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Part I: Adaptive Systems

Preface

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Within the field of computational intelligence, *adaptive systems* are often described as novel mathematical and computational methods that have the ability to respond to and be influenced by their environment. Many of the techniques and methods derive their inspiration from nature in the form of artificial neural networks, evolutionary algorithms, particle swarm optimization, bee and ant colony optimization, and natural self-organizing systems, among others. Often, uncertainty and ambiguity of input data and output results are considered, with cooperation and the potential for agent-based interactions between components. Frequently, the key to a successful system is its ability to learn, whether the system is small and simple, large and complicated, or contained within a complex system network. Adaptive systems display these important characteristics, and as a result are providing a new focus and interest for researchers with difficult problems that previously seemed impossible to solve. As the following papers will illustrate, researchers from academia and industry are continuing to develop and utilize complex adaptive systems to solve some of the more challenging problems facing engineers and scientists. Within the 2013 CAS conference, the following broad themes related to adaptive systems are considered:

Machine Learning: To survive, systems must continuously adapt, whether or not those systems are natural or man-made. The ability to adapt allows systems to remain flexible in a changing environment, but still generalize beyond that datasets and environmental cues that were used to learn and create the current perception of reality. Learning is a key to adaption. To this end, conference researchers are using machine learning to design adaptive non-linear kernel filters. Furthermore, in an attempt to search for satisfactory solutions to complex combinatorial problems, meta-heuristic learning methods are being used to strike a balance between exploration and intensification, resulting in the development of an adaptive memory-programming framework. Finally, machine learning that utilizes a support vector machine classification scheme is being sued to predict warm-season rainfall. Details on these developments can be found in the following papers:

- Performance Analysis of Kernel Adaptive Filters Based on LMS Algorithm
- Employing Learning to Improve the Performance of Meta-RaPS

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- Warm-Season Thermodynamically-Driven Rainfall Prediction with Support Vector Machines

Self-Organization, Adaption, and Emergent Behavior: While many systems can learn to adapt, others simply self-organize without direction from historical training data. Within this theme, conference researchers are modelling biological neurons and complex neural dynamics using spiking neural networks, as well as using spiking neural networks to find hidden and evolving patterns in time varying signals. In this spirit, researchers are also using spiking neurons and the Hodgkin-Huxley model to mimic the neuron's electrical properties, in particular, the dynamic behaviour of the olfactory bulb. In other work, the initial positioning of neurons on a Hilbert curve has been used in a classical self-organizing map to provide higher coverage quality with less training epochs, while networks of simple probabilistic graphs have been used to predict emergent swarm behavior. Finally, agent-based modeling and activation were used to study the emergent population behavior of a well-documented model of civil unrest. Details on these developments can be found in the following papers:

- Information-Preserving Transforms: Two Graph Metrics for Simulated Spiking Neural Networks
- Variable Time Delays and Representational Capacity in Sparsely Connected Populations of Spiking Neurons
- Evolving Spike Neural Network Sensors to Characterize the Alcoholic Brain Using Visually Evoked Response Potential
- Biologically Inspired Olfactory Learning Architecture
- Initialization Issues in Self-Organizing Maps
- Predicting Behavior of Robotic Swarms in Search and Tag Tasks
- The Impact of Agent Activation on Population Behavior in an Agent-based Model of Civil Revolt

Evolutionary and Biologically Inspired Optimization: Over the last decade, biologically inspired techniques have been shown to offer new methods for learning and adaption. Nature often provides clues for solving classical problems, especially in the area of optimization, where traditional mathematical and computational techniques have proven ineffective for many challenging problems. As one example of related research, biological inspiration has resulted in the development of a new mutation technique that is used to reduce the search space when an optimizer seeks an optimal value. Multi-scale optimization of systems composed of discrete elements have also been studied using a plus-one-recall store. In another approach, a new optimization algorithm is developed from a novel combination of genetic algorithms and particle swarm optimization. Continuing with evolutionary systems, an assembly line optimization is performed using a multi-objective evolutionary algorithm with a special fitness function strategy. Shifting from evolutionary systems to group behavior has resulted in the development of a novel optimization technique based on the foraging behavior of worker ants within ant colonies, while other research considers a hybrid artificial bee colony algorithm to help solve the flexible job-shop scheduling problem under the constraint of completion time minimization. Finally, a hybrid task allocation strategy, inspired by the biological social behavior of insects, is used for decentralizing groups of mobile agents. Details on these developments can be found in the following papers:

