Quo vadis, computational intelligence?

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Abstract. What are the most important problems of computational intelligence? A sketch of the road to intelligent systems is presented. Several experts have made interesting comments on the most challenging problems.

1   Introduction.

In the introduction to the "MIT Encyclopedia of Cognitive Sciences" M. Jordan and S. Russell [33] used the term "computational intelligence" to cover two views of artificial intelligence (AI): engineering and empirical science. Traditional AI started as an engineering discipline concerned with the creation of intelligent machines. Computational modeling of human intelligence is an empirical science. Both are based on computations.

Artificial Intelligence (AI) has established its identity quite early, during the Dartmouth conference in 1956 [6]. It had clearly defined goals, exemplified by great early projects, such as the General Problem Solver of Simon and Newell. There are many definitions of AI [48,64], for example: "... the science of making machines do things that would require intelligence if done by humans" (Marvin Minsky), "The study of how to make computers do things at which, at the moment, people are better" [48]. In essence AI tries to solve problems for which effective algorithms do not exist, using knowledge–based methods.

In the 1970-ties AI has contributed to the development of cognitive science and to the goal of creating "unified theories of cognition", as Allen Newell called it. Ambitious theories of high cognitive functions were formalized by John Anderson in his Act* theory [3], and by Newell and his collaborators in the Soar theory [43]. Both were very successful and led to many practical (and commercial) applications. In the last decade intelligent agents become the focus of AI, entities that can perceive and act in a rational goal directed way to achieve some objectives.

Machine learning has been important from the beginning in AI. Samuel's checker-playing system (1959) learned to play far superior checkers than its creator. Although initially research on perceptrons has developed as a part of AI in the late 1950-ties machine learning became preoccupied with inductive, rule based knowledge [50]. AI development has always been predominately concerned with high-level cognition, where symbolic models are appropriate.

Quo Vadis Computational Intelligence

Werner Weber,Jan Rabaey,Emile H.L. Aarts

Quo Vadis Computational Intelligence:

Machine Intelligence: Quo Vadis? Peter Sincak,Kaoru Hirota,Jan Vascak,2004-04-19 This book brings together the contributions of leading researchers in the field of machine intelligence covering areas such as fuzzy logic neural networks evolutionary computation and hybrid systems There is wide coverage of the subject from simple tools through industrial applications to applications in high level intelligent systems which are biologically motivated such as humanoid robots and selected parts of these systems like the visual cortex Readers will gain a comprehensive overview of the issues in machine intelligence a field which promises to play a very important role in the information society of the future *Quo Vadis Computational Intelligence?* Peter Sincak,Jan Vascak,2000-08-16 Computational intelligence integrates fields like neural networks fuzzy systems evolutionary computation and intelligent systems in general The new trends consist in the cooperation of various techniques into hybrid intelligent systems This multi author book with contributions from leading scientists as G Carpenter L Zadeh K Fukushima N Kasabov K Hirota H Takagi H Adeli B Igelnik L Koczy J Kacprzyk C Moraga T Gedeon and many others presents interesting and promising aspects of the future of computational intelligence as an important part of intelligent information systems With a foreword written by J Bezdek who first published the notion of computational intelligence Machine Intelligence. 1- ,1967 *Computational Intelligence in Intelligent Data Analysis* Christian Moewes,Andreas Nürnberger,2012-08-23 Complex systems and their phenomena are ubiquitous as they can be found in biology finance the humanities management sciences medicine physics and similar fields For many problems in these fields there are no conventional ways to mathematically or analytically solve them completely at low cost On the other hand nature already solved many optimization problems efficiently Computational intelligence attempts to mimic nature inspired problem solving strategies and methods These strategies can be used to study model and analyze complex systems such that it becomes feasible to handle them Key areas of computational intelligence are artificial neural networks evolutionary computation and fuzzy systems As only a few researchers in that field Rudolf Kruse has contributed in many important ways to the understanding modeling and application of computational intelligence methods On occasion of his 60th birthday a collection of original papers of leading researchers in the field of computational intelligence has been collected in this volume Computational Intelligence in Games Norio Baba,2012-08-11 The most powerful computers in the world are not only used for scientific research defence and business but also in game playing Computer games are a multi billion dollar industry Recent advances in computational intelligence paradigms have generated tremendous interest among researchers in the theory and implementation of games Game theory is a branch of operational research dealing with decision theory in a competitive situation Game theory involves the mathematical calculations and heuristics to optimize the efficient lines of play This book presents a sample of the most recent research on the application of computational intelligence techniques in games This book contains 7 chapters The first chapter by Chen Fanelli Castellano and Jain is an introduction to

