editors

Takeshi Yamakawa
Gen Matsumoto

IIZUKA'96

Proceedings

of the 4th

International

Conference on

Soft Computing

Vol. 1

Methodologies for the Conception, Design, and Application of Intelligent Systems

IFSA
International Fuzzy Systems Asscociation (IFSA)

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Takeshi Yamakawa

Organizing Committee Chairman

Kyushu Institute of Technology, Japan

Fuzzy Logic Systems Institute, Japan

Gen Matsumoto

Program Committee Chairman

Electrotechnical Laboratory, Japan

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ABOUT THE CONFERENCE SYMBOL

Objects and concepts change their shapes and aspects in accordance with viewpoints. The most significant interest of computer scientists lies on the human brain. A human brain is dissected to be examined and analyzed by neurophysiologists, physicists, mathematicians and engineers. One of the viewpoints is that the brain is seen namely through the glasses of weighting and "sigmoidal thresholding" (the right wall of the symbol) as a massively parallel signal processor. From another viewpoint, the brain is seen as a nonlinear dynamical system typically discussed in terms of a "logistic map"(the left wall of the symbol) and also "evolutions" (over view of the symbol). Other researchers describe and estimate a conceptual behavior of a human brain with if-then rules including fuzzy linguistic terms. These terms are characterized by "membership functions", the typical shape of which can be found out on two walls of the symbol. By turning the viewpoints and harmonizing the scenery, we may look through the scenery at a post-digital human friendly computer.

Takeshi Yamakawa, Ph.D.

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A Message from the Honorary Chairman

Prof. Walter J. Freeman
University of California, Berkeley

The organizers of this Conference extend a cordial welcome to worldwide participants in our continuing efforts to bring machine intelligence to its full potential in the service of mankind. The break-throughs in programmable computers 50 years ago totally transformed our societies in ways that were not foreseen at that time. By separating the concept of information from the concept of meaning, Shannon and Weaver enabled our predecessors to expand and elaborate our capacities to accumulate and analyze immense data bases rapidly and efficiently, to spread the results to workers in all parts of the globe via Internet, and to support interactive communication to achieve flexibility and cooperation in applications of the data.

Now we work at the threshold of a second revolution, which will have effects on our societies of even greater magnitude. Like primitive mammals among the dinosaurs we have seen in the past decade the developing algorithmic systems based equally in digital technology and in the new understanding of brain function, which is steadily growing in the neurosciences. Fuzzy logic and neural networks have already become established as secure disciplines having important practical applications in a wide range of industrial, commercial, and economic activities, because they incorporate into rigid digitally based programs the flexibility of judgement and response, the immediate access to extensive data bases, and the capacities to learn and adapt that characterize human thinking.

The next steps will incorporate more fully the emerging disciplines of contemporary studies of brain function, particularly nonlinear neurodynamics, which goes beyond transistor-like neurons and describes in mathematical form the operations of great populations of interactive neurons. Emphasis in these studies is placed on the capabilities of neural populations for self-organization, by which they create endogenous patterns of activity through sequential state transitions. Each state is characterized as having a transitory attractor and a surrounding basin, at the edge of which critical instability occurs, leading to a new state. The activity by itself changes the synaptic web and thereby alters the new states, so that each brain continuously evolves along its individual trajectory into the future. The sensory input that is constantly sought by brains shapes these alterations and new states, enabling brains to comprehend the environment by changing themselves through learning. Even more importantly, brains, by their motor actions, alter the environment to correspond to their needs and creative visions.

Our mathematical descriptions of these operations give us the opportunity to build new machines which have these properties and thereby to create fully competent forms of artificial intelligence. We have a long road to follow before we can reach that goal, which is why we are assembling in this Conference to communicate, challenge each other's ideas, and plan new tasks. One intermediate goal will be to simulate the operations of the vertebrate sensory cortices, thereby to give our digital machines the eyes and ears that they will need to interface effectively with the infinitely complex environment that we all share. This cannot be done with the finite stores of representations, which constitute the backbone of current AI. It must be done with nonrepresentational dynamics, through which new devices will construct matrices of meaning in the way that animals and humans do. They will also require the motor control systems by which to probe and modify the environment, in order to test as hypotheses their endogenous constructs that are shaped by their sensory input.

Meaning differs from information in being the relations between data points. Meaning is a place in the structure of memory within brains, by which the entire body of their past experience serves to shape each new state transition and emergent understanding, as the basis for each new action. This is the essence of consciousness. As scientists and engineers we need not ask whether these devices will be conscious. That is an ethical question to be answered by courts of law and Societies for the Prevention of Cruelty to Intelligent Beings. We should ask how the meaningless firing of neurons in our brains leads to the emergence of meaning. Using the computer resources we have already at hand, we can come to know our human selves by building systems which also have our capability.

Again, we welcome you and invite you to join in this historic enterprise, working toward the better understanding of mankind.

Walter J. Freeman
Honorary Chairman

Greetings from the Organizing Committee Chairman

Prof. Dr. Takeshi Yamakawa
Dean of Computer Science and Systems Engineering,
Kyushu Institute of Technology, Iizuka
also
Chairman of Fuzzy Logic Systems Institute (FLSI)

On behalf of the Organizing Committee of the 4th International Conference on Soft Computing (IIZUKA'96), I would like to welcome you to this conference.

The intelligent systems behaves so that the users may desire. The first generation of intelligence was based on the program. The more complicated the system becomes to be, the longer program it needs, which may not be designed logically in some cases. The more number of intelligent machines becomes to be, the more the programs should be developed. This aspect leads our computer society to the so called software crises. To cope with this problem, system establishment without program should be achieved. By the bio-mimetic approach, we are establishing the design methodology, in which we have only to present training data to the system, otherwise we have only to present what function it should possess finally. Thus the learning approach and GA approach provide us with the possibility of new system establishment which is too complicated to achieve, at the sacrifice of a long time elapsed.

The bio-mimetic approach will also implies us the ***consciousness*** which will enhance the effect of learning, recognition, data acquisition and other intelligent behaviors of the system. The new paradigm of intelligence in this conference is the effect of the consciousness on the intelligent behaviors. A hardware or a software system is a product created by human beings and it does not ordinarily give any feelings and spirit. In order to develop human friendly systems and establish a computer society for human beings, but not a human society for computers, research on ***emotion*** is very important. ***Consciousness and emotion*** are two paradigms of intelligence of this conference, which will be the key words to open the door to future computer science.

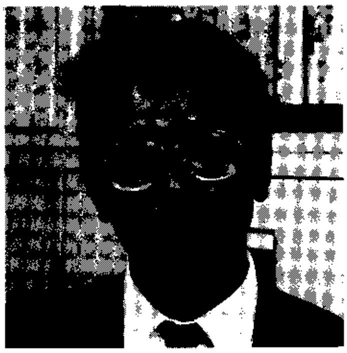
Scientific program aiming at this topics has been established by the supports and suggestions of members of the Organizing and Program Committees. Session organizers also contributed to this program arrangement. Paper reviewers worked so hard to select the excellent papers for proceedings. I would express my sincere thanks to all of these contributors.

Monbusho (The Ministry of Education, Science, Sports and Culture) provided us with significant financial support, encouraging our creation of new paradigm in computer science. I must especially acknowledge the financial support of Monbusho.

I would like to thank all the staffs in Fuzzy Logic Systems Institute (FLSI), especially Secretary General Mr. Goto, for their devotedly hard work. Finally, I want to thank my wife Tamae for her work as the Social Program Committee Chair and also my two sons Toshitaka and Tsuyoshi for understanding my important work as the Organizing Committee Chair of IIZUKA'96 during these two years.

