FEATURE TOPIC: ARTIFICIAL INTELLIGENCE

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Review Articles

AI tools in decision making support systems: A review (USA) 2012
Author(s): Phillips-Wren, G
Source: INTERNATIONAL JOURNAL ON ARTIFICIAL INTELLIGENCE TOOLS Volume: 21 Issue: 2 Special Issue: SI Article Number: 1240005 DOI: 10.1142/S0218213012400052 Published: APR 2012
ABSTRACT: AI tools have advanced sufficiently such that they are integrated into decision making support systems for real applications and are impacting decision making in substantive ways. This paper reviews decision making theories and AI tools and the intelligent decision systems that result from the integration of these concepts.
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Times Cited: 3
Number of references: 35
Tags: Review article

Artificial Intelligence techniques applied as estimator in chemical process systems - A literature survey (Malaysia) 2015
Author(s): Ali, JM (Ali, Jarinah Mohd); Hussain, MA (Hussain, M. A.); Tade, MO (Tade, Moses O.); Zhang, J (Zhang, Jie)
Source: EXPERT SYSTEMS WITH APPLICATIONS Volume: 42 Issue: 14 Pages: 5915-5931 DOI: 10.1016/j.eswa.2015.03.023 Published: AUG 15 2015
ABSTRACT: The versatility of Artificial Intelligence (AI) in process systems is not restricted to modelling and control, only, but also as estimators to estimate the unmeasured parameters as an alternative to the conventional observers and hardware sensors. In this paper, we provide a broad literature survey of several AI algorithms implemented as estimators in chemical systems together with their advantages, limitations, practical implications and comparisons between one another to guide researchers in selecting and designing the AI-based estimators. Future research suggestions and directions in improvising and extending the usage of these estimators in various chemical operating units are also presented. (C) 2015 Elsevier Ltd. All rights reserved.
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Times Cited: 0
Number of references: 142
Tags: Review article, Applications, Algorithms

Artificial intelligence techniques for photovoltaic applications: A review (Cyprus) 2008
Author(s): Mellit, A; Kalogirou, SA
Source: PROGRESS IN ENERGY AND COMBUSTION SCIENCE Volume: 34 Issue: 5 Pages: 574-632 DOI: 10.1016/j.pecs.2008.01.001 Published: OCT 2008
ABSTRACT: Artificial intelligence (AI) techniques are becoming useful as alternate approaches to conventional techniques or as components of integrated systems. The paper outlines an understanding of how all systems operate by way of presenting a number of problems in photovoltaic systems application. Problems presented include three areas: forecasting and modeling of meteorological data, sizing of photovoltaic systems and modeling, simulation and control of photovoltaic systems. Published literature presented in this paper show the potential of AI as design tool in photovoltaic systems. (c) 2008 Elsevier Ltd. All rights reserved.
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Times Cited: 137
Number of references: 331
Tags: Review article, Applications, Algorithms
Artificial neural networks applications in wind energy systems: a review (Turkey) 2015

Author(s): Ata, R


ABSTRACT: Neural networks approaches are becoming useful as an alternate way to classical methods. As a computation and learning paradigm, they are presented as a different modeling approach to solve complicated problems. This study presents various applications of neural networks used in wind energy systems. The applications of neural networks in wind energy systems could be grouped in three major categories: forecasting and prediction, prediction and control, identification and evaluation. The main purpose of this paper is to present an overview of the neural network applications in wind energy systems. Published literature presented in this study indicate the potential of ANN as a useful tool for wind energy systems. Author strongly believes that this survey will be very much useful to the researchers, scientific engineers working in this area to find out the relevant references and current state of the field. (C) 2015 Elsevier Ltd. All rights reserved.

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Times Cited: 1
Number of references: 167
Tags: Review article, Applications, Algorithms

Commonsense Reasoning and Commonsense Knowledge in Artificial Intelligence (USA) 2015

Author(s): Davis, E; Marcus, G


ABSTRACT: AI has seen great advances of many kinds recently, but there is one critical area where progress has been extremely slow: ordinary commonsense.

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Times Cited: 0
Number of references: 50
Tags: Review article

Economic reasoning and artificial intelligence (USA) 2015

Author(s): Parkes, DC; Wellman, MP

Source: SCIENCE Volume: 349 Issue: 6245 Special Issue: SI Pages: 267-272 DOI: 10.1126/science.aaa8403 Published: JUL 17 2015

ABSTRACT: The field of artificial intelligence (AI) strives to build rational agents capable of perceiving the world around them and taking actions to advance specified goals. Put another way, AI researchers aim to construct a synthetic homo economicus, the mythical perfectly rational agent of neoclassical economics. We review progress toward creating this new species of machine, machina economicus, and discuss some challenges in designing AIs that can reason effectively in economic contexts. Supposing that AI succeeds in this quest, or at least comes close enough that it is useful to think about AIs in rationalistic terms, we ask how to design the rules of interaction in multi-agent systems that come to represent an economy of AIs. Theories of normative design from economics may prove more relevant for artificial agents than human agents, with AIs that better respect idealized assumptions of rationality than people, interacting through novel rules and incentive systems quite distinct from those tailored for people.

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Times Cited: 1
Number of references: 90
Tags: Review article
Learning like a baby: a survey of artificial intelligence approaches (Scotland) 2011

Author(s): Guerin, F

Source: KNOWLEDGE ENGINEERING REVIEW Volume: 26 Issue: 2 Pages: 209-236 DOI: 10.1017/S0269888911000038 Published: JUN 2011

ABSTRACT: One of the major stumbling blocks for artificial intelligence remains the commonsense knowledge problem. It is not clear how we could go about building a program which has all the commonsense knowledge of the average human adult. This has led to growing interest in the 'developmental' approach, which takes its inspiration from nature (especially the human infant) and attempts to build a program which could develop its own knowledge and abilities through interaction with the world. The challenge here is to find a learning program which can continuously build on what it knows, to reach increasingly sophisticated levels of knowledge. This survey reviews work in this area, with the emphasis on those that focus on early learning, for example, sensorimotor learning. The concluding discussion assesses the progress thus far and outlines some key problems which have yet to be addressed, and whose solution is essential to achieve the goals of the developmental approach.

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Times Cited: 4
Number of references: 79
Tags: Review article

MPPT-based artificial intelligence techniques for photovoltaic systems and its implementation into field programmable gate array chips: Review of current status and future perspectives (Algeria) 2014

Author(s): Mellit, A; Kalogirou, SA

Source: ENERGY Volume: 70 Pages: 1-21 DOI: 10.1016/j.energy.2014.03.102 Published: JUN 1 2014

ABSTRACT: In this paper, the applications of artificial intelligence-based methods for tracking the maximum power point have been reviewed and analysed. The reviewed methods are based upon neural networks, fuzzy logic, evolutionary algorithms, which include genetic algorithms, particle swarm optimization, ant colony optimization, and other hybrid methods. Rapid advances in programmable logic devices (PLIDs) including field programmable gate arrays (FPGAs) give good opportunities to integrate efficiently such techniques for real time applications. An attempt is made to highlight the future trends and challenges in the development of embedded intelligent digital maximum power point tracking (MPPT) controllers into FPGA chip. Special attention is also given to the cost, complexity of implementation, efficiency, and possible practical realization. We believe that this review provides valuable information for engineers, designers and scientist working in this area and show future trends in the development of embedded intelligent techniques for renewable energy systems. (C) 2014 Elsevier Ltd. All rights reserved.