- EA-EMA Optimization Applied to Killer Sudoku Puzzles
- Using the PORS Problems to Examine Evolutionary Optimization of Multiscale Systems
- The Genetic Flock Algorithm
- Multiobjective Evolutionary Algorithm with Strong Convergence of Multi-area for Assembly Line Balancing Problem with Worker Capability
- A Novel Optimization Algorithm Based on the Natural Behavior of the Ant Colonies
- A Hybrid Artificial Bee Colony Algorithm with Local Search for Flexible Job-shop Scheduling Problem
- Ant-Inspired Decentralised Task Allocation Strategy in Groups of Mobile Agents

Mathematical and Computational Approaches for Data Analysis: The correct, or optimal approach to classifying and analyzing data is often the first step to finding problem solutions, and/or advancing the current field of knowledge. With this in mind, a number of research papers are centered on extracting, organizing, and analyzing data. As an example, an effective estimation of a distribution algorithm is used to solve a stochastic job-shop problem utilizing a formulated probability model of operation sequencing, while the theory of imprecise sets is extended by another researcher for fuzzy sets that obey the law of non-contradiction. In other data-based applications of complex adaptive systems, a robust optimization framework is used to improve the managed pressure drilling process for safer and superior drilling operations, while a data mining classifier was constructed that optimally partitions historical versus recent data to study temperature changes over southeastern Australia. Elsewhere, a complex system was designed that integrates advanced machine learning with high performance computing to extract information from large acoustic datasets, while another researcher developed a model to support cyber forensics by utilizing an ontological knowledge base within a document retrieval system. In a different twist, the effects of team-based learning as a policy for statistical learning systems are studied for multi-agent systems when mixed personalities are put together. Finally, transfer function models are used to estimate and study chemical transport in undisturbed soils, while the impact of dispersivity dependency on sampling fraction is also studied. Details on these developments can be found in the following papers:

- Effective Estimation of Distribution Algorithm for Stochastic Job Shop Scheduling Problem
- Toward Theory and Practice of Continuous Imprecise Numbers and Categories
- A H_∞ Control Approach for Oil Drilling Processes
- Classification of Changes in Extreme Heat Over Southeastern Australia
- Using High Performance Computing to Explore Large Complex Bioacoustic Soundscapes: Case Study for Right Whale Acoustics
- Domain Ontology of Hand-Drawn Avatars as Online Self-Representations for Cyber Forensics
- Team-Based Learning and Leadership Effect in Multi-Agent System of Mixed Personalities
- Chemical Transport in Undisturbed Soils Estimated Using Transfer Function Models
- Chemical Dispersivity Affected by Homogenous and Fractal Porous Media

Computational Intelligence for Forecasting and Prediction Applications: Past forecasting and time series problems that appeared too complex, difficult, or even impossible to solve have generated renewed interest when approached with the use of computational intelligence methods. In the area of short-term interest rate forecasting, a fuzzy type-2 neural network with fuzzy clustering and differential optimization was used to predict short-term interest rates, while in another application convolutional neural networks are used for online detection of hockey players from video sequences. Finally, particle swarm optimization, differential optimization, and a firefly algorithm were used to investigate the dynamics of a rotor-stator system with mass imbalance induced rub-impact interactions. Details on these developments can be found in the following papers:

- Type-2 Fuzzy Clustering and a Type-2 Fuzzy Inference Neural Network for the Prediction of Short-Term Interest Rates
- Fast and Reliable Detection of Hockey Players
- On the Investigation of Nonlinear Dynamics of a Rotor with Rub-Impact Using Numerical Analysis and Evolutionary Algorithms