computational intelligence paradigms It presents the basics of the main constituents of compu tational intelligence paradigms including knowledge representation probability based approaches fuzzy logic neural networks genetic algorithms and rough sets In the second chapter Chellapilla and Fogel present the evolution of a neural network to play checkers without human expertise This chapter focuses on the use of a population of neural networks where each network serves as an evaluation function to describe the quality of the current board position After only a little more than 800 generations the evolutionary process has generated a neural network that can play checkers at the expert level as designated by the u s Chess Federation rating system The program developed by the authors has also competed well against commercially available software **Data Mining and Computational Intelligence** Abraham Kandel,Mark Last,Horst Bunke,2013-11-11 Many business decisions are made in the absence of complete information about the decision consequences Credit lines are approved without knowing the future behavior of the customers stocks are bought and sold without knowing their future prices parts are manufactured without knowing all the factors affecting their final quality etc All these cases can be categorized as decision making under uncertainty Decision makers human or automated can handle uncertainty in different ways Deferring the decision due to the lack of sufficient information may not be an option especially in real time systems Sometimes expert rules based on experience and intuition are used Decision tree is a popular form of representing a set of mutually exclusive rules An example of a two branch tree is if a credit applicant is a student approve otherwise decline Expert rules are usually based on some hidden assumptions which are trying to predict the decision consequences A hidden assumption of the last rule set is a student will be a profitable customer Since the direct predictions of the future may not be accurate a decision maker can consider using some information from the past The idea is to utilize the potential similarity between the patterns of the past e g most students used to be profitable and the patterns of the future e g students will be profitable *Computational and Ambient Intelligence* Francisco Sandoval,Alberto Prieto,Joan Cabestany,Manuel Graña,2007-09-21 This book constitutes the refereed proceedings of the 9th International Work Conference on Artificial Neural Networks IWANN 2007 held in San Sebasti n Spain in June 2007 Coverage includes theoretical concepts and neurocomputational formulations evolutionary and genetic algorithms data analysis signal processing robotics and planning motor control as well as neural networks and other machine learning methods in cancer research *Artificial General Intelligence 2008* P. Wang,B. Goertzel,S. Franklin,2008-02-18 The field of Artificial Intelligence AI was initially directly aimed at the construction of thinking machines that is computer systems with human like general intelligence But this task proved more difficult than expected As the years passed AI researchers gradually shifted focus to producing AI systems that intelligently approached specific tasks in relatively narrow domains In recent years however more and more AI researchers have recognized the necessity and the feasibility of returning to the original goal of the field Increasingly there is a call to focus less on highly specialized narrow AI problem solving systems and more on confronting the difficult issues involved in

creating human level intelligence and ultimately general intelligence that goes beyond the human level in various ways Artificial General Intelligence AGI as this renewed focus has come to be called attempts to study and reproduce intelligence as a whole in a domain independent way Encouraged by the recent success of several smaller scale AGI related meetings and special tracks at conferences the initiative to organize the very first international conference on AGI was taken with the goal to give researchers in the field an opportunity to present relevant research results and to exchange ideas on topics of common interest In this collection you will find the conference papers full length papers short position statements and also the papers presented in the post conference workshop on the sociocultural ethical and futurological implications of AGI