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Times Cited: 5
Number of references: 150
Tags: Review article, AI systems, Applications

Probabilistic machine learning and artificial intelligence (England) 2015

Author(s): Ghahramani, Z

Source: NATURE Volume: 521 Issue: 7553 Pages: 452-459 DOI: 10.1038/nature14541 Published: MAY 28 2015

ABSTRACT: How can a machine learn from experience? Probabilistic modelling provides a framework for understanding what learning is, and has therefore emerged as one of the principal theoretical and practical approaches for designing machines that learn from data acquired through experience. The probabilistic framework, which describes how to represent and manipulate uncertainty about models and predictions, has a central role in scientific data analysis, machine learning, robotics, cognitive science and artificial intelligence. This Review provides an introduction to this framework, and discusses some of the state-of-the-art advances in the field, namely, probabilistic programming, Bayesian optimization, data compression and automatic model discovery.

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E-mail Author affiliation: zoubin@eng.cam.ac.uk
Times Cited: 0
Number of references: 100
Tags: Review article

A Review of Real-Time Strategy Game AI (New Zealand) 2014
Author(s): Robertson, G; Watson, I
Source: AI MAGAZINE Volume: 35 Issue: 4 Pages: 75-104 Published: WIN 2014

ABSTRACT: This literature review covers AI techniques used for real-time strategy video games, focusing specifically on Star Craft. It finds that the main areas of current academic research are in tactical and strategic decision making, plan recognition, and learning, and it outlines the research contributions in each of these areas. The paper then contrasts the use of game AI in academe and industry, finding the academic research heavily focused on creating game-winning agents, while the industry aims to maximize player enjoyment. It finds that industry adoption of academic research is low because it is either inapplicable or too time-consuming and risky to implement in a new game, which highlights an area for potential investigation: bridging the gap between academe and industry. Finally, the areas of spatial reasoning, multiscale AI, and cooperation are found to require future work, and standardized evaluation methods are proposed to produce comparable results between studies.

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Towards a 'siliconeural computer': technological successes and challenges (Scotland) 2015
Author(s): Hughes, MA (Hughes, Mark A.); Shipston, MJ (Shipston, Mike J.); Murray, AF (Murray, Alan F.)

ABSTRACT: Electronic signals govern the function of both nervous systems and computers, albeit in different ways. As such, hybridizing both systems to create an iono-electric brain-computer interface is a realistic goal; and one that promises exciting advances in both heterotic computing and neuroprosthetics capable of circumventing devastating neuropathology. 'Neural networks' were, in the 1980s, viewed naively as a potential panacea for all computational problems that did not fit well with conventional computing. The field bifurcated during the 1990s into a highly successful and much more realistic machine learning community and an equally pragmatic, biologically oriented 'neuromorphic computing' community. Algorithms found in nature that use the non-synchronous, spiking nature of neuronal signals have been found to be (i) implementable efficiently in silicon and (ii) computationally useful. As a result, interest has grown in techniques that could create mixed 'siliconeural' computers. Here, we discuss potential approaches and focus on one particular platform using parylene-patterned silicon dioxide.

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Times Cited: 1
Number of references: 38
Tags: Review article, Neuromorphic computing

APPLICATION - Communications, Computation, Cyber security, Manufacturing, Medicine, Robotics

AI tools for use in assembly automation and some examples of recent applications (England) 2013
Author(s): Sanders, D; Gegov, A
Source: ASSEMBLY AUTOMATION Volume: 33 Issue: 2 Pages: 184-194 DOI: 10.1108/01445151311306717 Published: 2013

ABSTRACT: Purpose - This paper aims to review seven artificial intelligence tools that are useful in assembly automation: knowledge-based systems, fuzzy logic, automatic knowledge acquisition, neural networks, genetic algorithms, case-based reasoning...
and ambient-intelligence. Design/methodology/approach - Each artificial intelligence tool is outlined, together with some examples of their use in assembly automation. Findings - Artificial intelligence has produced a number of useful and powerful tools. This paper reviews some of those tools. Applications of these tools in assembly automation have become more widespread due to the power and affordability of present-day computers. Research limitations/implications - Many new assembly automation applications may emerge and greater use may be made of hybrid tools that combine the strengths of two or more of the tools reviewed in the paper. The tools and methods reviewed in this paper have minimal computation complexity and can be implemented on small assembly lines, single robots or systems with low-capability microcontrollers. Practical implications - It may take another decade for engineers to recognize the benefits given the current lack of familiarity and the technical barriers associated with using these tools and it may take a long time for direct digital manufacturing to be considered commonplace ... but it is expanding. The appropriate deployment of the new AI tools will contribute to the creation of more competitive assembly automation systems. Social implications - Other technological developments in AI that will impact on assembly automation include data mining, multi-agent systems and distributed self-organising systems. Originality/value - The novel approaches proposed use ambient intelligence and the mixing of different AI tools in an effort to use the best of each technology. The concepts are generically applicable across all industrial assembly processes and this research is intended to prove that the concepts work in manufacturing.

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Times Cited: 5
Number of references: 95
Tags: Applications, Algorithms, Review article

Cognitive robots learning failure contexts through real-world experimentation (Turkey) 2015

Author(s): Karapinar, S (Karapinar, Sertac); Sariel, S (Sariel, Sanem)

ABSTRACT: Learning is essential for cognitive robots as humans to gain experience and to adapt to the real world. We propose an experiential learning method for robots to build their experience online and to transfer knowledge among appropriate contexts. Experience gained through learning is used as a guide to future decisions of the robot for both efficiency and robustness. We use Inductive Logic Programming (ILP) learning paradigm to frame hypotheses represented in first-order logic that are useful for further reasoning and planning processes. Furthermore, incorporation of background knowledge is also possible to generalize the framed hypotheses. Partially specified world states can also be easily represented by these hypotheses. All these advantages of ILP make this approach superior to the other supervised learning methods. We have analyzed the performance of the learning method on our autonomous mobile robot and on our robot arm both building their experience on action executions online. It has been observed in both domains that our experience-based learning and learning-based guidance methods frame sound hypotheses that are useful for constraining and guiding the future tasks of the robots. This learning paradigm is promising especially for the contexts where abstraction is useful for efficient transfer of knowledge.

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Times Cited: 0
Number of references: 52
Tags: Applications, Algorithms

Cooperative multi-robot control for target tracking with onboard sensing (USA) 2015

Author(s): Hausman, K (Hausman, Karol); Muller, J (Mueller, Joerg); Hariharan, A (Hariharan, Abishek); Ayanian, N (Ayanian, Nora); Sukhatme, GS (Sukhatme, Gaurav S.)
Source: INTERNATIONAL JOURNAL OF ROBOTICS RESEARCH Volume: 34 Issue: 13 Special Issue: SI Pages: 1660-1677 DOI: 10.1177/0278364915602321 Published: NOV 2015

ABSTRACT: We consider the cooperative control of a team of robots to estimate the position of a moving target using onboard sensing. In this setting, robots are required to estimate their positions using relative onboard sensing while concurrently tracking the target. Our probabilistic localization and control method takes into account the motion and sensing capabilities of the individual robots to minimize the expected future uncertainty of the target position. Two measures of uncertainty are extensively evaluated...
and compared: mutual information and the trace of the extended Kalman filter covariance. Our approach reasons about multiple possible sensing topologies and incorporates an efficient topology switching technique to generate locally optimal controls in polynomial time complexity. Simulations illustrate the performance of our approach and prove its flexibility in finding suitable sensing topologies depending on the limited sensing capabilities of the robots and the movements of the target. Furthermore, we demonstrate the applicability of our method in various experiments with single and multiple quadrotor robots tracking a ground vehicle in an indoor environment.