Takeshi Yamakawa, Ph.D.
Organizing Committee Chairman

Preface by the Program Committee Chairman



Dr. Gen Matsumoto
Chief Scientist
Electrotechnical Laboratory, Tsukuba
Japan

Brain Computing

The brain is an automatic algorithm acquisition system. Acquired algorithm is represented both as configurational and as activity changes in the neuron networks. The organism has another automatic algorithm acquisition system, genetic information system, where the algorithm is expressed in terms of base sequence of DNA. The acquisition modes of algorithm in both systems differ from each other in its strategy and representation.

One of the essential strategies for the brain to acquire algorithms is learning. The brain acquires algorithms through learning, and represents them in the form of configurations and activities of the neural networks. New in-coming information is used as a sort of trigger for activating some of the existing neuronal circuits, which enables the brain to provide output in the form of behavior. Giving an output will exercise a learning effect, to rewrite the algorithm. That is to say, the brain compiles a conversion table in advance on the basis of learning, and the in-coming information allows to select one of pre-arranged responses, which has the highest correlation with itself as an output. Giving an output results in a learning effect, and permits to modify responses in the repertory in accordance with the effects of output.

Lets us examine the nature of learning, which is genetically provided as a brain strategy for acquiring algorithm. The learning effect is induced when a neuron or a neural network or a brain receives a "significant" stimulus. Here, the matter concerns what a significant stimulus is, and what a learning effect is. The learning effect may be defined as a factor to cause a change (reinforcement or attenuation) in the signal transmission efficiency between neurons, and the "significant" stimulus may be defined as an input information causing a neuron or a neural network or a brain launch an output.

A neuron checks the amount of synaptic memory at the input end in the moment an output is given out, and either reinforces or attenuates the coupling depending upon the memory amount. In this way, signals coming into a neuron in temporally separated manner are integrated when the neuron gives an output. The rule of time-sequence learning is dependent on the output, and creates an asymmetrically coupled neuron circuit. As the activity in the neural circuit induced in time sequence propagates unidirectionally, it seems that putting things in the temporary order is "brain-compatible" based on this principle. The rule of time-sequence learning is very interesting when considering how the brain perceives time. While a physical time span is the same for both the young and the aged, the quantity of information received by a young brain as "significant stimuli" is far greater than that received by an aged brain, inducing much more intensive learning effect and impressing much greater amount of relevant information in the brain. If an aged person feels that a year in the past was too short, it means that the amount of information of which correlation had been established through learning and which had been stored in the brain as memory of experience was very small. Living "rich" in time depends upon how far the learning effect has been enhanced through moving or impressive experience, and how much "engram" has been engraved in the brain in a limited span of physical time. Leading an "affluent" life may be defined not as living a longer span of physical time, but as acquiring much greater amount of information in the course of human existence and inducing by far the more abundant learning effects in the brain within that span of physical time.

What is an input information entitled to be a "significant" stimulus? A sensory stimulus of higher physical strength can be an input of higher intensity. However, though a physically strong stimulus can induce an output in the initial stage, soon the accommodation steps in to reduce the effectiveness of the stimulation. A strong stimulus can be accepted as an effective stimulus in sustained manner only when it is related to emotion. For instance, whether or not a loud sound input is perceived as a strong stimulus depends not on its physical loudness, but on its emotional effect, such as hatred or scare.

The brain activity is controlled in the manner of feed-forward. The input information to the brain is handled in parallel by dual information processing systems: a cognitive information system in the cerebral cortex and an emotional information system involving amygdaloid body of the lymbic system.

The emotional information system decides whether the input information is pleasant or unpleasant, or in other words, valuable or valueless for the existence of an individual. This is a judgment of poor resolution, but gets to the conclusion very quickly. On the other hand, the cognitive information system is characterized by high precision, but requires longer time for processing. If an input information is proved to be emotionally pleasant, and valuable on the basis of judgment including results of cognitive processing, the brain activity is enhanced through the humoral control mechanism such as diffusible transmitter substance, to induce learning effects. The enhanced brain activity makes it ready to launch an output, which in its turn exercises the learning effect, consequently. That is, the brain constructs automatically a circuit to process such an information of which value has been recognized.

It may be no exaggeration to state, therefore, that the brain activity is controlled most effectively by the emotional or value information, and all the information handled by a human being is ascribed to the emotion. For instance, when a little boy tells to his mother, "Daddy gave me 10 bucks, and I'm going to buy a picture book.", the most important information the boy wishes to convey to his mother is his happiness caused by the interaction with his father, rather than the fact that he gets money or his plan how to use it. If the information is defined as things responsible for the brain activity, the information significant for the brain should be things concerning the emotion underlying the activity, rather than things concerning facts and/or ideas. The objective of the information processing in the brain is to determine the value of input information, and the "significant" information for a human being is the value information. It may be claimed, therefore, that the objective of the human life is to create his/her own value system to support the value recognition.

Since the information processing in the brain is characterized by constructing a conversion table through learning, involving a pre-arranged set of responses, or repertories, and letting the input information to pick up one of them, there must be a strategy to derive an appropriate solution very efficiently. The strategy being employed by the brain in this respect is a hypothesis-verifying system. That is, just like the emotional evaluation based on rough concepts in the hypothalamus-lymbic system, the cognitive information processing system in the cerebral neocortex is supposed to be controlled in the direction of backing up the conceptual logic at an earlier stage. This mechanism will allow to activate a neuronal circuit to be selected in the neocortex for a particular response, and the cognitive information system works so as to provide a logical backup for the initial rough assumption. There is an important device to support this mechanism: focal attention system. It has been known in the visual cognitive mechanism that a projection system innervates from the pulvinar nucleus of the thalamus in the radiating manner the primary visual area, the pre-visual area and the temporal association area, to selectively activate a particular neuronal pathway in the visual recognition circuits. Let us consider a typical example of pattern recognition in the visual cognitive processing. I would like to propose a stepwise recognition mechanism in place of the conventional thinking of package recognition. In the latter, the brain analyzes the input pattern sequentially and attains to a recognition that the pattern currently being viewed is that of Miss A's face. According to my thinking, the first step is a rough categorization that the object being viewed is a human face. Then, the primary cognitive system provides a number of potential candidates: Miss A's face, Miss B's face, and so on. Recently, a feedback pathway from the temporal association area to the primary visual area via the pre-visual area has been demonstrated. Following a rough conceptualization of cognition on the trial basis, interactive verification of the assumption is repeated until a final pattern recognition is reached after having eliminated every trace of self-inconsistency.

The brain has adopted the hypothesis-verifying strategy as a means of effectively selecting a response it needs out of a set of repertories acquired through learning. When you convince yourself that a thing can be achieved, the cognitive information system is put into the full activity to provide a logical backup for your conviction. In this way, what you believe to be realizable is realized without fail. On the contrary, if you have nothing to believe in, the brain loses the motivational orientation for information processing, and is put into confusion. You need a conviction on how to lead yourself, or your information processing in regard to what you want or what you have not experienced. It seems that this is a possible origin of belief, and the desire for belief is fully "brain-compatible". "Letters to the Hebrew" Paragraph 1, Chapter 11 of the New Testament defines the belief in this way: "The belief is to convince of what you want and to confirm what you have never seen." When we encounters an experience of acquiring unexpected power or achieving a great success by convincing of something, we feel the existence of non-perceptible control. This feeling leads to the joy of believing, and having faith in the existence of an almighty. It seems that the system of religion evolved in this way as the civilization grew. Science also has the same way of development starting with the birth of civilization, aiming at understanding the nature through pile-up of logics and achieving what the man wants. The decisive difference between science and religion is that the religion relies upon the predisposed conviction, while in science the conviction is acquired as a result of investigating facts. The difference which has separated the two from each other, just like water and oil, is vividly reflecting the difference in the mode of information processing between the computer and the brain. If the intuitive conviction in the brain should lead the information processing in the brain to a wrong direction, an erroneous logical backup would be provided, resulting in a fallacious behavioral output. This is a sort of uncontrollable convicted criminal. However, the information processing of higher order, such as creativeness, owes much to such a fallible mechanism of information processing in the brain. The boundary between the genius and the madness is as thin as a sheet of paper.

