

# An Overview of Computational Intelligence

N. Malathi Rao <sup>1</sup>, K J Sarma <sup>2</sup>

Siddhartha Institute of technology and Sciences,  
Narapally, Hyderabad, India

1. [Nmalathirao@yahoo.co.in](mailto:Nmalathirao@yahoo.co.in), 2. [jskalavendi@gmail.com](mailto:jskalavendi@gmail.com)

**ABSTRACT:** It has been the endeavor of the scientists and technologists to investigate and design systems which perform like human beings. Indeed, the characteristic of "intelligence" is usually attributed to humans. More recently, many products and items also claim to be "intelligent", an attribute which is directly linked to the reasoning and decision making. **Computational intelligence (C.I.)** is a set of nature-inspired computational methodologies and approaches to address complex real-world problems to which mathematical or traditional modeling can be useless for a few reasons: the processes might be too complex for mathematical reasoning, it might contain some uncertainties during the process, or the process might simply be stochastic in nature.

Computational intelligence techniques and their applications are fast-growing with attention & tremendous effort by researchers over the years. It brings together many different aspects of the current research on intelligence technologies such as neural networks, support vector machines, fuzzy logic and evolutionary computation, and covers a wide range of applications from pattern recognition and system modeling, to intelligent control problems and biomedical applications. It would interesting to study theoretical foundations which have been carried and also both theoretical & practical applications. Computational intelligence could be used to obtain the solutions in scientific and commercial application areas. The aim of this paper has been to circumvent briefly the classification and applications studies.

**Key words:** *computational intelligence, fuzzy logic systems, evolutionary computation, Artificial Intelligence, Genetic Algorithms, Particle swarm Optimization, Applications.*

## I. INTRODUCTION:

Scientific problem solving stems from the acquisition of knowledge from a specific environment, the manipulation of such knowledge, and the intervention in the real world with the manipulated knowledge. The more exhaustive and better structured the knowledge base, the more it emulates a scientific advancements and therefore the easier the solution is to explore more scientific problems with adequate interpretations. As its history proves, computational intelligence is not just about robots. It is also about understanding the nature of intelligent thought and action using computers as experimental devices.

The IEEE Computational Intelligence Society included new areas of interest such as fuzzy systems and evolutionary computation, which they related to Computational Intelligence in 2011.

Computers have been used for better understanding and interpretation of process behavior based on the available information to obtain input-output mapping and decision making. The utilization of expert (operator) knowledge, ability to use imprecise, uncertain information, integration of knowledge over multiple disciplines, automated machine learning inspired from nature (neuroscience, genetics, behavioral science), development of models for optimizing the system performance satisfying the inherent system/process constraints. CI is something in which Intelligence is built in computer programs. The first clear definition of Computational Intelligence was introduced by Bezdek in 1994: a system is called computationally intelligent if it deals with low-level data such as numerical data, has a pattern-recognition component and does not use knowledge in the AI sense, and additionally when it begins to exhibit computational adaptively, fault tolerance, speed approaching human-like turnaround and error rates that approximate human performance. According to Bezdek (1994), Computational Intelligence is a subset of

Artificial Intelligence. The artificial one based on hard computing techniques and the computational one based on soft computing method, which enable adaptation to many situations.

Artificial Intelligence and Computational Intelligence seek a similar long-term goal: reach general intelligence, which is the intelligence of a machine that could perform any intellectual task that a human being can; there's a clear difference between them. According to Bezdek (1994), Computational Intelligence is a subset of Artificial Intelligence.

There are two types of machine intelligence 1. The artificial one based on hard computing techniques and 2. The computational one based on soft computing methods, which enable adaptation to many situations.

The main applications of Computational Intelligence include computer science, engineering, data analysis and bi-medicine. In the following we try to classify the application areas and analyse where and how of using C.I. This broadly covers Evolutionary computing, Fuzzy computing, neuro-computing and soft computing. Computational Intelligence is thus a way of performing like human beings. Indeed, the characteristic of "intelligence" is usually attributed to humans. More recently, many products and items also claim to be "intelligent", an attribute which is directly linked to the reasoning and decision making.

## II. TECHNOLOGIES:

Basically Computational intelligence techniques include artificial Intelligence (AI) techniques [ artificial Neural Networks (ANNs), fuzzy Logic (FL), support Vector Machines (SVM), Self Organizing Maps (SOM) (unsupervised) ] ; genetic Algorithms (GA), genetic Programming (GP) and swarm Intelligence or particles swarm optimization (PSO).

