of quantized learning rule with unipolar binary weights that is useful for the optical implementation of neural networks is reported. An input-dependent thresholding operation is also proposed to remove the unwanted effects that are due to the insufficient contrast ratio of spatial light modulators as synaptic connection devices. Moreover, the recognition of 26 characters of the alphabet is experimentally demonstrated by using the single set of an optoelectronic three-layered network.

**A91-10781 An optical pattern classification using computer-generated holograms.** YOSHINORI KAJIKI, KENJI MATSUSHITA, and EIJI SHIMIZU, (International Commission for Optics, Japan Society of Applied Physics, and Optoelectronic Industry and Technology Development Association, International Topical Meeting on Optical Computing - OC'90, Kobe, Japan, Apr. 8-12, 1990) *Japanese Journal of Applied Physics, Part 2* (ISSN 0021-4922), Vol. 29, July 1990, pp. L1274-L1276.

An optical pattern classification system is proposed which performs weighting and summation by the optical system using computer-generated holograms (CGHs). The system makes it possible to simplify the structure and to improve the processing speed. A trainable pattern classification system which performs weight modification by using a CGH matrix and a dot matrix liquid crystal display (LCD) as a shutter array is proposed. The trainable pattern classifier using a CGH matrix and LCD is described, and the experimental results are presented.