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Times Cited: 0
Number of references: 32
Tags: Applications, Algorithms

Review of information extraction technologies and applications (USA) 2014

Author(s): Small, SG; Medsker, L


ABSTRACT: Information extraction (IE) is an important and growing field, in part because of the development of ubiquitous social media networking millions of people and producing huge collections of textual information. Mined information is being used in a wide array of application areas from targeted marketing of products to intelligence gathering for military and security needs. IE has its roots in artificial intelligence fields including machine learning, logic and search algorithms, computational linguistics, and pattern recognition. This review summarizes the history of IE, surveys the various uses of IE, identifies current technological accomplishments and challenges, and explores the role that neural and adaptive computing might play in future research. A goal for this review is also to encourage practitioners of neural and adaptive computing to look for interesting applications in the important emerging area of IE.

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Times Cited: 0
Number of references: 68
Tags: Applications, Big data

A review on artificial intelligence applications to the optimal design of dedicated and reconfigurable manufacturing systems (Italy) 2014

Author(s): Renzi, C; Leali, F; Cavazzuti, M; Andrisano, AO

Source: INTERNATIONAL JOURNAL OF ADVANCED MANUFACTURING TECHNOLOGY Volume: 72 Issue: 1-4 Special Issue: SI Pages: 403-418 DOI: 10.1007/s00170-014-5674-1 Published: APR 2014

ABSTRACT: Reconfigurable manufacturing systems (RMS) are considered the future of manufacturing, being able to overcome both dedicated (DMS) and flexible manufacturing systems (FMS). In fact, they provide significant cost and time reductions in the launch of new products, and in the integration of new manufacturing processes into existing systems. The goals of RMS design are the extension of the production variety, the adaption to rapid changes in the market demand, and the minimization of the investment costs. Despite the interest of many authors, the debate on RMS is still open due to the lack of practical applications. This work is a review of the state-of-the-art on the design of cellular RMS, compared to DMS, by means of optimization. The problem addressed belongs to the NP-Hard family of combinatorial problem. The focus is on non-exact meta-heuristic and artificial intelligence methods, since these have been proven to be effective and robust in solving complex manufacturing design problems. A wide investigation on the most recurrent techniques in DMS and RMS literature is performed at first. A critical analysis over these techniques is given in the end.

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continued
Space Applications of Artificial Intelligence (USA) 2014

Author(s): Chien, S; Morris, R
Source: AI MAGAZINE  Volume: 35  Issue: 4  Pages: 3-6  Published: WIN 2014

ABSTRACT: We are pleased to introduce the space application issue articles in this issue of AI Magazine. The exploration of space is a testament to human curiosity and the desire to understand the universe that we inhabit. As many space agencies around the world design and deploy missions, it is apparent that there is a need for intelligent, exploring systems that can make decisions on their own in remote, potentially hostile environments. At the same time, the monetary cost of operating missions, combined with the growing complexity of the instruments and vehicles being deployed, make it apparent that substantial improvements can be made by the judicious use of automation in mission operations.

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Thirty years of artificial intelligence in medicine (AIME) conferences: A review of research themes (England) 2014

Author(s): Peek, N; Combi, C; Marin, R; Bellazzi, R
Source: ARTIFICIAL INTELLIGENCE IN MEDICINE  Volume: 65  Issue: 1  Special Issue: SI  Pages: 61-73  DOI: 10.1016/j.artmed.2015.07.003  Published: SEP 2015

ABSTRACT: Objectives: To review the history of AIME conferences, investigate its impact on the wider research field, and identify challenges for its future. Methods: We analyzed a total of 122 session titles to create a taxonomy of research themes and topics. We classified all 734 AIME conference papers published between 1985 and 2013 with this taxonomy. We also analyzed the citations to these conference papers and to 55 special issue papers. Results: We identified 30 research topics across 12 themes. AIME was dominated by knowledge engineering research in its first decade, while machine learning and data mining prevailed thereafter. Together these two themes have contributed about 51% of all papers. There have been eight AIME papers that were cited at least 10 times per year since their publication. Conclusions: There has been a major shift from knowledge-based to data-driven methods while the interest for other research themes such as uncertainty management, image and signal processing, and natural language processing has been stable since the early 1990s. AIME papers relating to guidelines and protocols are among the most highly cited. (C) 2015 Elsevier B.V. All rights reserved.

The use of artificial intelligence based techniques for intrusion detection: a review (India) 2010

Author(s): Kumar, G; Kumar, K; Sachdeva, M
Source: ARTIFICIAL INTELLIGENCE REVIEW  Volume: 34  Issue: 4  Pages: 369-387  DOI: 10.1007/s10462-010-9179-5  Published: DEC 2010

ABSTRACT: The Internet connects hundreds of millions of computers across the world running on multiple hardware and software platforms providing communication and commercial services. However, this interconnectivity among computers also enables malicious users to misuse resources and mount Internet attacks. The continuously growing Internet attacks pose severe challenges...
to develop a flexible, adaptive security oriented methods. Intrusion detection system (IDS) is one of most important component being used to detect the Internet attacks. In this paper, various AI based techniques have been reviewed focusing on development of IDS. Related studies have been compared by their source of audit data, processing criteria, technique used, dataset, classifier design, feature reduction technique employed and other experimental environment setup. Benefits and limitations of AI based techniques have been discussed. The paper will help the better understanding of different directions in which research has been done in the field of IDS. The findings of this paper provide useful insights into literature and are beneficial for those who are interested in applications of AI based techniques to IDS and related fields. The review also provides the future directions of the research in this area.

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E-mail Author affiliation: gulshanahuja@gmail.com
Times Cited: 14
Number of references: 96
Tags: Applications - Cyber security, Review article

AI SYSTEMS - Intelligent agents, Smart computers

Adaptive intelligent agents based on efficient behaviour differentiation models (UK) 2010

Author(s): Gongora, M. ; Centre for Comput. Intell., De Montfort Univ., Leicester, UK ; Irvine, D.
Source: ANDESCON, 2010 IEEE, 15-17 Sept., 2010, Bogota, ; pages 1 - 6; DOI: 10.1109/ANDESCON.2010.5630082
ABSTRACT: This paper describes our novel methodology for the creation of efficient AI based Agents capable of adapting. We use AI concepts established and used in the implementation of character behaviour for games, such as the Belief-Desire-Intention model and Finite State Machines. A discussion on their role in efficient agent behaviour encoding is presented. We then suggest a novel differentiated combination of these techniques to enable the process of self-adaptation for intelligent agents used to represent characters in virtual environments.

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Times cited: 0
Number of references: 18
Tags: AI Systems

Evaluation of artificial intelligent techniques to secure information in enterprises (Malaysia) 2014

Author(s): Rehman, A; Saba, T
Source: ARTIFICIAL INTELLIGENCE REVIEW Volume: 42 Issue: 4 Pages: 1029-1044 DOI: 10.1007/s10462-012-9372-9 Published: DEC 2014
ABSTRACT: This paper is aimed at discussing the current issue in artificial intelligent (A.I.) techniques that could help in developing a better threat detection algorithm to secure information in enterprises. It is also investigated that the current information security techniques in enterprises have shown an inclination towards A.I. Conventional techniques for detection and response mostly requires human efforts to extract characteristics of malicious intent, investigate and analyze abnormal behaviors and later encode the derived results into the detection algorithm. Instead, A.I. can provide a direct solution to these requirements with a minimal human input. We have made an effort in this paper to discuss the current issues in information security and describe the benefits of artificially trained techniques in security process. We have also carried out survey of current A.I. techniques for IDS. Limitations of the techniques are discussed to identify the factors to be taken into account for efficient performance. Lastly, we have provided a possible research direction in this domain.