Artificial Intelligence and Soft Computing Leszek Rutkowski,Marcin Korytkowski,Rafal Scherer,Ryszard Tadeusiewicz,Lotfi A. Zadeh,Jacek M. Zurada,2015-06-04 The two volume set LNAI 9119 and LNAI 9120 constitutes the refereed proceedings of the 14th International Conference on Artificial Intelligence and Soft Computing ICAISC 2015 held in Zakopane Poland in June 2015 The 142 revised full papers presented in the volumes were carefully reviewed and selected from 322 submissions These proceedings present both traditional artificial intelligence methods and soft computing techniques The goal is to bring together scientists representing both areas of research The first volume covers topics as follows neural networks and their applications fuzzy systems and their applications evolutionary algorithms and their applications classification and estimation computer vision image and speech analysis and the workshop large scale visual recognition and machine learning The second volume has the focus on the following subjects data mining bioinformatics biometrics and medical applications concurrent and parallel processing agent systems robotics and control artificial intelligence in modeling and simulation and various problems of artificial intelligence *Computational Intelligence in Emerging Technologies for Engineering Applications* Orestes Llanes Santiago,Carlos Cruz Corona,Antônio José Silva Neto,José Luis Verdegay,2020-02-14 This book explores applications of computational intelligence in key and emerging fields of engineering especially with regard to condition monitoring and fault diagnosis inverse problems decision support systems and optimization These applications can be beneficial in a broad range of contexts including water distribution networks manufacturing systems production and storage of electrical energy heat transfer acoustic levitation uncertainty and robustness of infinite dimensional objects fatigue failure prediction autonomous navigation nanotechnology and the analysis of technological development indexes All applications mathematical and computational tools and original results are presented using rigorous mathematical procedures Further the book gathers contributions by respected experts from 22 different research centers and eight countries Brazil Cuba France Hungary India Japan Romania and Spain The book is intended for use in graduate courses on applied computation applied mathematics and engineering where tools like computational intelligence and numerical methods are applied to the solution of real world problems in emerging areas of engineering , **Algorithms in Ambient Intelligence** W. Verhaegh,Emile Aarts,Jan Korst,2013-03-09 The advent of

the digital era the Internet and the development of fast com puting devices that can access mass storage servers at high communication bandwidths have brought within our reach the world of ambient intelligent systems These systems provide users with information communication and entertainment at any desired place and time Since its introduction in 1998 the vision of Ambient Intelligence has attracted much attention within the re search community Especially the need for intelligence generated by smart al gorithms which run on digital platforms that are integrated into consumer elec tronics devices has strengthened the interest in Computational Intelligence This newly developing research field which can be positioned at the inter section of computer science discrete mathematics and artificial intelligence contains a large variety of interesting topics including machine learning con tent management vision speech data mining content augmentation profiling contextual awareness feature extraction resource management security and privacy **Hardware Implementation of Intelligent Systems** Horia-Nicolai Teodorescu,Abraham Kandel,2013-11-11 Intelligent systems are now being used more commonly than in the past These involve cognitive evolving and artificial life robotic and decision making systems to name a few Due to the tremendous speed of development on both fundamental and technological levels it is virtually impossible to offer an up to date yet comprehensive overview of this field Nevertheless the need for a volume presenting recent developments and trends in this domain is huge and the demand for such a volume is continually increasing in industrial and academic engineering 1 communities Although there are a few volumes devoted to similar issues none offer a comprehensive coverage of the field moreover they risk rapidly becoming obsolete The editors of this volume cannot pretend to fill such a large gap However it is the editors intention to fill a significant part of this gap A comprehensive coverage of the field should include topics such as neural networks fuzzy systems neuro fuzzy systems genetic algorithms evolvable hardware cellular automata based systems and various types of artificial life system implementations including autonomous robots In this volume we have focused on the first five topics listed above The volume is composed of four parts each part being divided into chapters with the exception of part 4 In Part 1 the topics of Evolvable Hardware and GAs are addressed In Chapter 1 Automated Design Synthesis and Partitioning for Adaptive Reconfigurable Hardware Ranga Vemuri and co authors present state of the art adaptive architectures their classification and their applications *Advances in Computational Intelligence* Jing Liu,Cesare Alippi,Bernadette Bouchon-Meunier,Garrison W. Greenwood,Hussein A. Abbass,2012-07-06 This state of the art survey offers a renewed and refreshing focus on the progress in evolutionary computation in neural networks and in fuzzy systems The book presents the expertise and experiences of leading researchers spanning a diverse spectrum of computational intelligence in these areas The result is a balanced contribution to the research area of computational intelligence that should serve the community not only as a survey and a reference but also as an inspiration for the future advancement of the state of the art of the field The 13 selected chapters originate from lectures and presentations given at the IEEE World Congress on Computational Intelligence WCCI 2012 held in Brisbane Australia in

