

Computational Intelligence (CI) - Techniques and Applications

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ABSTRACT

Computational Intelligence is the most promising technique which has been introduced in every field for optimized results. Computational Intelligence is a set of processing technique which is capable of handling the real world problems. The aim of this review paper is to analyze computational intelligence feature, various branches of it and detailed study about its wide range of applications is analyzed. Applications of Computational Intelligence discussed in this paper itself shows versatility of computational intelligence in this modern society. Computational intelligence plays major role in the field of research because of its capability of adopting the real world problems and which produces the optimized results.

Keyword: Computational Intelligence, Artificial Neural Networks, Genetic Algorithm, Fuzzy logic, Evolutionary Computation, Expert System, Ant colony and Tabu search

1. INTRODUCTION

Computational Intelligence is a well-recognized paradigm in Intelligent Systems. It impeccably combines three main techniques like granular computing, neural networks and evolutionary optimization, which are intended to develop an Intelligent System. In the design of such systems, there are few challenging issues such as knowledge representation, adaptive properties and learning abilities and structural developments. So, it is a requisite to tackle the issues and develop a new system

Prof. James Bezdek define Computational Intelligence as “A system is computationally intelligent when it deals with only numerical (low level) data, has pattern recognition components, does not use knowledge in the Artificial Intelligence sense; and additionally when it (begins to) exhibit i) computational adaptivity, ii) computational fault tolerance, iii) speed approaching human-like turnaround and iv) error rates that approximate human performance”.

2. CHARACTERISTICS OF COMPUTATIONAL INTELLIGENCE

- Learning
- Planning
- Recognition
- Classification

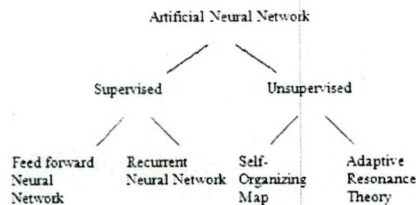
3. TECHNIQUES OF COMPUTATIONAL INTELLIGENCE

Various computational intelligence techniques are discussed below

3.1 Artificial Neural Networks (ANN)

An information processing pattern which is motivated for the brain is a biological nervous system. Much number of interconnected processing elements which gives a narrative structure is the important component. In the year 1949, Hebb introduced a training algorithm that explains about a network of neurons which reveals learning behavior is a preliminary process of Artificial Neural Network (ANN). Noisy and variable information can be

handled with its own capability. Artificial neural network is classified into two types such as supervised learning and unsupervised learning. Supervised learning is further classified into two types Feed forward Neural Network and Recurrent Neural Network. Unsupervised learning is classified into two such as Self-Organizing Map and Adaptive Resonance Theory (ART). [1][4] [5]



3.2 Genetic Algorithms

Genetic Algorithm is introduced by John Holland at University of Michigan in the year 1970. Genetic algorithm is one of the classes of evolutionary algorithm which helps to handle the optimization problems such as inheritance, mutation, selection and crossover. Genetic algorithm can be explained as problem solver, technical puzzle, basis for machine learning, while searching for parameter it employs the objective function. [1] [8] [9]

3.3 Fuzzy Logic

In the year 1965, fuzzy logic was developed by Lotfi A. Zadeh to address the engineering problems. Later in the year 1979, in order to solve the problems with the power system fuzzy logic is introduced. According to classical set theory, an element of the universe may or may not belong to the set. Generalization of this theory can be taken as Fuzzy theory. It can be used to handle the values ranging between completely truths and completely false. The association of an element can be varying continuously in Fuzzy theory. Fuzzy set is nothing but a membership function from the universe of discourse to the closed interval. It is the similarity between any elements in the universe of discourse with a fuzzy subset. Generally used membership functions are triangular, trapezoidal, piecewise-linear and Gaussian functions. It was designed considering the requirements and drawbacks of the problem. Put together, the logic implements human experiences and preferences via membership functions and fuzzy rules [1][4][5].

3.4 Evolutionary Computation: Evolutionary Strategies and Evolutionary Programming

Evolutionary computation is a field extension of computational intelligence stands as the concern for combinatorial optimization problems. The computation was introduced by Lawrence J. Fogel based on Darwin's principle on "survival of the fittest strategy". The survival of the fittest is the biological evolution such as Reproduction, mutation, recombination and natural selection.