CI also makes use of ANN consisting of multi-layer Perceptron concept (MLP), radial Basis Function (RBF), and probabilistic Neural Networks (PNN). Also fuzzy Logic & ANN techniques makes use of adaptive neuro-fuzzy inference system (ANFIS).

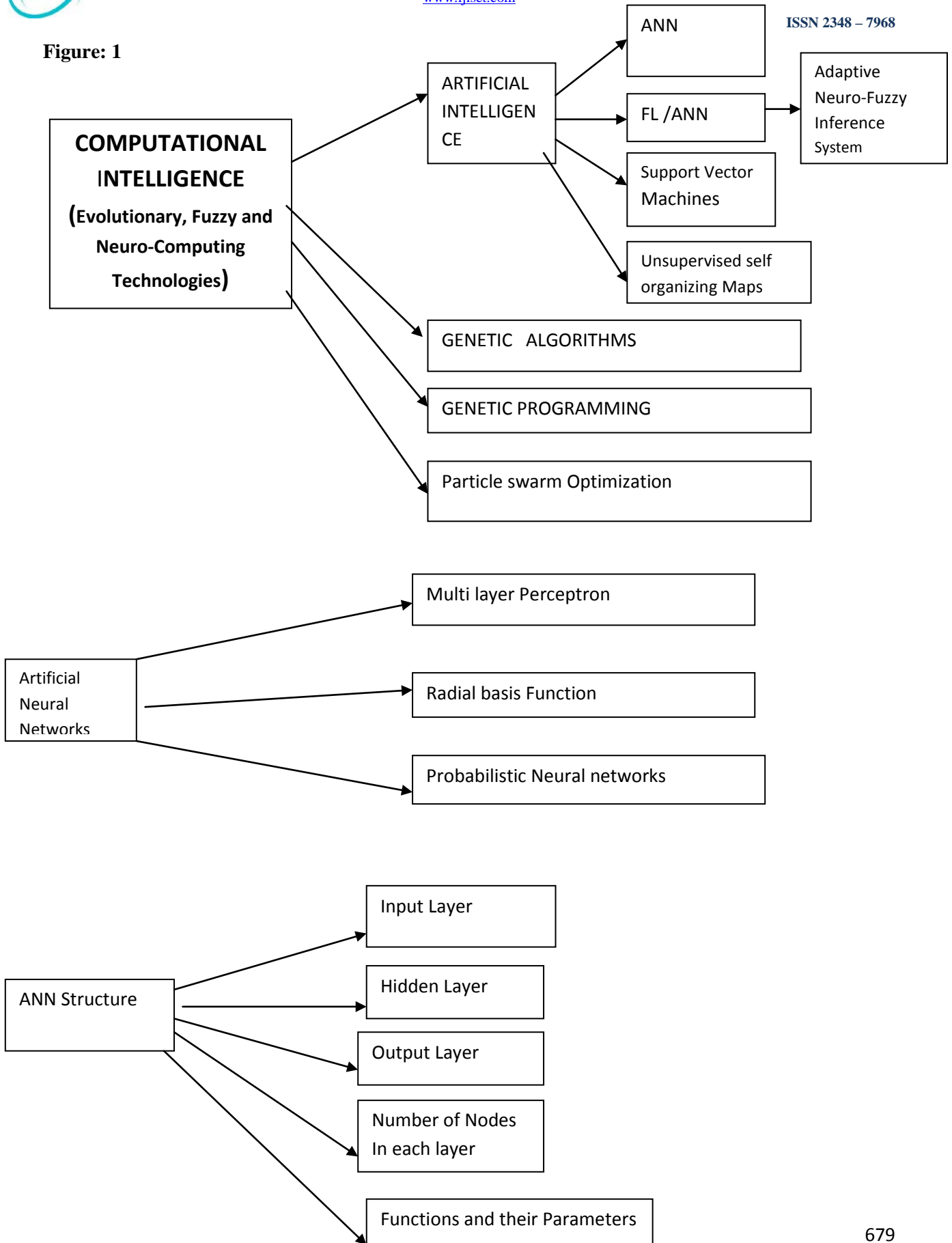
The ANN structure consists of an input layer, hidden Layer (s), Output layer, number of nodes in each layer and functions and their parameters.