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Times Cited: 4
Number of references: 48
Tags: AI systems, Applications - cyber security

continued
From expert systems to context-based intelligent assistant systems: a testimony (France) 2011

Author(s): Brezillon, P

Source: KNOWLEDGE ENGINEERING REVIEW Volume: 26 Issue: 1 Special Issue: SI Pages: 19-24 DOI: 10.1017/S0269888910000366 Published: MAR 2011

ABSTRACT: This paper presents a personal interpretation of the evolution of artificial intelligence (AI) systems during these last 25 years. This evolution is presented along five generations of AI systems, namely expert systems, joint cognitive systems, intelligent systems, intelligent assistant systems, and the coming generation of context-based intelligent assistant systems. Our testimony relies on different real-world applications in different domains, especially for the French national power company, the subway companies in Paris and in Rio de Janeiro, in medicine, a platform for e-maintenance, road safety, and open sources. Our main claim is to underline that the next generation of AI systems (context-based intelligent assistant systems) requires a radically different consideration on context and its relations with the users, the task at hand, the situation, and the environment in which the task is accomplish by the user; the observation of users through their behaviors and not a profile library; a robust conceptual framework for modeling and managing context; and a computational tool for representing in a uniform way pieces of knowledge, of reasoning, and of contexts.

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Intrusion Detection Systems Based on Artificial Intelligence Techniques in Wireless Sensor Networks (Saudi Arabia) 2013

Author(s): Alrajeh, NA; Lloret, J

Source: INTERNATIONAL JOURNAL OF DISTRIBUTED SENSOR NETWORKS Article Number: 351047 DOI: 10.1155/2013/351047 Published: 2013

ABSTRACT: Intrusion detection system (IDS) is regarded as the second line of defense against network anomalies and threats. IDS plays an important role in network security. There are many techniques which are used to design IDSs for specific scenario and applications. Artificial intelligence techniques are widely used for threats detection. This paper presents a critical study on genetic algorithm, artificial immune, and artificial neural network (ANN) based IDSs techniques used in wireless sensor network (WSN).

Making the Mission Computer Intelligent - A Step Ahead (India) 2013

Author(s): Pitchammal, R; Sadda, V

Source: DEFENCE SCIENCE JOURNAL Volume: 63 Issue: 2 Special Issue: SI Pages: 174-180 Published: MAR 2013

ABSTRACT: Increasing the complexity of fighter aircraft like modern cockpit environments, covering highly integrated, and complex automatic functions, pose various demands on the crew and adding a heavy workload. Cognitive systems appear to be a promising approach to overcome these deficiencies in future combat aircraft. Developing human-centered automation and designing advanced technology that will capitalize on the relative strengths of humans and machines, are key to the success. This paper presents the approach of applying the artificial intelligence (AI) techniques in the critical mission computer (MC). The mission computer is the central controller of the entire avionics and acts as the front end to the pilot and all other avionic systems by providing all the sensors information, presenting the pilot-vehicle interface and thereby helping a lot in reducing the heavy workload of the pilot. Hence cognitive processing in the MC will make MC to act as an electronic crew assistant sharing the workload of the pilot and helping him in severe situations. Intricate aircraft systems increase the need for intelligent cooperation between pilots and aircraft which will be fulfilled by making the MC as smart or intelligent MC.

Memristor-Based Cellular Nonlinear/Neural Network: Design, Analysis, and Applications (China) 2015

Author(s): Duan, SK (Duan, Shukai); Hu, XF (Hu, Xiaofang); Dong, ZK (Dong, Zhekang); Wang, LD (Wang, Lidan); Mazumder, P (Mazumder, Pinaki)

Source: IEEE TRANSACTIONS ON NEURAL NETWORKS AND LEARNING SYSTEMS Volume: 26 Issue: 6 Pages: 1202-1213 DOI: 10.1109/TNNLS.2014.2334701 Published: JUN 2015

ABSTRACT: Cellular nonlinear/neural network (CNN) has been recognized as a powerful massively parallel architecture capable of solving complex engineering problems by performing trillions of analog operations per second. In this paper, a compact CNN model based on memristors is presented along with its performance analysis and applications. In the new CNN design, the memristor bridge circuit acts as the synaptic circuit element and substitutes the complex multiplication circuit used in traditional CNN architectures. In addition, the negative differential resistance and nonlinear current-voltage characteristics of the memristor have been leveraged to replace the linear resistor in conventional CNNs. The proposed CNN design has several merits, for example, high density, nonvolatility, and programmability of synaptic weights. The proposed memristor-based CNN design operations for implementing several image processing functions are illustrated through simulation and contrasted with conventional CNNs. Monte-Carlo simulation has been used to demonstrate the behavior of the proposed CNN due to the variations in memristor synaptic weights.

continued
Navigation of multiple mobile robots in a highly clutter terrains using adaptive neuro-fuzzy inference system (India) 2015

Author(s): Pothal, JK (Pothal, Jayanta Kumar); Parhi, DR (Parhi, Dayal R.)


ABSTRACT: In recent years, the interest in research on robots has increased extensively; mainly due to avoid human to involve in hazardous task, automation of Industries, Defence, Medical and other household applications. Different kinds of robots and different techniques are used for different applications. In the current research proposes the Adaptive Neuro Fuzzy Inference System (ANFIS) Controller for navigation of single as well as multiple mobile robots in highly cluttered environment. In this research it has tried to design a control system which will be able decide its own path in all environmental conditions to reach the target efficiently. Some other requirement for the mobile robot is to perform behaviours like obstacle avoidance, target seeking, speed controlling, knowing the map of the unknown environments, sensing different objects and sensor-based navigation in robot's environment. (C) 2015 Elsevier B.V. All rights reserved.

A neuromorphic network for generic multivariate data classification (Germany) 2014

Author(s): Schmuker, M (Schmuker, Michael); Pfeil, T (Pfeil, Thomas); Nawrot, MP (Nawrot, Martin Paul)


ABSTRACT: Computational neuroscience has uncovered a number of computational principles used by nervous systems. At the same time, neuromorphic hardware has matured to a state where fast silicon implementations of complex neural networks have become feasible. Taking inspiration from the olfactory system of insects, we constructed a spiking neural network for the classification of multivariate data, a common problem in signal and data analysis. In this model, real-valued multivariate data are converted into spike trains using “virtual receptors” (VRs). Their output is processed by lateral inhibition and drives a winner-take-all circuit that supports supervised learning. VRs are conveniently implemented in software, whereas the lateral inhibition and classification stages run on accelerated neuromorphic hardware. When trained and tested on real-world datasets, we find that the classification performance is on par with a naive Bayes classifier. An analysis of the network dynamics shows that stable decisions in output neuron populations are reached within less than 100 ms of biological time, matching the time-to-decision reported for the insect nervous system. Through leveraging a population code, the network tolerates the variability of neuronal transfer functions and trial-to-trial variation that is inevitably present on the hardware system. Our work provides a proof of principle for the successful implementation of a functional spiking neural network on a configurable neuromorphic hardware system that can readily be applied to realworld computing problems.

Performance evaluation of artificial intelligence algorithms for virtual network embedding (China) 2013

Author(s): Chang, XL (Chang, X. L.); Mi, XM (Mi, X. M.); Muppala, JK (Muppala, J. K.)