A hypothetical population-based optimization process is a natural evolution. Simulation of the process on a computer results in stochastic optimization techniques that will mostly perform better than classical methods of optimization for real-world problems. Initializing a population of solutions to a problem is the beginning of evolutionary computation. Randomly varying the initial population creates new solutions. These solutions are measured with how well they address the task. The final step is to apply a selection criterion to weed out those solutions which are below the standard. Until a specific criterion is met these steps are repeated. The benefits of the computation is adaptability to change and ability to generate good enough solutions but that has to be understood in relation to computing requirements and convergence properties. The computation can be further subdivided into GA, Evolution Strategies, Evolutionary Programming (EP), Genetic Programming, Classified Systems, Simulated Annealing (SA), etc. Fraser reported the first work in the field of evolutionary computation in 1957 to study the aspects of genetic system using a computer. Later on a number of evolutionary inspired optimization techniques were developed. Evolution strategies (ES) employs real-coded variables and the original form of it relied on mutation as the search operator and a population size of one. From that time it has evolved to share many features with GA. The biggest similarity between these two types of algorithms is that they both maintain populations of potential solutions and use a selection mechanism for choosing the best individuals from the population [1] [4] [5].

3.5 Expert System

The first successful artificial intelligence software is known as Expert System. Bruce Buchanan, Edward Shortliffe, Randall Davis, William vanMelle, Carl Scott are the key persons who is responsible. It is first developed in the year 1970 and expanded later in the year 1980. In order to solve complex problem expert system is developed to give solutions like an expert. It widely differs from traditional programs with its exclusive construction. It has two components in it and they are inference engine and knowledge base. They are inter-related with each other. Teaching

ability, accessibility, capability of knowledge to make use of, dependability, measurable, etc., are some of the advantages furnished by an expert system, [8].

3.6 Ant Colony and Tabu Search

Marco Dorigo in the year 1992 developed an optimization algorithm to solve the computational problems using graph for finding the best path like an ant searching for food in its colony and is known as Ant Colony Search (ACS). In a transmission network, the shortest path can be found out using ACS. Ant Colony Optimization can be extended as Elitist ant system, Max-Min ant system, Ant Colony System, Rank-based ant system, Continuous orthogonal ant colony, Ant Colony Optimization with Fuzzy Logic. Static and dynamic are the two assessment methods used for searching in Ant Colony Optimization. For mathematical optimization, Tabu search is introduced by Fred W. Glover as a local search method in the year 1986 but described in the year 1989. It also provides solution for combinatorial optimization problems. Whenever the Tabu search searches for a solution it ensures for improved solution by checking the direct neighbor. The accomplishment of the Tabu search can be done by using the memory structure so that there will be a clarity about the visited solution and some set of rules framed by user. Short-term, intermediate term and long term are various categories of memory structure. The Tabu list will maintain the list of information that indicates about the existing visit and stores unwanted messages also. Apart from this process two other parameters that are considerations are Aspiration and Diversification.

4. APPLICATIONS OF COMPUTATIONAL INTELLIGENCE

Computational Intelligence can be used for many applications. They are:

4.1 Fingerprint Identification

Asker M. Bazen and Sabih H. Gerez(2000) in this research work clearly state the capability of image exploring agent using genetic programming helps to detect features ridges, valleys and minutiae of fingerprints.

4.2 Data Mining

Janos Abonyi et.al, (2004) has said that computational Intelligence based data mining method are for feature selection, feature extraction, model optimization and model reduction. In their research work, they have used process of knowledge discovery which consists of nine steps. They are

Developing and understanding the application domain, Creating target data set, Data cleaning and preprocessing, Data reduction and projection, Matching the goals of the KDD process, Choosing the data mining algorithm, Data mining, Interpreting mined patterns and Consolidating discovered knowledge. The Wine data is widely applied for comparing the capabilities of different data mining tools. They have suggested that these tools can be applied in a synergistic manner through the nine steps of knowledge discovery.