If it could be clarified through the brain research what a man is, our way of living and the objective of our life would be provided with a solid ground. The objective of human life may be described as realizing oneself. Then, what realizing oneself means ? As stated in the above, realizing oneself is to establish one's own value system. A society in which individuals having heterogeneous value systems coexist while mutually respecting other persons' value systems, may be regarded as a fruitful society. The organizational pattern of value systems is identical for both individuals and societies, in spite of hierarchical difference. If societies having their own value systems or cultures could coexist while mutually respecting other societies' value systems or cultures, it would be possible to achieve the global peace. If a particular society claims exclusive righteousness of its own value system, a war will ensue.

The religion and the science have been repulsive to each other as antipodal entities. In consideration of the fact that the religion has been and still is playing a significant role as a mental support for living, and that the brain is also providing a support for the mental activity in the inner world, it is a matter of utmost importance for the human being, I believe, to define the position of religion from the viewpoint of brain science and to clarify the relation between religion and science.

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Gen Matsumoto
Program Committee Chairman

CONTENTS

VOLUME 1

OPENING LECTURES

1. **The Roles of Soft Computing and Fuzzy Logic in the Conception, Design and Deployment of Intelligent Systems** 3
Prof. Lotfi A. Zadeh
University of California, Berkeley (U.S.A.)

2. **Digital Representational Neural Networks for Modeling Nonrepresentational Brain Dynamics** 5
Prof. Walter J. Freeman
University of California, Berkeley (U.S.A.)

PLENARY LECTURES

1. **Linear Demon** 13
Prof. Ichiro Tsuda
Hokkaido University (Japan)

2. **Brain Computing** 15
Dr. Gen Matsumoto, Dr. Michinori Ichikawa and Dr. Yukifumi Shigematsu
Electrotechnical Laboratory (Japan)

3. **Numerical Estimation of the State of Mind** 25
Dr. Toshimitsu Musha, Dr. Yuniko Terasaki, Dr. Toshimitsu Takahashi and Dr. Hasnine A. Haque
Brain Functions Laboratory, Inc. (Japan)

4. **DNA Biosoft Computing** 30
Prof. Elie Sanchez
NEURINFO (France)

5. **Multiresolution Analyses of Fuzzy Membership Functions by Chaotic Neural Network** 38
Prof. Harold Szu and Dr. Charles Hsu
University of Southwestern Louisiana, Lafayette (U.S.A.)

6. **Artificial Emotional Creature Project for Intelligent System — Human Robot Interaction** 43
Prof. Takanori Shibata
M.I.T. (U.S.A.) and Mechanical Engineering Laboratory (Japan)

7. **Four-Terminal Device Concept for Intelligent Soft Computing on Silicon Integrated Circuits** 49
Prof. Tadahiro Ohmi, Prof. Tadashi Shibata and Dr. Koji Kotani
Tohoku University (Japan)

INVITED / ORDINARY SESSIONS

A-1 SOFT COMPUTING APPROACHES TO KNOWLEDGE ACQUISITION (INVITED)

Organizer: Prof. Hisao Ishibuchi
University of Osaka Prefecture (Japan)

1. **Evolutionary Simulation for Group Behavior of Multi-Agent Robot** 61
Yoichiro Maeda
Osaka Electro-Communication University (Japan)

2. **Concept Learning for Interface Agent Through Adaptive Feature Selection and GA-Based Feature Discovery** 65
Tetsuo Sawaragi*, Naoki Tani** and Osamu Katai*
*Kyoto University (Japan)
**West Japan Railway Company (Japan)

3. **An Adaptive Fuzzy Rule Extraction Using Hybrid Model of the Fuzzy Self-Organizing Map and the Genetic Algorithm with Numerical Chromosomes** 70
Tatsuya Nomura* and Tsutomu Miyoshi**
*ATR Human Information Processing Research Laboratories (Japan)
**SHARP Corporation (Japan)

4. **Connectionist Methods for Fuzzy Rules Extraction, Reasoning and Adaptation** 74
Nikola K. Kasabov
University of Otago (New Zealand)

A-2 FUZZY RULE GENERATION (INVITED)

Organizer: Prof. Hisao Ishibuchi
University of Osaka Prefecture (Japan)

1. **Sensor Based Knowledge Acquisition and Modification** 78
Tomomi Hashimoto and Toru Yamaguchi
Utsunomiya University (Japan)

2. **Auto-Generation of Fuzzy Production Rules Using Hyper Elliptic Cone Membership Function by Genetic Algorithm** 82
Hiroyuki Inoue, Katsuari Kamei and Kazuo Inoue
Ritsumeikan University (Japan)

3. **Fuzzy Rule Generation by Hyperellipsoidal Clustering** 86
Mina Ryoke*, Hiroyuki Tamura* and Yoshiteru Nakamori**
*Osaka University (Japan)
**Konan University (Japan)

4. **Functional Completeness of Hierarchical Fuzzy Modeling** 90
Hiroaki Kikuchi, Akihiro Otake and Shouhachirou Nakanishi
Tokai University (Japan)

A-3 NEW ARCHITECTURES AND ALGORITHMS FOR SOFT COMPUTING (INVITED)

Organizer: Prof. Tadashi Shibata
Tohoku University (Japan)

1. **A Multiplex Computing Paradigm** 95
Tatsuo Higuchi and Takafumi Aoki
Tohoku University (Japan)

2. **Non-Volatile One-Transistor-Cell CAM and Its Applications** 101
Takahiro Hanyu, Naoki Kanagawa and Michitaka Kameyama
Tohoku University (Japan)

3. **Flow-Thru Processing Concept and Its Applications to Soft-Computing** 105
Hiroaki Terada, Yan Xu, Makoto Iwata, Tetsuya Takine and Koso Murakami
Osaka University (Japan)

4. **A Module Generator of 2-Level Neuron MOS Circuits** 109
Kenjirou Ike, Kei Hirose and Hiroto Yasuura
Kyushu University (Japan)

A-4 HARDWARE VISION AND RECOGNITION (INVITED)
Organizer: Prof. Tadashi Shibata
Tohoku University (Japan)

1. **A Tree Structure of Automata for Selective Image Scanning and Its Implementation** 113
Kunihiro Asada, Junichi Akita and Ryota Watabe
University of Tokyo (Japan)

2. **Massively Parallel Processing Vision and Its Applications** 117
Masatoshi Ishikawa, Takashi Komuro, Yoshihiro Nakabo and Idaku Ishii
University of Tokyo (Japan)

3. **Computational Image Sensors for Focal Plane Compression** 121
K. Aizawa*, Y. Egi,* H. Hamamoto*, A. Motoki*, M. Hatori*, H. Maruyama** and J. Yamazaki**
*University of Tokyo (Japan)
**NHK (Japan)