The steps of fuzzy logic approach are Fuzzification using membership functions (MFs)-input, generation of rule base, aggregation and De-fuzzification using MFs –output. The input-output of membership functions need number, type, parameters and a rule base. The Neuro-fuzzy system combines the procedures of fuzzy logic (FL) and ANNs. This actually starts with an initial FL structure. Further the Neuro fuzzy system also uses ANN for adapting the FL (MF) parameters and the rule base to the training data.

The *Genetic algorithms* contain the steps 1. Construction of genome (individual), 2. Generation of initial population (group of individuals), 3. Evaluation of individuals, 4. Selection of individuals based on criteria, 5. Generation of new individuals (Mutation, Crossover) 6. Repetition of the process - generation, evaluation, selection, 7. Termination of the process based on max generation no. and/or performance criteria.

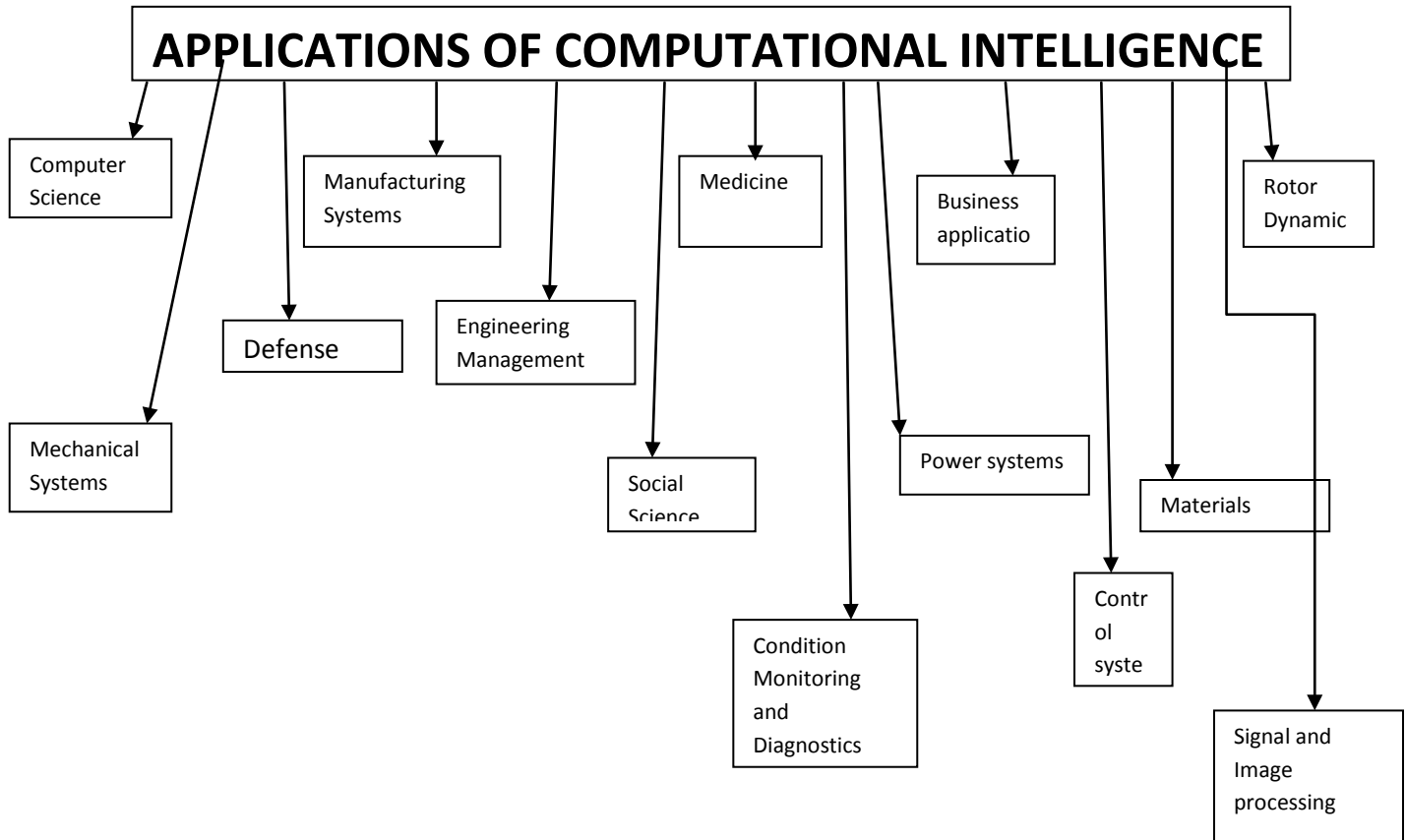
Sometimes we may use combinations where in we Combine advantages of GA and other classifiers, GA and ANN, GA and ANFIS, GA and SVM, automatic selection of classifier structure and parameters, Selection of most important system features from a pool, Selection of most important sensors (in the context of on-line condition monitoring and diagnostics)- sensor fusion. In fact automatic selection of classifier structure and parameters consist of ANNs -Number of neurons in hidden layer, ANFIS - Number of MFs and their parameters and SVM parameters.

