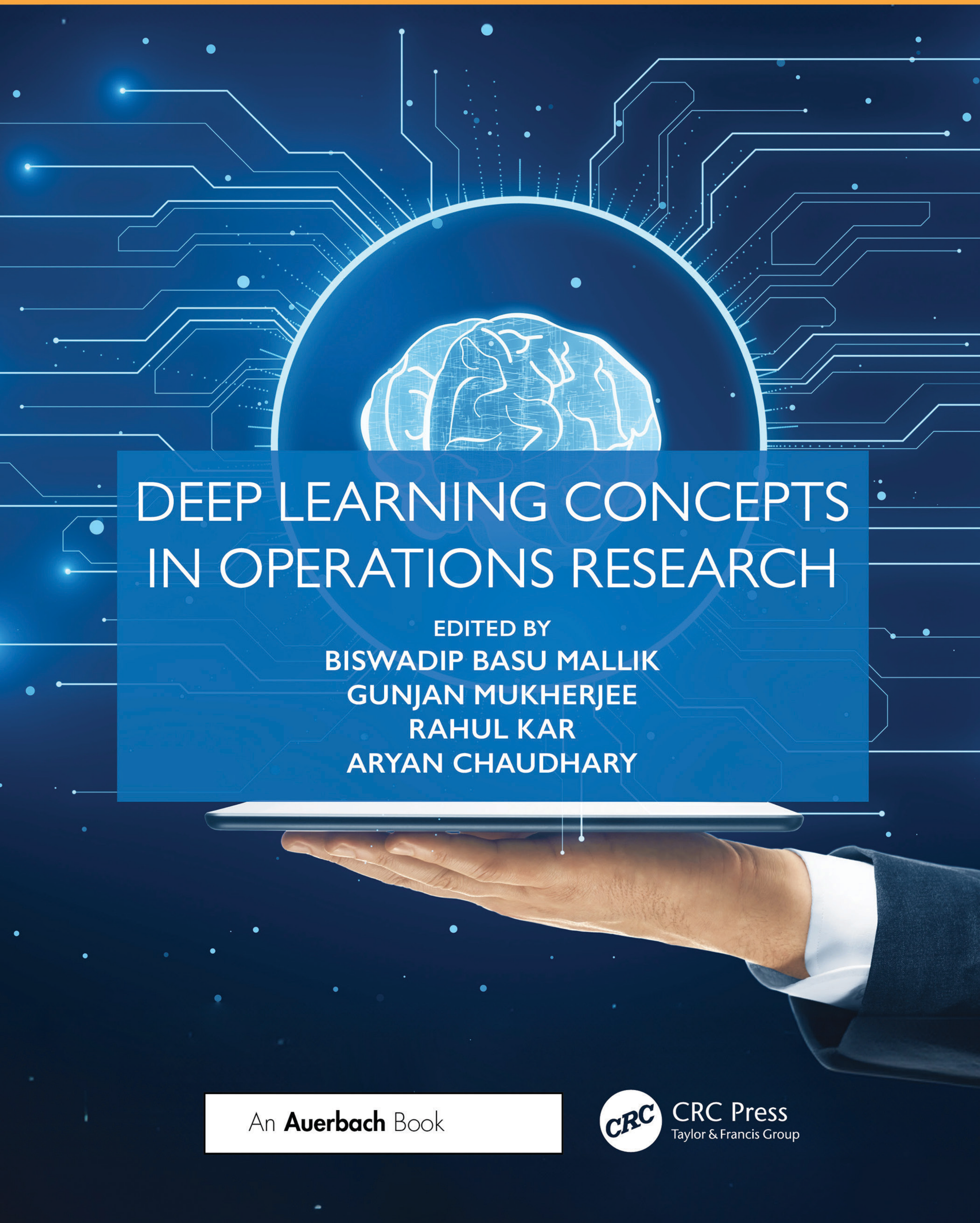
ADVANCES IN COMPUTATIONAL COLLECTIVE INTELLIGENCE