4. **Event Recognition Hardware Based on Neuron-MOS Soft-Computing Circuits** 125
Tadashi Shibata, Yuichiro Yamashita, Masahiro Konda, Tatsuo Morimoto and Tadahiro Ohmi
Tohoku University (Japan)

A-5 BIO-INSPIRED INTEGRATED CIRCUITS (INVITED)
Organizer: Prof. Tadashi Shibata
Tohoku University (Japan)

1. **Ferroelectric Neuron Circuits with Adaptive-Learning Function** 131
Hiroshi Ishiwara and Eisuke Tokumitsu
Tokyo Institute of Technology (Japan)

2. **Self-Organized Arrangement of Neurons for Feature Extraction Using Adaptive Neuro-Devices** 135
Hiroo Yonezu, Kiyotaka Tsuji and Jang-Kyoo Shin
Toyohashi University of Technology (Japan)

A-6 SYSTEM ANALYSIS OF COMPLEX NONLINEAR DYNAMICS PART 1 (INVITED)

Organizer: Prof. Masahiro Okamoto
Kyushu Institute of Technology (Japan)

1. **An Integrated Approach for Metabolic Pathway Analysis Based on Metabolic Signal Flow Diagram and Cellular Energetics for *Saccharomyces cerevisiae* Grown on Glucose** 139
   Huidong Shi and Kazuyuki Shimizu
   Kyushu Institute of Technology (Japan)

2. **Steady-State Synergisms in Kinetic Models: Estimation and Applications** 143
   Armindo Salvador
   Instituto de I. C. Bento da Rocha Cabral (Portugal)

3. **Scanning Algorithm for Refinement of Complex Biological Models** 147
   Ta-Chen Ni* and Michael A. Savageau**
   *University of Southern California (U.S.A.)
   **The University of Michigan (U.S.A.)

4. **Algorithms for Non-Positive Variables in Generalized Mass Action Systems** 151
   Philip F. Rust
   Medical University of South Carolina (U.S.A.)

A-7 SYSTEM ANALYSIS OF COMPLEX NONLINEAR DYNAMICS PART 2 (INVITED)

Organizer: Prof. Masahiro Okamoto
Kyushu Institute of Technology (Japan)

1. **Parameter Estimation and Sensitivity Analysis of S-Systems Using a Genetic Algorithm** 155
   Zhen Zhang, Eberhard O. Voit and Lorelei H. Schwacke
   Medical University of South Carolina (U.S.A.)

2. **Dynamics of Distributed Variables** 159
   Eberhard O. Voit
   Medical University of South Carolina (U.S.A.)

3. **Symbolical and Numerical Simulations of Adenylosuccinate Lyase Deficiency in Man** 163
   Raul Curto*, Eberhard O. Voit** and Marta Cascante*
   *Universitat de Barcelona (Spain)
   **Medical University of South Carolina (U.S.A.)

4. **Comparison of Completely Uncoupled and Perfectly Coupled Gene Expression in Repressible Biosynthetic Systems** 167
   William S. Hlavacek and Michael A. Savageau
   The University of Michigan (U.S.A.)

A-8 SYSTEM ANALYSIS OF COMPLEX NONLINEAR DYNAMICS PART 3 (INVITED)
Organizer: Prof. Masahiro Okamoto
Kyushu Institute of Technology (Japan)

1. **Optimization of Metabolic Systems with Linear Programming: Application to Biotechnological Processes** 171
Néstor V. Torres*, Carlos Glez-Alcón* and Eberhard O. Voit**
*Universidad de La Laguna (Spain)
**Medical University of South Carolina (U.S.A.)

2. **Buffering Components in Integrative Systems Models** 175
António E. N. Ferreira and Eberhard O. Voit
Medical University of South Carolina (U.S.A.)

3. **Exploring the Properties of Signal Transduction Pathways by Mathematical Controlled Comparisons Based on Power-Law Models** 179
Albert Sorribas
Universitat de Lleida (Spain)

4. **Application of Biochemical Systems Theory to Determination of Intrinsic Kinetic Parameters of an Immobilized Enzyme Reaction Following Michaelis–Menten Kinetics** 183
Takahiro Hasegawa and Fumihide Shiraishi
Kyushu Institute of Technology (Japan)

5. **Fractal Kinetic Effects on Equilibrium** 187
Michael A. Savageau
The University of Michigan (U.S.A.)

B-1 FUZZY IMAGE PROCESSING (INVITED)
Organizer: Dr. Nikhil R. Pal
Indian Statistical Institute (India)

1. **A New Class of FIRE Filters Based on Piecewise Linear Fuzzy Sets** 193
Fabrizio Russo
University of Trieste (Italy)

2. **Fractal Dimension of a Fuzzy Set** 197
B. B. Chaudhuri
Indian Statistical Institute (India)

3. **A Psychovisual Fuzzy Reasoning Edge Detector** 201
Nikhil R. Pal and Supratik Mukhopadhyay
Indian Statistical Institute (India)

4. **Recognition of Binary Character Images with a Fuzzy Neural Network** 205
Gautam K. Mandal
Surendranath College (India)

B-2 HYBRID APPROACH FOR PATTERN RECOGNITION (INVITED)
Organizer: Dr. Sankar K. Pal
Indian Statistical Institute (India)

1. **Machine Intelligence, Pattern Recognition and Future Generation Computing Systems** 209
Sankar K. Pal
Indian Statistical Institute (India)

3. **Partition of Attributes and Fuzzy Integral Model for Evaluation Process** 303
Yutaka Matsushita and Hiroshi Kambara
Shimizu Corporation (Japan)

4. **Decision Process Modeling Based on Consensus Among Fuzzy Integral and AHP** 308
Takashi Washio*, Hiroshi Motoda* and Masaharu Kitamura**
*Osaka University (Japan)
**Tohoku University (Japan)

5. **On Identification of Hierarchical Structure of Fuzzy Integral Systems** 312
Katsushige Fujimoto
Tohoku University (Japan)

6. **Alternative Representations of Discrete Fuzzy Measures for Decision Making** 316
Michel Grabisch
Thomson-CSF (France)

C-1 FUZZY MATHEMATICS

1. **Fuzzy Systems and Wavelets: Relationship Study (Invited)** 323
Yi Yu*, Shaohua Tan* and Joos Vandewalle**
*National University of Singapore (Singapore)
**Katholieke Universiteit Leuven (Belgium)

2. **On the Closure of Generation Processes of Implication Functions from a Conjunction Function** 327
Masahiro Inuiguchi and Masatoshi Sakawa
Hiroshima University (Japan)

3. **Composite Fuzzy Relational Equations with Non-Commutative Conjunctions** 331
Mayuka F. Kawaguchi and Masaaki Miyakoshi
Hokkaido University (Japan)

4. **Fuzzy Ordered Classification** 336
Eugene V. Bauman
Russian Academy of Sciences (Russia)

C-2 FUZZY LOGIC CONTROL PART 1

1. **A Fuzzy Logic Wheelchair Controller** 338
Pablo Martinez, Dan Corbett and Lakhmi Jain
University of South Australia (Australia)

2. **Fuzzy-Impedance Control and Isotropic Behavior of Manipulating Robots** 342
Petar B. Petrovic and Vladimir R. Milačić
Belgrade University (Yugoslavia)

3. **The Application of Fuzzy Control System in the Industrial Process** 346
Zaki A. Azmy
CABINET of the Deputy, Prime Minister for Council of Ministers
(Sultanate of Oman)

4. **Adaptive Fuzzy Controllers with Rule Dependent Inferencing** 350
Nikhil R. Pal and Chinmoy Bose
Indian Statistical Institute (India)