Source: ENGINEERING APPLICATIONS OF ARTIFICIAL INTELLIGENCE Volume: 26 Issue: 10 Pages: 2540-2550 DOI: 10.1016/j.engappai.2013.07.007 Published: NOV 2013

ABSTRACT: Network virtualization is not only regarded as a promising technology to create an ecosystem for cloud computing applications, but also considered a promising technology for the future Internet. This paper aims to compare the computational effectiveness and efficiency of different AI techniques for handling the cost-aware VNE problem. We first propose two kinds of
VNE algorithms, based on Ant Colony Optimization and genetic algorithm. Then we carry out extensive simulations to compare the proposed VNE algorithms with the existing AI-based VNE algorithms in terms of the VN Acceptance Ratio, the long-term revenue of the service provider, and the VN embedding cost. (C) 2013 Published by Elsevier Ltd.

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Times Cited: 1
Number of references: 22
Tags: AI systems, Applications, Algorithms

**Prediction of elastic properties using seismic prestack inversion and neural network analysis** *(Egypt) 2015*

**Author(s):** Mohamed, IA (Mohamed, Islam A.); El-Mowafy, HZ (El-Mowafy, Hamed Z.); Fathy, M (Fathy, Mohamed)

**Source:** Interpretation-A Journal of Subsurface Characterization  Volume: 3  Issue: 2  Pages: T57-T68  DOI: 10.1190/INT-2014-0139.1  Published: MAY 2015

**ABSTRACT:** The use of artificial intelligence algorithms to solve geophysical problems is a recent development. Neural network analysis is one of these algorithms. It uses the information from multiple wells and seismic data to train a neural network to predict properties away from the well control. Neural network analysis can significantly improve the seismic inversion result when the outputs of the inversion are used as external attributes in addition to regular seismic attributes for training the network. We found that integration of prestack inversion and neural network analysis can improve the characterization of a late Pliocene gas sandstone reservoir. For inversion, the input angle stacks was conditioned to match the theoretical amplitude-variation-with-offset response. The inversion was performed using a deterministic wavelet set. Neural network analysis was then used to enhance the V-P, V-S, and density volumes from the inversion. The improvement was confirmed by comparisons with logs from a blind well.

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Times Cited: 0
Number of references: 16
Tags: AI systems, Applications - geophysics

**Recent advances on artificial intelligence and learning techniques in cognitive radio networks** *(Lebanon) 2015*

**Author(s):** Abbas, N; Nasser, Y; El Ahmad, K

**Source:** EURASIP JOURNAL ON WIRELESS COMMUNICATIONS AND NETWORKING Pages: 1-20  Article Number: 174  DOI: 10.1186/s13638-015-0381-7  Published: JUN 19 2015

**ABSTRACT:** Cognitive radios are expected to play a major role towards meeting the exploding traffic demand over wireless systems. A cognitive radio node senses the environment, analyzes the outdoor parameters, and then makes decisions for dynamic time-frequency-space resource allocation and management to improve the utilization of the radio spectrum. For efficient real-time process, the cognitive radio is usually combined with artificial intelligence and machine-learning techniques so that an adaptive and intelligent allocation is achieved. This paper firstly presents the cognitive radio networks, resources, objectives, constraints, and challenges. Then, it introduces artificial intelligence and machine-learning techniques and emphasizes the role of learning in cognitive radios. Then, a survey on the state-of-the-art of machine-learning techniques in cognitive radios is presented. The literature survey is organized based on different artificial intelligence techniques such as fuzzy logic, genetic algorithms, neural networks, game theory, reinforcement learning, support vector machine, case-based reasoning, entropy, Bayesian, Markov model, multi-agent systems, and artificial bee colony algorithm. This paper also discusses the cognitive radio implementation and the learning challenges foreseen in cognitive radio applications.

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Times Cited: 0
Number of references: 101
Tags: AI systems, Applications - communications, Review article
A Reconfigurable Digital Neuromorphic Processor with Memristive Synaptic Crossbar for Cognitive Computing (USA) 2015

**Author(s):** Kim, Y (Kim, Yongtae); Zhang, Y (Zhang, Yong); Li, P (Li, Peng)

**Source:** ACM Journal on Emerging Technologies in Computing Systems Volume: 11 Issue: 4 Special Issue: SI Article Number: 38 DOI: 10.1145/2700234 Published: APR 2015

**ABSTRACT:** This article presents a brain-inspired reconfigurable digital neuromorphic processor (DNP) architecture for large-scale spiking neural networks. The proposed architecture integrates an arbitrary number of digital leaky integrate-and-fire (LIF) silicon neurons to mimic their biological counterparts and on-chip learning circuits to realize spike-timing-dependent plasticity (STDP) learning rules. We leverage memristor nanodevices to build an NxN crossbar array to store not only multibit synaptic weight values but also network configuration data with significantly reduced area overhead. Additionally, the crossbar array is designed to be accessible both column-and row-wise to expedite the synaptic weight update process for learning. The proposed digital pulse width modulator (PWM) produces binary pulses with various durations for reading and writing the multilevel memristive crossbar. The proposed column-based analog-to-digital conversion (ADC) scheme efficiently accumulates the presynaptic weights of each neuron and reduces silicon area overhead by using a shared arithmetic unit to process the LIF operations of all N neurons. With 256 silicon neurons, learning circuits and 64K synapses, the power dissipation and area of our DNP are 6.45 mW and 1.86 mm(2), respectively, when implemented in a 90-nm CMOS technology. The functionality of the proposed DNP architecture is demonstrated by realizing an unsupervised-learning based character recognition system.

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**Times Cited:** 0

**Number of references:** 34

**Tags:** AI systems, Applications - computation, Neuromorphic computing

Reconfigurable Neuromorphic Computing System with Memristor-Based Synapse Design (USA) 2015

**Author(s):** Liu, BY (Liu, Beiye); Chen, YR (Chen, Yiran); Wysocki, B (Wysocki, Bryant); Huang, TW (Huang, Tingwen)

**Source:** NEURAL PROCESSING LETTERS Volume: 41 Issue: 2 Special Issue: SI Pages: 159-167 DOI: 10.1007/s11063-013-9315-8 Published: APR 2015

**ABSTRACT:** Conventional CMOS technology is slowly approaching its physical limitations and researchers are increasingly utilizing nanotechnology to both extend CMOS capabilities and to explore potential replacements. Novel memristive systems continue to attract growing attention since their reported physical realization by HP in 2008. Unique characteristics like non-volatility, re-configurability, and analog storage properties make memristors a very promising candidate for the realization of artificial neural systems. In this work, we propose a memristor-based design of bidirectional transmission excitation/inhibition synapses and implement a neuromorphic computing system based on our proposed synapse designs. The robustness of our system is also evaluated by considering the actual manufacturing variability with emphasis on process variation.

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**Times Cited:** 0

**Number of references:** 20

**Tags:** AI systems, Neuromorphic computing

The reference ontology of collective behavior of autonomous agents and its extensions (Russia) 2015

**Author(s):** Gorodetsky, VI; Samoylov, VV; Trotskii, DV

**Source:** JOURNAL OF COMPUTER AND SYSTEMS SCIENCES INTERNATIONAL Volume: 54 Issue: 5 Pages: 765-782 DOI: 10.1134/S1064230715030089 Published: SEP 2015

**ABSTRACT:** A behavioral paradigm of artificial intelligence (AI) systems is considered. In this paradigm, it is assumed that the system’s “intelligence” emerges as a result of the individual behaviors and interaction of a set of distributed entities (robots, software agents, and the like) between themselves and with the external environment. An outline of the state of art in the field

**continued**
of behavioral models of artificial intelligence systems is given and, for such models, a unified semantically interpreted behavioral metamodel in the form of a domain-independent reference ontology and its extensions for two particular practically important classes of applications are proposed. The first class of applications deals with the team work of underwater robots autonomously inspecting underwater space in order to ensure its security. The second one corresponds to self-organizing systems composed of a large number of small satellites that autonomously communicate, observe, and inspect outer space. Directions of future research in the field of behavioral models of the distributed entities that cooperatively accomplish an autonomous mission are outlined.