DEEP LEARNING CONCEPTS IN OPERATIONS RESEARCH

EDITED BY

BISWADIP BASU MALLIK

GUNJAN MUKHERJEE

RAHUL KAR

ARYAN CHAUDHARY

An Auerbach Book

CRC Press
Taylor & Francis Group

Deep Learning Concepts in Operations Research

The model-based approach for carrying out classification and identification of tasks has led to the pervading progress of the machine learning paradigm in diversified fields of technology. **Deep Learning Concepts in Operations Research** looks at the concepts that are the foundation of this model-based approach. Apart from the classification process, the machine learning (ML) model has become effective enough to predict future trends of any sort of phenomena. Such fields as object classification, speech recognition, and face detection have sought extensive application of artificial intelligence (AI) and ML as well. Among a variety of topics, the book examines:

- An overview of applications and computing devices
- Deep learning impacts in the field of AI
- Deep learning as state-of-the-art approach to AI
- Exploring deep learning architecture for cutting-edge AI solutions

Operations research is the branch of mathematics for performing many operational tasks in other allied domains, and the book explains how the implementation of automated strategies in optimization and parameter selection can be carried out by AI and ML. Operations research has many beneficial aspects for decision making. Discussing how a proper decision depends on several factors, the book examines how AI and ML can be used to model equations and define constraints to solve problems and discover proper and valid solutions more easily. It also looks at how automation plays a significant role in minimizing human labor and thereby minimizes overall time and cost.

Dr. Biswadip Basu Mallik is an associate professor of Mathematics in the Department of Basic Science & Humanities at Institute of Engineering & Management, University of Engineering & Management, Kolkata, India.

Dr. Gunjan Mukherjee is an associate professor in the Department of Computational Science, Brainware University, Barasat, India.

Rahul Kar holds a Master's degree in Pure Mathematics from Burdwan University and is currently working as a SACT-II Mathematics faculty member of Kalyani Mahavidyalaya, Kalyani, Nadia, West Bengal, India.

Aryan Chaudhary is the chief scientific advisor at BioTech Sphere Research, India.

Advances in Computational Collective Intelligence

Edited by

Dr. Subhendu Kumar Pani
Principal, Krupajal Group of Institutions, India

Published

Technologies for Sustainable Global Higher Education
By Maria José Sousa, Andreia de Bem Machado, and Gertrudes Aparecida Dandolini
ISBN: 978-1-032-262895

Forthcoming

Artificial Intelligence and Machine Learning for Risk Management of Natural Hazards and Disasters
By Cees van Westen, Romulus Costache, Dimitrios A. Karras, R. S. Ajin, and Sekhar L. Kuriakose
ISBN: 978-1-032-232768

Computational Intelligence in Industry 4.0 and 5.0 Applications: Challenges and Future Prospects
Joseph Bamidele Awotunde, Kamalakanta Muduli, and Biswajit Brahma
ISBN: 978-1-032-539225

Deep Learning for Smart Healthcare: Trends, Challenges and Applications
K. Murugeswari, B.Sundaravadivazhagan, S. Poonkuntran, and Thendral Puyalnithi
ISBN: 978-1-032-455815

Edge Computational Intelligence for AI-Enabled IoT Systems
By Shrikaant Kulkarni, Jaiprakash Narain Dwivedi, Dinda Pramanta, and Yuichiro Tanaka
ISBN: 978-1-032-207667

Explainable AI and Cybersecurity
By Mohammad Tabrez Quasim, Abdullah Alharthi, Ali Alqazzaz, Mohammed Mujib Alshahrani, Ali Falh Alshahrani, and Mohammad Ayoub Khan
ISBN: 978-1-032-422213

Machine Learning in Applied Sciences
By M. A. Jabbar, Shankru Guggari, Kingsley Okoye, and Houneida Sakly
ISBN: 978-1-032-251721