C-3 FUZZY LOGIC CONTROL PART 2

1. **Stability Analysis of Fuzzy Control Systems Simplified as a Discrete System** 354
Takashi Hasegawa Takeshi Furuhashi and Yoshiki Uchikawa
Nagoya University (Japan)

2. **Stochastic Fuzzy Control — Part II: Relationships Among *a Priori* Probabilities, Fuzzy Sets and Control Rules** 358
Keigo Watanabe
Saga University (Japan)

3. **A Real-time Tuning Algorithm for Fuzzy Controller and It's Application for the Nuclear Power Plant** 363
Chul-Hwan Jung and Chang-Shik Ham
Korea Atomic Energy Research Institute (Korea)

4. **Simulation of an Adaptive Fuzzy Controller with Stability Conditions** 367
D. Barois, A. Bigand and R. Ikni
Université du Littoral (France)

C-4 FUZZY LOGIC CONTROL PART 3

1. **An Adaptive Fuzzy Control Using EPA for Power System Stabilizer** 370
Young Wan Cho*, Yong Joo Kim*, Seung Woo Kim** amd Mignon Park*
*Yonsei University (Korea)
**Soonchunhyang University (Korea)

2. **An Optimal Scaling Gain Tuning Method for Designing a Fuzzy Logic Controller** 374
Hansoo Shim*, Hyunseok Shin*, Cheol Kwon*, Hyungjin Kang*, Jie Kwan Kim** and Mignon Park*
*Yonsei University (Korea)
**Samsung Electronics Co., Ltd. (Korea)

3. **A Design of Stochastic Fuzzy Controller Using a Robust State Feedback Stabilization** 378
Keigo Watanabe*, Akira Nomiyama** and Jun Tang*
*Saga University (Japan)
**Nishinihon Soft Service Co., Ltd. (Japan)

4. **A Design of a Robust Adaptive Fuzzy Controller Globally Stabilizing the Multi-Input Nonlinear System with State-Dependent Uncertainty** 384
Young-Hwan Park* and Gwi-Tae Park**
*Seonam University (Korea)
**Korea University (Korea)

C-5 FUZZY LOGIC CONTROL PART 4

1. **Arc Welding Fuzzy Control Using Neural Net Supervisor** 390
André Bigand* and Katib Messaadi**
*Université du Littoral (France)
**Laboratoire ECS-ENSEA (France)

VOLUME 2

INVITED / ORDINARY SESSIONS

D-1 COGNITIVE SCIENCE (INVITED)

Organizer: Prof. Masumi Ishikawa
Kyushu Institute of Technology (Japan)

1. **A Statistical Analysis of Human Random Number Generators** 467
   Yukito Iba* and Mieko Tanaka-Yamawaki**
   *The Institute of Statistical Mathematics (Japan)
   **Sugiyama Jogakuen University (Japan)

2. **Computational View of Reflective Neural Networks in Neuro Computer System** 473
   Takumi Ichimura, Noboru Matsumoto and Eiichiro Tazaki
   Toin University of Yokohama (Japan)

3. **Locally Shift Invariant and Globally Location Dependent Recognition of Complex Figures by Neural Networks** 478
   Shinya Kawashima and Masumi Ishikawa
   Kyushu Institute of Technology (Japan)

4. **Categorization, Prototype Theory and Neural Dynamics** 482
   Wlodzislaw Duch
   Nicholas Copernicus University (Poland)

D-2 GENETIC ALGORITHM PART 1

1. **A Genetic Algorithm with a Local Improvement Mechanism for Dynamic Load Balancing in Distributed Systems** 486
   Seong-hoon Lee, Tae-won Kang and Chong-sun Hwang
   Korea University (Korea)

2. **Improvement of Input Interface for Interactive Genetic Algorithms and Its Evaluation** 490
   Hideyuki Takagi, Kimiko Ohya and Miho Ohsaki
   Kyushu Institute of Design (Japan)

3. **Minimal Generation Gap Model for GAs Considering Both Exploration and Exploitation** 494
   Hiroshi Satoh, Masayuki Yamamura and Shigenobu Kobayashi
   Tokyo Institute of Technology (Japan)

4. **Effects of New Mechanism of Development from Artificial DNA and Discovery of Fuzzy Control Rules** 498
   Tomohiro Yoshikawa, Takeshi Furuhashi and Yoshiki Uchikawa
   Nagoya University (Japan)

D-3 GENETIC ALGORITHM PART 2

1. **Symptom Parameters of Self-Reorganization for Failure Diagnosis by Genetic Algorithms** 502
   Masami Nasu, Peng Chen and Toshio Toyota
   Kyushu Institute of Technology (Japan)

2. **Fuzzy Multi-Staged Genetic Algorithm in Stock Investment Decision** 507
Chuen-Tsai Sun and Ming-Da Wu
National Chiao Tung University (R.O.C.)

3. **A Genetic Algorithm with Characteristic Preservation for Function Optimization** 511
Isao Ono, Masayuki Yamamura and Shigenobu Kobayashi
Tokyo Institute of Technology (Japan)

4. **Convergence of an Evolutionary Algorithm** 515
Paramartha Dutta and Dwijesh DuttaMajumder
Indian Statistical Institute (India)

D-4 GENETIC ALGORITHM PART 3

1. **Optimal Power Plant Start-up Scheduling: A Reinforcement Learning Approach Combined with Evolutionary Computation** 519
Akimoto Kamiya*, Masayuki Yamamura** and Shigenobu Kobayashi**
*Toshiba Corporation (Japan)
**Tokyo Institute of Technology (Japan)

2. **Fuzzy Logic Controller Design Using Genetic Algorithm** 525
Hung-Ching Lu, Shian-Tang Tzeng and Ming-Feng Yeh
Tatung Institute of Technology (R.O.C.)

3. **Co-Evolutionary Algorithm: A New Approach to Evolutionary Learning** 529
Qiangfu Zhao
The University of Aizu (Japan)

4. **Interactive GA-based Design Support System for Lighting Design in Computer Graphics** 533
Ken Aoki, Hideyuki Takagi and Naomi Fujimura
Kyushu Institute of Design (Japan)

D-5 GENETIC ALGORITHM PART 4

1. **Reconstruction of Gray Images by Neural Networks** 537
Zensho Nakao*, Yen-Wei Chen*, Masatomo Noborikawa*,
Satoshi Tobaru* and Takeshi Tengan**
*University of the Ryukyus (Japan)
**NTT Data, Inc. (Japan)

2. **The Application of Genetic Algorithms to Star Pattern Recognition** 541
Shaunna McClintock, Tom Lunney and Abdulla Hashim
University of Ulster (U.K.)