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Times Cited: 0
Number of references: 26
Tags: AI systems, Applications - robotics

Robustness of spiking Deep Belief Networks to noise and reduced bit precision of neuro-inspired hardware platforms England 2015

Author(s): Stromatias, E (Stromatias, Evangelos); Neil, D (Neil, Daniel); Pfeiffer, M (Pfeiffer, Michael); Galluppi, F (Galluppi, Francesco); Furber, SB (Furber, Steve B.); Liu, SC (Liu, Shih-Chii)

Source: FRONTIERS IN NEUROSCIENCE Volume: 9 Article Number: 222 DOI: 10.3389/fnins.2015.00222 Published: JUL 9 2015

ABSTRACT: Increasingly large deep learning architectures, such as Deep Belief Networks (DBNs) are the focus of current machine learning research and achieve state-of-the-art results in different domains. This article investigates how such hardware constraints impact the performance of spiking neural network implementations of DBNs. In particular, the influence of limited bit precision during execution and training, and the impact of silicon mismatch in the synaptic weight parameters of custom hybrid VLSI implementations is studied. Furthermore, the network performance of spiking DBNs is characterized with regard to noise in the spiking input signal. Our results demonstrate that spiking DBNs can tolerate very low levels of hardware bit precision down to almost two bits, and show that their performance can be improved by at least 30% through an adapted training mechanism that takes the bit precision of the target platform into account. Spiking DBNs thus present an important use-case for large-scale hybrid analog-digital or digital neuromorphic platforms such as SpiNNaker, which can execute large but precision-constrained deep networks in real time.


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Times Cited: 0
Number of references: 62
Tags: AI systems, Neuromorphic computing

Synaptic Weight States in a Locally Competitive Algorithm for Neuromorphic Memristive Hardware (USA) 2015

Author(s): Woods, W (Woods, Walt); Burger, J (Buerger, Jens); Teuscher, C (Teuscher, Christof)

Source: IEEE TRANSACTIONS ON NANOTECHNOLOGY Volume: 14 Issue: 6 Pages: 945-953 DOI: 10.1109/TNANO.2015.2449835 Published: NOV 2015

ABSTRACT: Memristors promise a means for high-density neuromorphic nanoscale architectures that leverage in situ learning algorithms. While traditional learning algorithms commonly assume analog values for synaptic weights, actual physical memristors may have a finite set of achievable states during online learning. In this paper, we simulate a learning algorithm with limitations on both the resolution of its weights and the means of switching between them to explore how these properties affect classification performance. For our experiments, we use the locally competitive algorithm (LCA) by Rozell et al. in conjunction with the MNIST dataset and a set of natural images. We investigate the effects of both linear and non-linear distributions of weight states. Our results show that as long as the weights are distributed roughly close to linear, the algorithm is still effective for classifying digits,
while reconstructing images benefits from non-linearity. Further, the resolution required from a device depends on its transition function between states; for transitions akin to round-to-nearest, synaptic weights should have around 16 possible states (4-bit resolution) to obtain optimal results. We find that lowering the threshold required to change states or adding stochasticity to the system can reduce that requirement down to four states (2-bit resolution). The outcomes of our research are relevant for building effective neuromorphic hardware with state-of-the-art memristive devices.

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Times Cited: 0
Number of references: 15
Tags: AI systems, Neuromorphic computing

NEUROMORPHIC COMPUTING - Materials, Hardware, Architecture

Ab Initio Molecular-Dynamics Simulation of Neuromorphic Computing in Phase-Change Memory Materials (England) 2015

Author(s): Skelton, JM (Skelton, Jonathan M.); Loke, D (Loke, Desmond); Lee, T (Lee, Taehoon); Elliott, SR (Elliott, Stephen R.)

Source: ACS APPLIED MATERIALS & INTERFACES Volume: 7 Issue: 26 Pages: 14223-14230 DOI: 10.1021/acsmi.5b01825 Published: JUL 8 2015

ABSTRACT: We present an in silico study of the neuromorphic-computing behavior of the prototypical phase-change material, Ge2Sb2Te5, using ab initio molecular-dynamics simulations. Step-wise changes in structural order in response to temperature pulses of varying length and duration are observed, and a good reproduction of the spike-timing-dependent plasticity observed in nanoelectronic synapses is demonstrated. Short above-melting pulses lead to instantaneous loss of structural and chemical order, followed by delayed partial recovery upon structural relaxation. We also investigate the link between structural order and electrical and optical properties. These results pave the way toward a first-principles understanding of phase-change physics beyond binary switching.

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Times Cited: 0
Number of references: 37
Tags: Neuromorphic computing

Amorphous Metal-Sulphide Microfibers Enable Photonic Synapses for Brain-Like Computing (Singapore) 2015

Author(s): Gholipour, B (Gholipour, Behrad); Bastock, P (Bastock, Paul); Craig, C (Craig, Chris); Khan, K (Khan, Khouler); Hewak, D (Hewak, Dan); Soci, C (Soci, Cesare)

Source: ADVANCED OPTICAL MATERIALS Volume: 3 Issue: 5 Pages: 635-641 DOI: 10.1002/adom.201400472 Published: MAY 2015

ABSTRACT: In the pursuit of all-optical brain-like computing, optical axons and photonic synapses are demonstrated using metal-sulphide microfibres, which allow the generation and propagation of optical action potentials. This gives rise to an all-optical implementation of a number of interneuronal and intraneuronal communication protocols that underlie learning and cognition in the brain.

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Times Cited: 0
Number of references: 42
Tags: Neuromorphic computing

continued
Associative Learning with Temporal Contiguity in a Memristive Circuit for Large-Scale Neuromorphic Networks (China) 2015
Author(s): Li, Y (Li, Yi); Xu, L (Xu, Lei); Zhong, YP (Zhong, Ying-Peng); Zhou, YX (Zhou, Ya-Xiong); Zhong, SJ (Zhong, Shu-Jing); Hu, YZ (Hu, Yang-Zhi); Chua, LO (Chua, Leon O.); Miao, XS (Miao, Xiang-Shui)
Source: ADVANCED ELECTRONIC MATERIALS Volume: 1 Issue: 8 Article Number: 1500125 DOI: 10.1002/aelm.201500125 Published: AUG 2015
ABSTRACT: Memristors, acting as artificial synapses, have promised their prospects in neuromorphic systems that imitate the brain’s computing paradigm. However, most studies focused on the understanding of the memristive mechanism and how to optimize the synaptic performance, and the implementations of higher-order cognitive functions are quite limited. Here the experimental demonstration of a representative network level learning function, i.e., associative learning and extinction, in a compact memristive neuromorphic circuit with only one memristor is reported. The association of the conditioned and unconditioned stimulus is established within a temporal window through the spike-timing-dependent plasticity rule, whereas the extinction of the formed memory is due to the synaptic depression. The temporal contiguity consists with biological behaviors and reflects nature’s cause and effect rule. An efficient methodology of integrating memristors into large-scale neuromorphic systems for massively parallel computing, such as pattern recognition, is provided herein.