Social Media and Crowdsourcing
By Sujoy Chatterjee, Thipendra P Singh, Sunghoon Lim, and Anirban Mukhopadhyay
ISBN: 978-1-032-386874

AI and IoT Technology and Applications for Smart Healthcare
By Alex Khang
ISBN: 978-1-032-684901

Innovations and Applications of Technology in Language Education
By Hung Phu Bui, Raghvendra Kumar, and Nilayam Kamila
ISBN: 978-1-032-560731

Data-Driven Modelling and Predictive Analytics in Business and Finance
By Alex Khang, Rashmi Gujrati, Hayri Uygun, RK Tailor and Sanjaya Singh Gaur
ISBN: 978-1-032-60191-5

Deep Learning Concepts in Operations Research

Edited by
Biswadip Basu Mallik
Gunjan Mukherjee
Rahul Kar
Aryan Chaudhary

CRC Press
Taylor & Francis Group
Boca Raton London New York

CRC Press is an imprint of the
Taylor & Francis Group, an **informa** business

First edition published 2025
by CRC Press
2385 NW Executive Center Drive, Suite 320, Boca Raton FL 33431

and by CRC Press
4 Park Square, Milton Park, Abingdon, Oxon, OX14 4RN

CRC Press is an imprint of Taylor & Francis Group, LLC

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library

ISBN: 9781032553795 (hbk)
ISBN: 9781032559971 (pbk)
ISBN: 9781003433309 (ebk)

DOI: 10.1201/9781003433309

Typeset in Times
by Newgen Publishing UK

Contents

Preface

The immense progress of Science and Technology has been prominently obvious for bringing human civilization to the forefront of the modern era. The extensive research work in the field of computing has brought about many changes in human lives. The technological progress timeline has been redefined with the advent of artificial intelligence. The innovative introduction of AI and its allied branches are gradually evolving to turn many impossible scenarios into possibilities. AI and its sub-branch, machine learning has simulated human perception, concepts and behavior to a great extent and with high precision.

The construction of the model and its application in many classification and identification tasks has materialized due to continuous research and progress in the domain of artificial intelligence and machine learning. Apart from the classification process, the machine learning model has become effective enough to predict future trends of any sort of phenomena. Fields such as object classification, speech recognition, face detection, and the like, have sought extensive application of artificial intelligence. The application of AI and ML has extended to almost all disciplines. The domains of agriculture, health sectors, insurances are just a few of these.

Optimization has taken a turn in the field of artificial intelligence and machine learning. Operations research is a branch of mathematics and can be used for performing so many operational tasks in many domains. The implementation of automated strategies in optimization and parameter selection can be carried out by means of artificial intelligence and machine learning.

Operations research has many beneficial aspects in decision making. A proper decision depends on a number of factors. Mathematical equations and the definition of constraints can easily solve problems and identify a proper and valid solution. The involvement of human labour in such processes can be mitigated by means of automation. The application of AI and ML has not only provided fruitful solutions, but also the concepts can successfully be used in tackling many problems typically with good result accuracy.

Artificial Intelligence (AI) and Machine Learning (ML) are the emerging topics in the computer world, and for good reason - they help companies streamline operations and unearth data so that they can make better business decisions. Business growth is directly or indirectly managed by proper trend analysis and the predictive approach to growth to the ultimate level of development. The very concept is boosting almost every industry by allowing employees to work more effectively, and they're rapidly becoming a critical piece of technology for businesses to remain competitive with others. The gradual advancement of technology and its influences on overall business growth has led the new path towards stability of the modern economy.