3. **Ship Collision Avoidance Using Genetic Algorithm** 545
Yong-Woon Kim and Dong-Jo Park
Korea Advanced Institute of Science and Technology (Korea)

4. **Design of Image Exploring Agent Using Genetic Programming** 549
Mario Köppen and Bertram Nickolay
Fraunhofer Institute IPK-Berlin (Germany)

D-6 LEARNING ALGORITHM

1. **A Tuning Method of Fuzzy Rules by Fuzzy Singleton-Type Reasoning Method** 553
Yan Shi*, Masaharu Mizumoto*, Naoyoshi Yubazaki** and Masayuki Otani**
*Osaka Electro-Communication University (Japan)
**Mycom Inc. (Japan)

2. **Comparison Between Connectionist and Fuzzy Q-Learning** 557
Lionel Jouffe and Pierre-Yves Glorennec
INSA (France)

3. **MarcoPolo: A Reinforcement Learning System Considering Tradeoff Exploration and Exploitation under Marcovian Environments** 561
Kazuteru Miyazaki, Masayuki Yamamura and Shigenobu Kobayashi
Tokyo Institute of Technology (Japan)

D-7 HYBRID CONNECTIONIST SYSTEMS FOR KNOWLEDGE ENGINEERING (INVITED)

Organizer: Prof. Nikola K. Kasabov
University of Otago (New Zealand)

1. **The Application of Neural Networks, Fuzzy logic, Genetic Algorithms, and Rough Sets to Automated Knowledge Acquisition** 565
Ilona Jagielska*, Chris Matthews** and Tim Whitfort**
*Monash University (Australia)
**La Trobe University (Australia)

2. **Learning Individual Characteristics in a Hybrid Neuro-Fuzzy Controller** 570
Dan Corbett
University of South Australia (Australia)

3. **Dynamical Neuro-Fuzzy Hybrid System for Medical Diagnosis** 574
Jeong-Yon Shim* and Chong-Sun Hwang**
*YongIn Technical College YongIn Si (Korea)
**Korea University (Korea)

4. **Learning Strategies for Adaptive Fuzzy Neural Networks** 578
Nikola K. Kasabov
University of Otago (New Zealand)

D-8 UNCERTAINTY MEASURES AND APPLICATIONS

1. **Overlap Index of Fuzzy Rating** 582
Hsin-Hui Lin, Ren-Jye Shieh and Kaung-Hwa Chen
National Sun Yat-sen University (R.O.C.)

2. **The Relationships Between Fuzziness and Fuzzy Correlation** 586
Kaung-Hwa Chen and Hsin-Hui Lin
National Sun Yat-sen University (R.O.C.)

3. **An Object Recognition System Based on Fuzzy Categorization and Classification of Fuzzy Concepts** 589
Kenneth H. L. Ho
RIKEN (Japan)

4. **Neural Networks Used for Optimization on Determining Belief Measures and Plausibility Measures from Data** 593
Zhenyuan Wang* and Jia Wang**
*Hebei University (P.R.China)
**Binghamton University-SUNY (U.S.A.)

5. **The Space of Fuzzy Random Variables** 596
Shoumei Li and Yukio Ogura
Saga University (Japan)

E-1 FUZZY NEURAL NETWORKS PART 1

1. **On the Development of Intelligent Control System for Recombinant Cell Culture (Invited)** 603
Sha Jin, Kaiming Ye and Kazuyuki Shimizu
Kyushu Institute of Technology (Japan)

2. **Grasping Control of Robot Hand by Multi-Valued Neural Network and Double Octahedron Force Sensors** 607
Shigeki Nakayama, Peng Chen and Toshio Toyota
Kyushu Institute of Technology (Japan)

3. **Multi-Module Network for Association of Vague Patterns and Symbols** 612
Yoichiro Hattori, Takeshi Furuhashi and Yoshiki Uchikawa
Nagoya University (Japan)

4. **Life Prediction of Electrical Parts with Fuzzy and Neural Methods** 616
T. Murata, I. Nagayama and E. Takaya
University of the Ryukyus (Japan)

E-2 FUZZY NEURAL NETWORKS PART 2

1. **Generating Linguistic Rules from Data Using Neuro-fuzzy Framework (Invited)** 618
Jacek M. Zurada and Andrzej Lozowski
University of Louisville (U.S.A.)

2. **Optical Method for Processing Information Depicted by Picture** 622
Kazuho Tamano
Hiroshima Institute of Technology (Japan)

3. **Output Estimation of Fuzzy Neural Networks** 626
Thomas Feuring and Wolfram-M. Lippe
Westfälische Wilhelms-Universität Münster (Germany)

4. **Using Combined Fuzzy-Neural Network Approach for Electrical Load Forecasting** 630
V. Popov, P. Ekel, F. Farret and S. Ansuj
Federal University of Santa Maria (Brazil)

E-3 CHAOS (INVITED)
Organizer: Dr. Tadashi Iokibe
MEIDENSHA Corporation (Japan)

1. **Are Japanese Vowels Chaotic?** 634
Takaya Miyano
Sumitomo Metal Industries, Ltd. (Japan)

2. **Evolutionary Parallel Computation Based on Chaotic Retrieval and Creation** 638
N. Kohata, T. Yamaguchi, Y. Wakamatsu and T. Baba
Utsunomiya University (Japan)

3. **Knowledge Creation Robots Based on Chaotic Retrieval** 642
T. Yamaguchi, Y. Wakamatsu and N. Kohata
Utsunomiya University (Japan)

4. **An Application of Short-Term Prediction by Chaotic Approach to Daily Peak Electric Power Demand** 646
Masaya Koyama, Minako Taniguchi and Tadashi Iokibe
Meidensha Corporation (Japan)

E-4 NEURAL NETWORK DESIGN AND EVOLUTION PART 1

1. **New Blind Separation Algorithm Using Neural Network** 650
Bin-Chul Ihm, Dong-Jo Park and Kwang-Seop Eom
Korea Advanced Institute of Science and Technology (Korea)

2. **A New Neural Network Construction Algorithm Using a Pool of Hidden Candidates** 654
Cheol Hoon Park, Jung Pil Yu, Lae-Jeong Park and Sangbong Park
Korea Advanced Institute of Science and Technology (Korea)

3. **A Study on the Networks with Column Structure** 658
Koji Morikawa, Takeshi Furuhashi and Yoshiki Uchikawa
Nagoya University (Japan)

4. **Neural α-Feature Detector: Extracting Features by Minimizing α-Information** 662
Ryotaro Kamimura and Shohachiro Nakanishi
Tokai University (Japan)

E-5 NEURAL NETWORK DESIGN AND EVOLUTION PART 2

1. **Blind Separation of Signals Through a Geometrical Approach** 667
C. G. Puntonet, M. Rodriguez-Alvarez and A. Prieto
Universidad de Granada (Spain)

2. **Recognition of Pattern Similarity in Time Series Signals Using Artificial Neural Network with Synaptic History** 671
Kouji Tanaka and Masahiro Okamoto
Kyushu Institute of Technology (Japan)

3. **Minimization of Least Squared Functions in Training Feedforward Neural Network Systems** 676
P. M. Nobar and Dapeng Tien
Ngee Ann Polytechnic (Singapore)

4. **Bayesian Estimation of Parameters of Various Regularizers in the Learning of Neural Networks** 680
Kazuhiro Yoshida and Masumi Ishikawa
Kyushu Institute of Technology (Japan)

5. **The Learning Capability of Cyclic Activation BP for Two-Spirals Problem** 684
Toshiki Yoshino*, Itaru Nagayama** and Norio Akamatsu*
*The University of Tokushima (Japan)
**University of the Ryukus (Japan)

E-6 CHAOS ENGINEERING PART 1

1. **Design Criteria for Robust Associative Memory Employing Non-equilibrium Network (Invited)** 688
Takeshi Yamakawa, Masayoshi Shimono and Tsutomu Miki
Kyushu Institute of Technology (Japan)

2. **A Scenario for the Onset of "Dynamical Associative Memory" in Chaotic Neural Network** 692
Tomomasa Nagashima, Yoshitake Shiroki and Isao Tokuda
Muroran Institute of Technology (Japan)

3. **Stability Studies in Physical Systems Using Coupled Map Lattice Method** 696
Shusuke Takei*, Robert Kozma*, Hidetoshi Konno** and Masaharu Kitamura*
*Tohoku University (Japan)
**University of Tsukuba (Japan)