4.3 Process Optimization for Tandem Cold Rolling

D. D. Wang and A. K. Tieu, (2005) say, to reduce the power distribution cost, maximize the safe level of strip tension, and obtain good strip shape achieved through computational intelligence. Optimal rolling scheduling method is introduced, which aims at achieving uniform power distribution, maximum safe level of strip tension and good flatness. They have declared that the proposed GA-based optimization approach have the potential to improve the empirical schedules for tandem cold rolling mills and clearly states that it is applicable to other engineering problems and can be used as reliable heuristic knowledge.

4.4 Computational Intelligence in Games

Risto Miikkulainen, (2006) says that methods such as control, coordination, decision making, and optimization, with severe uncertainty, material and time constraints are the existing challenges in the field of games using computational intelligence. For video game applications, Neuroevolution is a hopefully new technology for making them more fascinating, demanding, and to develop new game which is realistic.

4.5 Computational Intelligence in critical Infrastructure: Network Security, Robotics and System Modeling Enhancements

Ondrej Linda, (2009) presented that modern critical infrastructure is being computerized and automated due to the field of information technology. Network Security, Robotics and System Modeling Enhancements are concentrated in this research work. For network security the artificial neural networks is used for anomaly based intrusion detection system. A new architecture is developed by combining swarm behavior model with fuzzy logic control for making single-operator control system in an effective manner for emergency response from multi-robot system. Support vector machine is used to develop an algorithm for autonomous navigation of mobile robots.

4.6 Digital Steganalysis

Roshidi Din and Azman Samsudin (2009), have done an analysis on Steganalysis and it is divided into three types such as image steganalysis, audio steganalysis, and video steganalysis. They have suggested an algorithm including three computational Intelligence methods as bayesian, neural network, and genetic which suits steganalysis. The detailed study on computational intelligence, steganalysis have been done and hybrid systems are also analyzed. Some of the counter attack tools GA based methodology for breaking the steganalytic and secure steganographic encoding based on OutGuess is introduced. Finally they concluded that computational intelligence can be used effectively in steganalysis field.

4.7 Analysis of Friction Measurements

Dimitris Voukantsis et.al. (2010) in their research work aim to apply computational intelligence to analyze tribological data collected during a wear experiment, to demonstrate experimental result description and knowledge extraction. Computational intelligence methods such as Principal Component Analysis and Artificial Neural Network are used to evaluate the capability of modeling the performance of the friction coefficient. They declare that the application was successful and justified that it can be used for parameter selection concerning the construction of prediction/now-casting models for the friction coefficient.

4.8 Emerging power systems

D. Saxena, et.al, (2010), proposed a detailed study on applications and areas of power systems which can utilize computational intelligence which is evaluated in a detailed manner in their research work. Various computational intelligence techniques are discussed briefly. The applications of power system are Power system operation, planning, control, automation, power plant control, network control, electricity markets, Distribution system application, generation application and Forecasting application.

4.9 Intrusion Detection System

Shelly Xiaonan Wu (2010), proposes the consequence methods of computational intelligence including artificial neural networks, fuzzy systems, evolutionary computation, artificial immune systems, swarm intelligence and soft computing which are evaluated and correlated with one another in order to know the research challenges of the past and the future. This work also provides the description of features of the computational intelligence such as

adaptation, fault tolerance, high computational speed and error resilience in the face of noisy information enabling to develop a intrusion detection model.

4.10 Computer Security and Forensics

Sulaiman Al amro, (2011) presented a review on applying neural networks, fuzzy logic, and evolutionary computation to assess their use in computer security and forensics. The capabilities of the hybrid techniques are also discussed and their analysis states that hybrid system affords better results compared to original techniques. In computer security and forensics, fuzzy logic has shown its potential noticeably.

4.11 Life Sciences

Udo Seffert, et.al, (2011) points out the challenges in life sciences context of high-throughput processing to handle the high frequency of incoming data and its high-dimensionality by means of a large number of measured features and in life science supporting systems as the interface to the domain expert. For several years, biological and biomedical problems are handled using computational intelligence. Preprocess, models and analysis can be done using computational intelligence prospective.

V. CONCLUSION

Computational Intelligence has become important in solving many real-time applications. The possibilities of usage of various branches of computational intelligence techniques and applications are also reviewed in this paper.

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BIOGRAPHIES



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