Other core technologies such as face recognition on smart phones, personalized online shopping experiences, virtual assistants in homes, and even sickness diagnosis are all feasible due to extensive research work in these fields of technology. The demand for these technologies, as well as experts who are familiar with them, are on the rise. The average number of AI projects in place at a business is likely to more than treble over the next two years, according to a report by research firm, Gartner. Organizations face challenges because of this exponential expansion. They cite a lack of expertise, difficulties understanding AI use cases, and worries about data scope or quality as their top issues with these technologies. AI and machine learning, which were once the stuff of science fiction, are now becoming ubiquitous in enterprises. While these technologies are closely linked, there are significant distinctions between them. Here's a closer look at AI and machine learning, as well as some of the most popular vocations and talents, and how you can get started. Once again, the start-up policies of technology are being backed up by consistent persuasion from research along with the fruitful benefits of such notions. The novel application of the machine learning cum deep learning concept to smooth out the automation process for many mathematical models has become a real game changer in the new paradigm of technology.

Computing time reduction is a difficult problem to overcome. The complexity of any problem in any domain is based on the interrelationships between its involved entities and the effects due to its interactions with others even lying outside the defined peripheries, for example, social distance detection, voice and speech recognition, smooth traffic flow prediction and controlling congestions, prediction of the stock prices. All such emancipation of problems can be mitigated by research contributions collected in this book, providing enough insights into optimization and its mathematical connections through a research oriented approach towards a better goal, with the novel objective of presenting a conducive societal ambience to human beings.

Contributors

Gurjapna Anand
The NorthCap University
Haryana, India

Minal Aggarwal
Ramarao Adik Institute of Technology
D.Y. Patil (deemed to be University)
Nerul, Navi, Mumbai, India

Shivam Baghel
Vellore Institute of Technology
Vellore, Tamil Nadu, India

Yash Bhardwaj
GBPIET
Pauri Garhwal Uttarakhand, India

Arpitam Chatterjee
Department of Printing Engineering
Jadavpur University
West Bengal, India

Aswathy K. Cherian
SRM Institute of Science and Technology
Kattankulathur, Chennai, India

R. Narmada Devi
Vel Tech Rangarajan Dr. Sagunthala R&D
Institute of Science and Technology
Avadi, Chennai, Tamil Nadu, India

Subhasmita Ghosh
Surendranath Evening College
Sealdah, India

Arpan Ghoshal
Seacom Engineering College
West Bengal, India

Nimish Goel
Vellore Institute of Technology
Vellore, Tamil Nadu, India

Reshma Gulwani
Ramrao Adik Institute of Technology
D.Y. Patil (Deemed to be University)
Nerul, Navi Mumbai, India

Dipti Jadhav
Ramarao Adik Institute of Technology
D.Y. Patil (deemed to be University)
Nerul, Navi, Mumbai, India

Subrata Jana
Jadavpur University
West Bengal, India

Jogendra Kumar
GBPIET
Puri Garhwal Uttarakhand, India

Sathish Kumar Kumaravel
Vel Tech Rangarajan Dr. Sagunthala R&D
Institute of Science and Technology
Avadi, Chennai, Tamil Nadu, India.

S. Lavanya
Karpagam College of Engineering
Coimbatore, India

Binay Maji
Maulana Abul Kalam Azad University of Technology
West Bengal, India

Biswadip Basu Mallik
Department of Basic Science and Humanities
Institute of Engineering & Management, University of Engineering & Management
Kolkata, India

Mayank Mehra
GBPIET
Pauri Garhwal Uttarakhand, India

Sucharita Mitra
Netaji Nagar Day College
West Bengal, India

Santanu Modak
Bengal College of Engineering and Technology
Durgapur, India

Kala Raja Mohan
Vel Tech Rangarajan Dr. Sagunthala R&D
Institute of Science and Technology
Avadi, Chennai, Tamil Nadu, India

Soumik Kumar Mohanta
Silicon Institute of Technology
Bhubaneswar, Odisha, India

Anita Mohanty
Silicon Institute of Technology
Bhubaneswar, Odisha, India

Ambarish G. Mohapatra
Silicon Institute of Technology
Bhubaneswar, Odisha, India

Parthiban Krishna Moorthy
Vellore Institute of Technology
Vellore, Tamil Nadu, India