4. **Competition among Synchronizing Chaotic Systems: Implication for Neural Computation** 700
Sitabhra Sinha* and Suvranshu Kar**
*Indian Statistical Institute (India)
**East India Pharmaceutical Works (India)

E-7 CHAOS ENGINEERING PART 2

1. **Nonlinear Dynamic System Identification Using Modified Diagonal Recurrent Neural Network** 704
Jae-Soo Cho, Yong-Woon Kim and Dong-Jo Park
Korea Advanced Institute of Science and Technology (Korea)

2. **A Study of Autonomous Chaos Neural Network** 708
Masahiro Nakagawa
Nagaoka University of Technology (Japan)

3. **Engineering Applications Based on Chaotic Systems for Personal Satellite Communications** 714
Mura*, M. Barbieri*, Antonio L. Perrone* and G. Basti**
*TER-Technology (Italy)
**Pontifical Gregorian University (Italy)

E-8 HARDWARE IMPLEMENTATION OF NEURAL SYSTEMS

1. **Novel Synapse Design for VLSI Implementation of Neural Networks** 718
B. Roche, T. M. McGinnity, L. McDaid and A. Hashim
University of Ulster (U.K.)

2. **A Pseudo-Parallel Architecture for Hardware Implementations of Neural Networks** 722
T. M. McGinnity, L. P. Maguire, L. J. McDaid and A. A. Hashim
University of Ulster (U.K.)

3. **A Neural Network with Self-Synchronized Coupled Nonlinear Oscillators** 726
Kimiko Kajiya and Kenichi Yoshikawa
Nagoya University (Japan)

4. **A Flexible FLSI Processor for Fast Neural Network and Fuzzy Control Implementation** 730
Alessandro Zorat*, Alvise Sartori**, Gianpietro Tecchiolli** and László T. Kóczy***
*University of Trento (Italy)
**IRST (Italy)
***Technical University of Budapest (Hungary)

F-3 CONTROL WITH SOFT COMPUTING

1. **Intelligent Control of Neural-Net Systems** 737
Yoshitake Yamazaki*, Geuntaek Kang** and Moyuru Ochiai***
*Kyushu Institute of Technology (Japan)
**National Fisheries University of Pusan (Korea)
***North-Shore College (Japan)

2. **Refrigerator Temperature Control with Soft Computing** 741
Yun-Seog Kang*, Seong-Wook Jeong*, Jae-In Kim*, Hong-Won Lee*, Wonchang Lee** and Geuntaek Kang**
*Samsung Electronics Co., Ltd. (Korea)
**National Fisheries University of Pusan (Korea)

3. **Evolutionary Learning of Fuzzy Controller for a Mobile Robot** 745
Sung-Bae Cho and Seung-Ik Lee
Yonsei University (Korea)

4. **A Heating Control Based on Analysis of Charcoal Temperature** 749
Hiroyoshi Nomura, Hiroshi Kutsumi, Shinji Kondo and Tetsuya Kouda
Matsushita Electric Industrial Co., Ltd. (Japan)

F-4 PATTERN RECOGNITION

1. **Fuzzy Reasoning for Image Compression Using Adaptive Triangular Plane Patches** 753
Lisong Wang, Minkai Wang, Masashi Yamada, Hirohisa Seki and Hidenori Itoh
Nagoya Institute of Technology (Japan)

2. **A Fuzzy Self-Organizing Vector Quantization for Image** 757
Kwang Baek Kim* and Eui Young Cha**
*Dong-Eui Technical Junior College (Korea)
**Pusan National University (Korea)

3. **Analysis and Modelling of Face Images** 761
Michel Grabisch, Jean Figue and Marie-Pierre Charbonnel
Thomson-CSF (France)

4. **Complex Quantization for Image Compression** 765
Antonio L. Perrone* and Gianfranco Basti**
*TER-Technology (Italy)
**Pontifical Gregorian University (Italy)

F-5 IMAGE PROCESSING

1. **Vague Patterns and Symbols Treated in a Three-Layered Associative Memory Network** 770
T. Furuhashi, Y. Hattori and Y. Uchikawa
Nagoya University (Japan)

2. **Genetic Combining Multiple Neural Networks for Handwritten Numeral Recognition** 774
Sung-Bae Cho
Yonsei University (Korea)

3. **Rejection of Garbage Patterns for Improving Reliability in Continuous Handwritten Numeral Recognition** 778
Sunna Kim, Sujeong You and Yeongwoo Choi
LG Electronics Research Center (Korea)

4. **An Evaluation Method of Calligraphy Education Applying Fuzzy Reasoning** 782
Seiichi Shimizu* and Hajime Yamashita**
*Kawamo PR. School (Japan)
**Waseda University (Japan)

F-6 EMOTIONAL INFORMATION PROCESSING PART 1

1. **Analysis on Emotional Expressions and Designs** 786
Mineko Nantani and Yoshiteru Nakamori
Konan University (Japan)

2. **A Human Cognitive Model Based on Mapping Function - An Application to Emotion Processing -** 790
Naruki Shirahama*, Masahiro Nagamatsu**, Kaori Yoshida** and Kazunori Miyamoto**
*Kitakyushu National College of Technology (Japan)
**Kyushu Institute of Technology (Japan)

3. **Inference Model of Facial Expressions and Emotion** 794
Sachiko Kitazaki and Takehisa Onisawa
University of Tsukuba (Japan)

4. **Study on Fundamental Mechanism and Activity of the Artificial Emotion Processing System based on Neural Networks** 798
Chiharu Fukushima*, Masayuki Okuma**, Masahiro Nagamatsu** and Torao Yanaru**
*Kumamoto National College of Technology (Japan)
**Kyushu Institute of Technology (Japan)

F-7 EMOTIONAL INFORMATION PROCESSING PART 2

1. **A Proposal of Emotional Processing System** 802
Kaori Yoshida, Masahiro Nagamatsu and Torao Yanaru
Kyushu Institute of Technology (Japan)

2. **An Analysis of Decision Making Problem Introducing Subjective Observation** 806
Hirohisa Aman*, Torao Yanaru* and Yoshihiro Morimoto**
*Kyushu Institute of Technology (Japan)
**Kumamoto National College of Technology (Japan)

3. **Dynamic Analysis of Decision Making Problem by Subjective Observation Theory** 810
Yoshihiro Morimoto* and Yasuo Nakayama**
*Kumamoto National College of Technology (Japan)
**Kumamoto Gakuen University (Japan)

4. **Mathematical Model for Decision Making in Association with Personnel Allocation — Optimizing Job Placement of New Hires** 814
Yoshihiro Morimoto, Taeko Abe and Chiharu Fukushima
Kumamoto National College of Technology (Japan)

F-8 SIMILARITY AND CLASSIFICATION

1. **Relationship Between Subjective Degree of Similarity and Some Similarity Indices of Fuzzy Sets** 818
Ayumi Yoshikawa and Takeshi Nishimura
Kyoto Institute of Technology (Japan)

2. **Combining Multiple Fuzzy-Rule-Based Classification Systems** 822
Hisao Ishibuchi, Takehiko Morisawa and Tomoharu Nakashima
Osaka Prefecture University (Japan)

3. **The Application of Fuzzy Inference on the Discrimination of Arbitrary Concentration for Inflammable Gases** 826
Byeongdeok Yea, Tomoyuki Osaki, Kazunori Sugahara and Ryosuke Konishi
Tottori University (Japan)

G-6 NOVEL DEVICES FOR INTELLIGENCE

1. **Neuron MOS Quasi-Two-Dimensional Image Processor for Real-Time Motion Vector Detection** 833
Tsutomu Nakai, Tadashi Shibata and Tadahiro Ohmi
Tohoku University (Japan)

2. **A Real-Time Center-Of-Mass Tracker Circuit Implemented by Neuron MOS Technology** 837
Ning Mei Yu, Tadashi Shibata and Tadahiro Ohmi
Tohoku University (Japan)

3. **A MVL Interpretation of the MOS Implementation of a Fuzzy Flip-flop** 841
N. P. Lavery, T. M. McGinnity, L. P. Maguire and A. A. Hashim
University of Ulster (U.K.)