June 2012   Soft Computing and Industry Rajkumar Roy,Mario Köppen,Seppo Ovaska,Takeshi Furuhashi,Frank Hoffmann,2012-12-06 Soft computing embraces various methodologies for the development of intelligent systems that have been successfully applied to a large number of real world problems Soft Computing in Industry contains a collection of papers that were presented at the 6th On line World Conference on Soft Computing in Industrial Applications that was held in September 2001 It provides a comprehensive overview of recent theoretical developments in soft computing as well as of successful industrial applications It is divided into seven parts covering material on keynote papers on various subjects ranging from computing with autopoietic systems to the effects of the Internet on education intelligent control classification clustering and optimization image and signal processing agents multimedia and Internet theoretical advances prediction design and diagnosis The book is aimed at researchers and professional engineers who develop and apply intelligent systems in computer engineering   **Ambient Intelligence** Werner Weber,Jan Rabaey,Emile H.L. Aarts,2005-12-12 Ambient intelligence is the vision of a technology that will become invisibly embedded in our natural surroundings present whenever we need it enabled by simple and effortless interactions attuned to all our senses adaptive to users and context sensitive and autonomous High quality information access and personalized content must be available to everybody anywhere and at any time This book addresses ambient intelligence used to support human contacts and accompany an individual s path through the complicated modern world From the technical standpoint distributed electronic intelligence is addressed as hardware vanishing into the background Devices used for ambient intelligence are small low power low weight and very importantly low cost they collaborate or interact with each other and they are redundant and error tolerant This means that the failure of one device will not cause failure of the whole system Since wired connections often do not exist radio methods will play an important role for data transfer This book addresses various aspects of ambient intelligence from applications that are imminent since they use essentially existing technologies to ambitious ideas whose realization is still far away due to major unsolved technical challenges   **Computational Intelligence: A Compendium** John Fulcher,2008-05-28 Computational Intelligence A Compendium presents a well structured overview about this rapidly growing field with contributions from leading experts in Computational Intelligence The main focus of the compendium is on applied methods tried and proven as being effective to realworld problems which is especially useful for practitioners researchers students and also newcomers to the field This state of handbook style book has contributions by leading experts   Fuzzy Modeling and Control Andrzej Piegat,2013-03-19 In the last ten years a true explosion of investigations into fuzzy modeling and its applications in control diagnostics decision making optimization pattern recognition robotics etc has been observed The attraction of fuzzy modeling results from its intelligibility and the high effectiveness of the models obtained Owing to this the modeling can be applied for the solution of problems which could not be solved till now with any known conventional methods The book provides the reader with an advanced introduction to the problems of fuzzy modeling and to one of its most important applications fuzzy

control It is based on the latest and most significant knowledge of the subject and can be used not only by control specialists but also by specialists working in any field requiring plant modeling process modeling and systems modeling e g economics business medicine agriculture and meteorology   Complex-Valued Neural Networks: Utilizing High-Dimensional Parameters Nitta, Tohru,2009-02-28 This book covers the current state of the art theories and applications of neural networks with high dimensional parameters Provided by publisher   **Dynamical Aspects in Fuzzy Decision Making** Yuji Yoshida,2013-06-05 The concept of fuzziness inspired by Zadeh 1965 brings us fruitful results when it is applied to problems in decision making Recently problems in fuzzy decision making are getting more complex and one of the most complex fac tors is dynamics in systems Dynamical approach to fuzzy decision making has been proposed by Bellman and Zadeh s celebrated paper Decision making in a fuzzy environment 1970 The idea has developed into fuzzy mathemati cal programming and has been applied in many fields including management science operations research control theory engineering systems analysis computer science mathematical finance etc Dynamic programming advo cated in Bellmans book Dynamic programming 1957 is one of the most powerful tools to deal with dynamics in systems and Bellman and Zadeh has proposed the optimality principle in fuzzy decision making by 1970 introducing fuzzy dynamic programming Fuzzy dynamic programming and fuzzy mathematical programming has been making remakable progress after they were given life by Bellman and Zadeh s paper 1970 In this volume various kinds of dynamics not only time but also structure of systems are considered This volume contains ten reviewed papers which deal with dynamics in theory and applications and whose topics are poten tially related to dynamics and are expected to develope dynamical study in near future first fuzzy dynamic programming is reviewed from a viewpoint of its origin and consider its developement in theory and applications

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