Gunjan Mukherjee
Department of Computational Sciences
Brainware University
Kolkata, West Bengal, India

Anjali Munde
Southampton Malaysia Business School
University of Southampton, Malaysia

Regan Murugesan
Vel Tech Rangarajan Dr. Sagunthala R&D
Institute of Science and Technology
Avadi, Chennai, Tamil Nadu, India

Nagadevi Bala Nagaram
Vel Tech Rangarajan Dr. Sagunthala R&D
Institute of Science and Technology
Avadi, Chennai, Tamil Nadu, India

Bhaskar Nandi
Seacom Engineering College
West Bengal, India

Sasmita Nayak
Government College of Engineering
Kalahandi, Odisha, India

Gokarna Patil
Ramrao Adik Institute of Technology
D.Y. Patil (Deemed to be University)
Nerul, Navi Mumbai, India

Suman Patra
Netaji Nagar Day College
West Bengal, India

E. Poovammal
SRM Institute of Science and Technology
Kattankulathur, Chennai, India

Harshita Rana
GBPIET
Pauri Garhwal Uttarakhand, India

Siddharth Sahasrabuddhe
Ramrao Adik Institute of Technology
D.Y. Patil (Deemed to be University)
Nerul, Navi Mumbai, India

Sanat Kumar Sahu
Govt. V.Y.T. PG Autonomous College
Durg (C.G.) Chhattisgarh, India

Sushil Kumar Sahu
Christ College
Jagdalpur (C.G.), India

Anirban Sarkar
Department of Management and Marketing
West Bengal State University
Barasat, West Bengal, India

Pooja Swaroop Saxena
DIT University
Dehradun India

Divyanshu Semwal
GBPIET
Pauri Garhwal, Uttarakhand, India

Wasswa Shafik
School of Digital Science
Universiti Brunei Darussalam
Gadong, Jalan Tungku Link, Brunei Darussalam

Pooja Sharma
IIMT University
Meerut, India

Chinmay Shirsath
Ramrao Adik Institute of Technology
D.Y. Patil deemed to be University
Nerul, Navi Mumbai, India

Arpita Shome
Abacus Institute of Engineering & Management
Natungram, Dist. Hooghly, Mogra, West Bengal, India

Prabhatkumar Singh
Ramrao Adik Institute of Technology
D.Y. Patil deemed to be University
Nerul, Navi Mumbai, India

Simar Preet Singh
Bennett University
Greater Noida, Uttar Pradesh, India

A. Suganya
Karpagam College of Engineering
Coimbatore, India

Shubhada Tambe
Ramrao Adik Institute of Technology
D.Y. Patil deemed to be University
Nerul, Navi Mumbai, India

Purva Tekade
Ramrao Adik Institute of Technology
D.Y. Patil deemed to be University
Nerul, Navi Mumbai, India

Bipan Tudu
Dept of Instrumentation & Electronics Engineering
Jadavpur University, WB, India