4. **Design of High Speed Bidirectional Current-Mode Multiple-Valued Adder Using Signed-Digit Number Representation** 845
Toru Tabata and Fumio Ueno
Kumamoto National College of Technology (Japan)

G-7 DIAGNOSTIC SYSTEMS

1. **Building Probabilistic Decision Trees Reflecting the Locality of Discriminating Power of Attribute** 849
Koji Yoshida, Masayuki Yamamura and Shigenobu Kobayashi
Tokyo Institute of Technology (Japan)

2. **Generating Pareto Optimal Decision Trees by GAs** 854
Koji Yoshida, Masayuki Yamamura and Shigenobu Kobayashi
Tokyo Institute of Technology (Japan)

3. **Applying Fuzzy Logic to Rotating Machinery Diagnosis** 859
Luis J. de Miguel, Jesús Fernández and José R. Perán
University of Valladolid (Spain)

4. **A Proposal of Abductive Inference Using Fuzzy Logic** 863
Yujiro Miyata, Takeshi Furuhasi and Yoshiki Uchikawa
Nagoya University (Japan)

G-8 NOVEL APPLICATIONS OF SOFT COMPUTING

1. **A Synthesis of a RBF Based General Nonlinear Filter for an Arbitrary Non-Gaussian System with Applications (Invited)** 867
Eiji Uchino, Shin Nakamura and Takeshi Yamakawa
Kyushu Institute of Technology (Japan)

2. **Double-Weighted Lagrange Programming Neural Network for Satisfiability Problems of Propositional Calculus** 871
Masahiro Nagamatu, Akihiko Yamaguchi and Torao Yanaru
Kyushu Institute of Technology (Japan)

3. **Continuous Valued Approach with Analog Rip-up Reroute for Wire Routing Problem** 875
Masahiro Nagamatu, Shakeel Ismail and Torao Yanaru
Kyushu Institute of Technology (Japan)

4. **Routing in Multistage Interconnection Networks based on the Simulated Annealing Technique** 879
Seoung-Soo Kim* and Seong-Gon Kong**
*Maxon Electronics, Co. (Korea)
**Soongsil University (Korea)

5. **Evaluation of Efficiency for DMUs by Fuzzy Loglinear Regression Analysis** 883
Yoshiki Uemura*, Masaki Kobayashi** and Kazuki Hiro***
*Mie University (Japan)
**Osaka University (Japan)
***Nara National College of Technology (Japan)

6. **Accuracy Improvement of Vehicle Load Measurement Using Fuzzy Logic** 887
Laiping Su
YAZAKI Corporation (Japan)

7. **Data Manifolds, Natural Coordinates, Replicator Neural Networks, and Optimal Source Coding** 891
Robert Hecht-Nielsen
HNC Software Inc. (U.S.A.)

POSTER SESSION

Poster-1. Chaotic Behavior in Silicon Thyristor 899
Naoyuki Miyata, Yasutoshi Hideki and Hiroshi Shimono
Toa University (Japan)

Poster-2. **Chaos in Cellular Neural Networks** 903
Naoyuki Miyata, Masayuki Fujimoto and Hiroshi Shimono
Toa University (Japan)

Poster-3. **A Genetic Approach to Feature Selection for Pattern Recognition Systems** 907
Minoru Fukumi and Norio Akamatsu
University of Tokushima (Japan)

Poster-4. **On-Line Handwritten Character Recognition Using Fuzzy Theory** 911
Katsumi Nishimori, Kouji Sawada, Hajime Miyauchi and Naganori Ishihara
Tottori University (Japan)

Poster-5. **Optimization Parameters of Several Fuzzy Reasoning Methods for Driving Control of a Model Car** 915
Hajime Miyauchi*, Katsumi Nishimori**, Yoshito Kato**, Naganori Ishihara** and Masaya Sato**
*Matsue National College of Technology (Japan)
**Tottori University (Japan)

Poster-6. **Synchronous Control of Two Motion Axes Using a Neural Network** 917
Hyun C. Lee and Gi J. Jeon
Kyungpook National University (Korea)

Poster-7. **A Self-Organizing Fuzzy Logic Controller with Hierarchical Structure** 921
Gi J. Jeon*, Dong H. Kim* and Pyeong G. Lee**
*Kyungpook National University (Korea)
**Uiduk University (Korea)

Poster-8. **Automatic Acquisition of Probabilistic Dialogue Models** 925
Kenji Kita and Minoru Sasaki
Tokushima University (Japan)

Poster-9. **Improvement of a Probabilistic CFG Using a Cluster-Based Language Modeling Technique** 929
Kenji kita and Minoru Sasaki
Tokushima University (Japan)

Poster-10. **On the Patterns in Search of Associative Memory by Matching Features** 933
Toshinori Deguchi* and Naohiro Ishii**
*Gifu National College of Technology (Japan)
**Nagoya Institute of Technology (Japan)

Poster-11. **Robust and High Performance Outline Detection of Handwritten Characters from Noisy OCR Images** 937
Itaru Nagayama* and Toshiki Yoshino**
*University of the Ryukyus (Japan)
**University of Tokushima (Japan)

Poster-12. **Elaboration of Structural Learning for Rule Elicitation and Understanding by Neural Network** 941
Taro Ishige, Shoichi Sato, Robert Kozma and Masaharu Kitamura
Tohoku University (Japan)

Poster-13. **Schematic Analysis of Intermittency Chaos in the Fold Map Obtained by Recurrent Neural Network** 945
Itaru Nagayama and Tomio Takara
University of the Ryukyus (Japan)

Poster-14. **Convolution Filter Design Based on Neural Network Learning Algorithm** 949
Keon-Myung Lee*, Joël Favrel** and Hyung Lee-Kwang***
*Park Scientific Instruments (U.S.A.)
**PRISMa (France)
***Korea Advanced Institute of Science and Technology (Korea)

DEMONSTRATION SESSION

Demo-1. **DynaFLIP++: A Knowledge Interpreter That Matches Dynamic Domain Knowledge with Static Fuzzy Constraints** 955
Wolfgang Slany
Technical University of Vienna (Austria)

Demo-2. **Analysis of Anaerobic Fermentation Pathway of *Saccharomyces cerevisiae* with Semi-Algebraic Model by SYMMET (Invited)** 959
Pedro de Atauri*, Raul Curto*, Albert Sorribas**, Naoto Sakamoto*** and Marta Cascante*
*Universitat de Barcelona (Spain)
**Universitat de Lleida (Spain)
***University of Tsukuba (Japan)

Demo-3. **PARSYS — A Tool for Theoretical Analysis of Metabolic Processes (Invited)** 963
Armindo Salvador, João Garcia, João Sousa, Fernando Antunes, Rui Alves and Ruy E. Pinto
Instituto de Investigação Científica Bento da Rocha Cabral (Portugal)

AUTHOR INDEX 967