Figure: 1



*Genetic Programming (GP)* is a branch of GA with a lot of similarities. The main difference of GP and GA is in the representation of the solution. In GA the output is in form of a string of numbers representing the solution. GP produces a computer program in the form of a tree-based structure[ relating to the inputs or leaves, the mathematical functions (nodes) and the output (root node)].

**Figure 2: COMPUTATIONAL INTELLIGENCE APPLICATIONS INCLUDE**



### III. APPLICATIONS:

The main applications of C.I. include computer science, engineering, data analysis and bio-medicine. One must gain a good knowledge of the principles of C.I. like Fuzzy Logic, Neural Networks, Evolutionary computation, Learning Theory and Probabilistic methods to justify his process of research.

CI is responsible for solutions and decision making in several branches of science, engineering, business and management. There are many applications in Computer science, Mechanical systems, manufacturing systems, Engineering management, Medicines, social science and business. More specifically: 1. *Computer Science applications* pertain to Pattern Recognition (PR), NLP, speaker verification, Data Mining, Knowledge Discovery / Machine Learning, Feature Extraction and Selection. 2. *Mechanical systems* in which Condition monitoring and diagnostics, air pollution modeling, heating, ventilating, and air conditioning, Multi-objective optimization in design, Control System Design. 3. *Manufacturing Systems* dealing with Development of data-driven models, Multi-objective optimization of machining parameters. 4. *Engineering management* areas like Inventory management, Project selection, Facility layout design, Scheduling. 5. *Patient monitoring* related to medicine, gene regulatory

networks, molecular biology, kernels on protein structures, teaching & learning processes and also in business, economics and management.

Besides the above areas some other computer science applications of C.I. are in system modeling and simulations, network security, intrusion detection, robotics, modeling and optimization, multimedia processes, time series forecasting & power engineering

#### IV. RECENT STUDIES:

More recently there have been studies related to Machine Condition Monitoring and Diagnostics which use combinations of the techniques ANNs-MLP, RBF, PNN; SVM; ANFIS; GA-ANN; GA-ANFIS; GA-SVM; GP. Problems involving signal processing feature extraction, selection and sensor fusion have been studied. There have been applications related to the design of Rotor dynamics and Control System Design.

Also some of the mechanical engineering problems use ANN based estimation of fatigue life, Modeling of material properties in terms of heat treatment parameter, Intelligent Manufacturing Systems, Development of Tool Wear Model, Development of machined surface roughness model, Mutli-objective optimization of machining parameters, etc.

For the basics relating to computational intelligence one can make a thorough study of information in [ 1 ]. A good amount of theory can be found in Reusch, Bernd (Ed.) [19 ], Madarász, Ladislav, Živčák, Jozef (Eds.) [20], Introduction to computational Intelligence by Andries P. Engelbrecht, General principles and purpose of computational Intelligence by Leonid Reznik.

More recent studies relating to applications of Computational intelligence and Robotics refer to Ivan Giannoccaro [ 13 ]. Applications of C.I. in Power systems deal with solving the power system design, planning, operation and control problems. [ 15 ]. More recently studies are made in Granular Computing, Logic Processing, Abstraction and Linguistic Analysis of Conventional Numerical Dynamic Systems, Learning algorithms, Statistical Machine Learning, Hybrid PSO-EA Algorithm Recurrent Neural Networks for Challenging Problems, Modular Wavelet-Fuzzy Networks, Ant Colony Algorithms, Computational Complexities of Combinatorial Problems with Applications to Reverse Engineering of Biological Networks, Algorithms with Application, Adaptation and Predictive Control Observed in Neuromuscular Control Systems, for Under-actuated Systems one may see Fei-Yue Wang and Derong Liu [14 ]. Application of C.I. in defense and security [18 ], militarized conflict modeling [17 ] also have been studied C.I. Techniques are used in Modeling and Prediction in engineering [16].