Brain-like associative learning using a nanoscale non-volatile phase change synaptic device array (USA) 2014
Author(s): Eryilmaz, SB (Eryilmaz, Sukru B.); Kuzum, D (Kuzum, Duygu); Jeyasingh, R (Jeyasingh, Rakesh); Kim, S (Kim, SangBum); BrightSky, M (BrightSky, Matthew); Lam, C (Lam, Chung); Wong, HSP (Wong, H. -S. Philip)
Source: FRONTIERS IN NEUROSCIENCE Volume: 8 Article Number: 205 DOI: 10.3389/fnins.2014.00205 Published: JUL 22 2014
ABSTRACT: In this work, we demonstrate, using experiments, array level associative learning using phase change synaptic devices connected in a grid like configuration similar to the organization of the biological brain. Implementing Hebbian learning with phase change memory cells, the synaptic grid was able to store presented patterns and recall missing patterns in an associative brain-like fashion. We found that the system is robust to device variations, and large variations in cell resistance states can be accommodated by increasing the number of training epochs. We illustrated the tradeoff between variation tolerance of the network and the overall energy consumption, and found that energy consumption is decreased significantly for lower variation tolerance.

A CMOS Spiking Neuron for Brain-Inspired Neural Networks With Resistive Synapses and In Situ Learning (USA) 2015
Author(s): Wu, XY (Wu, Xinyu); Saxena, V (Saxena, Vishal); Zhu, KH (Zhu, Kehan); Balagopal, S (Balagopal, Sakkarapany)
Source: IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS II-EXPRESS BRIEFS Volume: 62 Issue: 11 Pages: 1088-1092 DOI: 10.1109/TCSII.2015.2456372 Published: NOV 2015
ABSTRACT: Nanoscale resistive memory devices are expected to fuel dense integration of electronic synapses for large-scale neuromorphic systems. To realize such a brain-inspired computing chip, a compact CMOS spiking neuron that performs in situ learning and computing while driving a large number of resistive synapses is desired. This brief presents a novel leaky
continued
integrate-and-fire neuron design that implements the dual-mode operation of current integration and synaptic drive, with a single
operational amplifier (opamp) and enables in situ learning with crossbar resistive synapses. The proposed design was implemented
in a 0.18-μm CMOS technology. Measurements show neuron’s ability to drive a thousand resistive synapses and demonstrate in
situ associative learning. The neuron circuit occupies a small area of 0.01mm(2) and has an energy efficiency value of 9.3 pJ/spike/
synapse.

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Times Cited: 0
Number of references: 16
Tags: Neuromorphic computing
clocked implementations of multineuron systems to massively parallel asynchronous ones and from purely digital systems to mixed analog/digital systems which implement more biological-like models of neurons and synapses together with a suite of adaptation and learning mechanisms analogous to the ones found in biological nervous systems. We describe the advantages of the different approaches being pursued and present the challenges that need to be addressed for building artificial neural processing systems that can display the richness of behaviors seen in biological systems.

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**Times Cited:** 0

**Number of references:** 165

**Tags:** Neuromorphic computing

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**Novel synaptic memory device for neuromorphic computing (USA) 2014**

**Author(s):** Mandal, S (Mandal, Saptarshi); El-Amin, A (El-Amin, Ammaarah); Alexander, K (Alexander, Kaitlyn); Rajendran, B (Rajendran, Bipin); Jha, R (Jha, Rashmi)

**Source:** SCIENTIFIC REPORTS Volume: 4 Article Number: 5333 DOI: 10.1038/srep05333 Published: JUN 18 2014

**ABSTRACT:** This report discusses the electrical characteristics of two-terminal synaptic memory devices capable of demonstrating an analog change in conductance in response to the varying amplitude and pulse-width of the applied signal. The devices are based on Mn doped HfO2 material. The mechanism behind reconfiguration was studied and a unified model is presented to explain the underlying device physics. The model was then utilized to show the application of these devices in speech recognition. A comparison between a 20 nm x 20 nm sized synaptic memory device with that of a state-of-the-art VLSI SRAM synapse showed similar to 10x reduction in area and >10(6) times reduction in the power consumption per learning cycle.

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**Times Cited:** 2

**Number of references:** 31

**Tags:** Neuromorphic computing

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**On-Chip Universal Supervised Learning Methods for Neuro-Inspired Block of Memristive Nanodevices (France) 2015**

**Author(s):** Chabi, D (Chabi, Djaafar); Zhao, WS (Zhao, Weisheng); Querlioz, D (Querlioz, Damien); Klein, JO (Klein, Jacques-Olivier)

**Source:** ACM JOURNAL ON EMERGING TECHNOLOGIES IN COMPUTING SYSTEMS Volume: 11 Issue: 4 Special Issue: SI Article Number: 34 DOI: 10.1145/2629503 Published: APR 2015

**ABSTRACT:** Scaling down beyond CMOS transistors requires the combination of new computing paradigms and novel devices. In this context, neuromorphic architecture is developed to achieve robust and ultra-low power computing systems. Memristive nanodevices are often associated with this architecture to implement efficiently synapses for ultra-high density. In this article, we investigate the design of a neuro-inspired logic block (NLB) dedicated to on-chip function learning and propose learning strategy. It is composed of an array of memristive nanodevices as synapses associated to neuronal circuits. Supervised learning methods are proposed for different type of memristive nanodevices and simulations are performed to demonstrate the ability to learn logic functions with memristive nanodevices. Benefiting from a compact implementation of neuron circuits and the optimization of learning process, this architecture requires small number of nanodevices and moderate power consumption.

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**Times Cited:** 0

**Number of references:** 59

**Tags:** Neuromorphic computing, AI systems

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continued
Phase change materials and phase change memory (Germany) 2014

Author(s): Raoux, S (Raoux, Simone); Xiong, F (Xiong, Feng); Wuttig, M (Wuttig, Matthias); Pop, E (Pop, Eric)
Source: MRS BULLETIN Volume: 39 Issue: 8 Pages: 703-710 DOI: 10.1557/mrs.2014.139 Published: AUG 2014

ABSTRACT: Phase change memory (PCM) is an emerging technology that combines the unique properties of phase change materials with the potential for novel memory devices, which can help lead to new computer architectures. Phase change materials store information in their amorphous and crystalline phases, which can be reversibly switched by the application of an external voltage. This article describes the advantages and challenges of PCM. The physical properties of phase change materials that enable data storage are described, and our current knowledge of the phase change processes is summarized. Various designs of PCM devices with their respective advantages and integration challenges are presented. The scaling limits of PCM are addressed, and its performance is compared to competing existing and emerging memory technologies. Finally, potential new applications of phase change devices such as neuromorphic computing and phase change logic are outlined.