#### V. CONCLUSIONS:

C.I. is gaining more popularity in respect of integrating capability over multiple disciplines, Capability of incorporating imprecision and uncertainty, suitability for hard-to-model processes /systems. The new applications of using computational intelligence and soft computing are still in development. Although computational intelligence and soft computing are established fields, the new applications of using computational intelligence and soft computing can be regarded as an emerging field, Better alternative to traditional hard computing scenario.

Currently popular approaches include biologically inspired algorithms such as swarm intelligence and artificial immune systems, which can be seen as a part of evolutionary computation, image processing, data mining, natural language processing, and artificial intelligence, which tends to be confused with Computational Intelligence. But although both Computational Intelligence (CI) and Artificial Intelligence (AI) seek similar goals, there's a clear distinction between them. In brief computational intelligence, can improve intellectual behavior of machines or complex systems.

## VI. REFERENCES

1. Computational intelligence - Wikipedia, the free encyclopedia, <https://en.wikipedia.org/wiki/>
2. Włodzisław Duch, What is Computational Intelligence and what could it become? . cogprints.org/5358/1/06-CIdef.pdf,
3. Ondrej Linda, Applications of Computational Intelligence In Critical Infrastructures: Network Security, Robotics, And System Modeling Enhancements, July 2009, University of Idaho.
4. D. Saxena , S.N. Singh and K.S. Verma; Application of computational intelligence in emerging power systems International Journal of Engineering, Science and Technology Vol. 2, No. 3, 2010, pp. 1-7.
5. Kevin E. Voges, Nigel Pope.( editors) ; Business Applications and Computational Intelligence, <https://books.google.co.in/books?isbn=1591407044> Kevin E. Voges, Nigel Pope – 2006.
6. Ali, Shawkat, Multidisciplinary Computational Intelligence Techniques: <https://books.google.co.in/books?isbn=1466618310>. - 2012
7. Shi, Yuhui , Recent Algorithms and Applications in Swarm Intelligence <https://books.google.co.in/books?isbn=1466624809> - 2012
8. Ladislav Madarász, Jozef Živčák ( editors) , Aspects of Computational Intelligence: Theory and Applications: . <https://books.google.co.in/books?isbn=3642306683>; 2012.
9. NP Belfiore, Applications of computational intelligence to mechanical engineering , [ieeexplore.ieee.org/xpls/abs\\_all.jsp?arnumber=7028702](http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=7028702), 2014 .
10. Yong-Hua Song, Johns, **Allan**, Aggarwal, Raj Computational Intelligence Applications to Power Systems , [www.springer.com/gp/book/9780792340751](http://www.springer.com/gp/book/9780792340751).
11. Tomasz G. Smolinski, Mariofanna G. Milanova, Aboul-Ella Hassanien ; Vol. 1: Applications of Computational Intelligence in Biology: Current Trends and Open Problems, Vol. 2: Computational Intelligence in Biomedicine and Bioinformatics: Current Trends and ; Application [www.biology.emory.edu/research/Prinz/Tomasz/ClinBiology/CfC.html](http://www.biology.emory.edu/research/Prinz/Tomasz/ClinBiology/CfC.html)..
12. Ivan Giannoccaro . Advances in computational intelligence and robotics,
13. **Fei-Yue Wang (The University of Arizona, USA), Derong Liu (University of Illinois at Chicago, USA. Advances in Computational Intelligence: Theory and Applications 2014.**
14. Saman K. Halgamuge, Lipo Wang. ,, Computational Intelligence for Modeling and Prediction,
15. Tshilidzi Marwala, Monica Lagazio; Militarized Conflict Modeling Using Computational Intelligence, Springer
16. Rami Abielmona, Rafael Falcon, Nur Zincir-Heywood, Hussein A. Abbass., Recent Advances in Computational Intelligence in Defense and Security, Springer
17. Reusch, Bernd (Ed.), Computational Intelligence, Theory and Applications; International Conference 9th Fuzzy Days in Dortmund, Germany, Sept. 2006.
18. **Madarász, Ladislav, Živčák, Jozef (Eds.); Aspects of Computational Intelligence: Theory and Applications, Revised and Selected Papers of the 15th IEEE International Conference on Intelligent.**
19. The Birth and historical Development of Computational Intelligence applications in archeology. Archeologia e Calcolatori, 20, 2009, 95-109.
20. Andries P. Engelbrecht , Computational Intelligence - An Introduction Wiley , 2007.