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Times Cited: 14
Number of references: 79
Tags: Neuromorphic computing

Programmable Spike-Timing-Dependent Plasticity Learning Circuits in Neuromorphic VLSI Architectures (Switzerland) 2015

Author(s): Azghadi, MR (Azghadi, Mostafa Rahimi); Moradi, S (Moradi, Saber); Fasnacht, DB (Fasnacht, Daniel B.); Ozdas, MS (Ozdas, Mehmet Sirin); Indiveri, G (Indiveri, Giacomo)
Source: ACM JOURNAL ON EMERGING TECHNOLOGIES IN COMPUTING SYSTEMS Volume: 12 Issue: 2 Special Issue: SI DOI: 10.1145/2658998 Published: AUG 2015

ABSTRACT: Hardware implementations of spiking neural networks offer promising solutions for computational tasks that require compact and low-power computing technologies. Here we present a neuromorphic multi-neuron VLSI device with on-chip programmable event-based hybrid analog/digital circuits; the event-based nature of the input/output signals allows the use of address-event representation infrastructures for configuring arbitrary network architectures, while the programmable synaptic efficacy circuits allow the implementation of different types of spike-based learning mechanisms. The main contributions of this article are to demonstrate how the programmable neuromorphic system proposed can be configured to implement specific spike-based synaptic plasticity rules and to depict how it can be utilised in a cognitive task. Specifically, we explore the implementation of different spike-timing plasticity learning rules online in a hybrid system comprising a workstation and when the neuromorphic VLSI device is interfaced to it, and we demonstrate how, after training, the VLSI device can perform as a standalone component (i.e., without requiring a computer), binary classification of correlated patterns.

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Times Cited: 0
Number of references: 52
Tags: Neuromorphic computing, AI systems

Spike-Time-Dependent Encoding for Neuromorphic Processors (USA) 2015

Author(s): Zhao, CY (Zhao, Chenyuan); Wysocki, BT (Wysocki, Bryant T.); Liu, YF (Liu, Yifang); Thiem, CD (Thiem, Clare D.); McDonald, NR (McDonald, Nathan R.); Yi, Y (Yi, Yang)
Source: ACM JOURNAL ON EMERGING TECHNOLOGIES IN COMPUTING SYSTEMS Volume: 12 Issue: 3 Special Issue: SI Article Number: 23 DOI: 10.1145/2738040 Published: SEP 2015

ABSTRACT: This article presents our research towards developing novel and fundamental methodologies for data representation using spike-timing-dependent encoding. Time encoding efficiently maps a signal's amplitude information into a spike time...
sequence that represents the input data and offers perfect recovery for band-limited stimuli. In this article, we pattern the neural activities across multiple timescales and encode the sensory information using time-dependent temporal scales. The spike encoding methodologies for autonomous classification of time-series signatures are explored using near-chaotic reservoir computing. The proposed spiking neuron is compact, low power, and robust. A hardware implementation of these results is expected to produce an agile hardware implementation of time encoding as a signal conditioner for dynamical neural processor designs.

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Times Cited: 0

Number of references: 77

Tags: Neuromorphic computing

Toward a Sparse Self-Organizing Map for Neuromorphic Architectures (France) 2015

Author(s): Rodriguez, L (Rodriguez, Laurent); Miramond, B (Miramond, Benoit); Granado, B (Granado, Bertrand)

Source: ACM Journal on Emerging Technologies in Computing Systems Volume: 11 Issue: 4 Special Issue: SI Article Number: 33 DOI: 10.1145/2638559 Published: APR 2015

ABSTRACT: In this context, we propose to reconsider the computation problem first in the specific domain of mobile robotics. Our main proposal consists in considering computation as part of a global adaptive system, composed of sensors, actuators, a source of energy and a controlling unit. During the adaptation process, the proposed brain-inspired computing structure does not only execute the tasks of the application but also reacts to the external stimulation and acts on the emergent behavior of the system. This approach is inspired by cortical plasticity in mammalian brains and suggests developing the computation architecture along the system’s experience. This article proposes modeling this plasticity as a problem of estimating a probability density function. This function would correspond to the nature and the richness of the environment perceived through multiple modalities. We define and develop a novel neural model solving the problem in a distributed and sparse manner. And we integrate this neural map into a bio-inspired hardware substrate that brings the plasticity property into parallel many-core architectures. The approach is then called Hardware Plasticity. The results show that the self-organization properties of our model solve the problem of multimodal sensory data clustering. The properties of the proposed model allow envisaging the deployment of this adaptation layer into hardware architectures embedded into the robot’s body in order to build intelligent controllers.

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Times Cited: 0

Number of references: 29

Tags: Neuromorphic computing, Applications - computation

Ultra-Low-Energy Three-Dimensional Oxide-Based Electronic Synapses for Implementation of Robust High-Accuracy Neuromorphic Computation Systems (China) 2014

Author(s): Gao, B (Gao, Bin); Bi, YJ (Bi, Yingjie); Chen, HY (Chen, Hong-Yu); Liu, R (Liu, Rui); Huang, P (Huang, Peng); Chen, B (Chen, Bing); Liu, LF (Liu, Lifeng); Liu, XY (Liu, Xiaoyan); Yu, SM (Yu, Shimeng); Wong, HSP (Wong, H. -S. Philip); Kang, JF (Kang, Jinfeng)

Source: ACS NANO Volume: 8 Issue: 7 Pages: 6998-7004 DOI: 10.1021/nn501824r Published: JUL 2014

ABSTRACT: Neuromorphic computing is an attractive computation paradigm that complements the von Neumann architecture. The salient features of neuromorphic computing are massive parallelism, adaptivity to the complex input information, and tolerance to errors. As one of the most crucial components in a neuromorphic system, the electronic synapse requires high device integration density and low-energy consumption. Oxide-based resistive switching devices have been shown to be a promising candidate to realize the functions of the synapse. However, the intrinsic variation increases significantly with the reduced spike energy due to the reduced number of oxygen vacancies in the conductive filament region. The large resistance variation may degrade the accuracy of neuromorphic computation. In this work, we develop an oxide-based electronic synapse to suppress the degradation caused by the intrinsic resistance variation. The synapse utilizes a three-dimensional vertical structure including several parallel oxide-based resistive switching devices on the same nanopillar. The fabricated three-dimensional electronic synapse exhibits the potential for low fabrication cost, high integration density, and excellent performances, such as low training energy per spike, gradual resistance
transition under identical pulse training scheme, and good repeatability. A pattern recognition computation is simulated based on a well-known neuromorphic visual system to quantify the feasibility of the three-dimensional vertical structured synapse for the application of neuromorphic computation systems. The simulation results show significantly improved recognition accuracy from 65 to 90% after introducing the three-dimensional synapses.

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**Times Cited:** 5

**Number of references:** 32

**Tags:** Neuromorphic computing

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**Wave Interference Functions for Neuromorphic Computing (USA) 2015**

**Author(s):** Rahman, M (Rahman, Mostafizur); Khasanvis, S (Khasanvis, Santosh); Shi, JJ (Shi, Jiajun); Moritz, CA (Moritz, Csaba Andras)

**Source:** IEEE TRANSACTIONS ON NANOTECHNOLOGY  Volume: 14  Issue: 4  Pages: 742-750  DOI: 10.1109/TNANO.2015.2438231  Published: JUL 2015

**ABSTRACT:** Neuromorphic computing mimicking the functionalities of mammalian brain holds the promise for cognitive capabilities enabling new intelligent applications. In this paper, we present a transformative approach for neuromorphic computing with Wave Interference Functions (WIF). This is a framework using emerging nonequilibrium wave phenomenon such as spin waves. WIF leverages inherent wave attributes for multidimensional, multivalued data representation and communication, resulting in reduced connectivity requirements and efficient neural function implementations. It also yields a compact implementation of an artificial neuron. Moreover, since WIF computation and communication are in the spin domain, extremely low-power operation is possible. Our evaluations indicate up to 57x higher density, 77x lower power and 2x better performance when compared to an equivalent 8-bit 45-nm CMOS neuron. Our scalability study using arithmetic circuits for higher bit-width neuron implementations indicate up to 63x density, 88x power and 3x performance benefits in comparison to a 32-bit CMOS equivalent design at 45 nm.

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**Number of references:** 19

**Tags:** Neuromorphic computing