M. Vaidhehi
SRM Institute of Science and Technology
Kattankulathur, Chennai, India

N. Varatharajan
Karpagam College of Engineering
Coimbatore, India

Priyanka Vashisht
Amity University
Noida, Uttar Pradesh, India

Sangeet Vashishtha
IIMT University
Meerut, India

R. Vikkram
Karpagam College of Engineering
Coimbatore, India

1 Deep Learning

Overview, Applications and Computing Devices

N. Varatharajan, S. Lavanya, A. Suganya, and R. Vikkram

1.1 INTRODUCTION

Machine learning has recently gained popularity in research and is used for a diversity of functions, together with content analysis, identifying spam, video inciting, picture dilution, and mixed media surface recovery. One of several machine learning calculations that is widely used in these applications is noteworthy learning (DL) [1]. One more name given to deep learning is representational learning. The best progress, such as in execution computing, which is making information obtaining capability intangible [2-5], may be the cause of the constant circulation of unneeded information within the ranges of important learning and dispersed learning. Deep learning is derived from traditional neural networks, but is much more efficient than its predecessors. Also, deep learning uses both transformations and graphs to create multi-layered learning models. Recently developed DL techniques include sound and discourse handling, visual information preparation, common dialect handling (NLP), and the like. It has achieved very good performance in many applications, including [4,6]. In general, the concept of the learning procedure depends upon the accuracy of any contribution information. Appropriate data depiction has been shown to provide better performance compared to poor data representation. For this reason, one of the important research interests in machine learning in recent years has been engineering studies which have seen a lot of research. This tactic emphasizes the creation of traits from natural data. Furthermore, it is very particular and demands a lot of work. For instance, distinct highlight types, such as the Situated Angles Histogram (Hoard) [5], the Scale Invariant Include Change (Filter) [7], and the Pack of Words [8], are depicted and differentiated in terms of dialect computers. When a new method is introduced and found to be effective, it becomes a research project that has been followed for decades. In contrast, feature extraction is used automatically throughout the DL algorithm [9]. This encourages researchers to eliminate discrimination with as little human effort and knowledge as possible. The primary layer of the multi-layer data representation engineering of these strategies evacuates low-level information, whereas the final layer expels high-level highlights [10]. It is worthy of note that this sort of plan, which empowers this method to happen in pivotal zones of the human brain, was at first based on incorrect pieces of knowledge (AI). The human brain has the capacity to extricate specialist information under different conditions. The data is particularly acknowledged as a representation of the input, but the result of this activity gets to be a special focus [11]. This strategy mirrors the capabilities of the human brain. In this way, it represents the key centers of DL. Due to its success DL has emerged as one of the foremost critical basic hypotheses in reaction to ML. This section provides an overview of deep learning from various perspectives, including fundamentals, architecture, competition, applications, computing tools, and transformation matrices which have published many deep learning analysis papers over the past few years. Nevertheless, deep learning [12], deep object search training [13],

DOI: 10.1201/9781003433309-1

interactive learning [14], and assessments present significant concerns. However, they serve the purpose of providing comprehensive information on DL concepts, including definitions, thorough investigations, computational disobedience, and DL organizations.

Prior to executing programs, DL factors such as utilization, concurrence, as well as substance need to be understood. To do this, one has got to have a thorough understanding of profound learning, especially its endless gaps and suggestions. As a result, to provide readers with a more grounded basis on which to understand profound learning, we advise studying a text that gives an in-depth outline of the subject. The objective is to talk about the most important components of DL, such as open-source issues, arrangements, and tools. In addition, our examination will serve as a springboard work with DL data. Here is an illustration of what we have provided: Practically all of the essential elements of profound learning are thoroughly examined in depth from various perspectives. This section helps students and trainees to fully understand the topic in hand. We discuss the current problems (limitations) with deep learning, such as the lack of training data, conflicting data, and information analysis: explicit parametric estimation, recall destruction, modeling compression, over fitting, during-problem, gradients solution dump, and inadequate specification. We investigate deep learning methods on computing systems (central processing units, graphical processing units, and field programmable gate arrays) by contrasting the characteristics of each device.

1.2 DEEP LEARNING: OVERVIEW

The background of deep learning is described in this section. We briefly introduce DL before describing how it differs from machine learning (ML). We'll give example that require DL.

The basis for a DL proposal are the last topic we cover. Mapping information found in an individual's brain leads to DL, a part of ML (Figure 1.1). The DL uses a great deal of metadata to represent input given to tags instead of human-written code to carry out its operations. A number of layers of simulated neural networks, or ANNs, have been utilized to build Deep Learning (DL) [15–18]. Each layer provides a different interpretation of the input data. Classical machine learning techniques require the sequential steps of prioritization, elimination, decision hiring, learning,

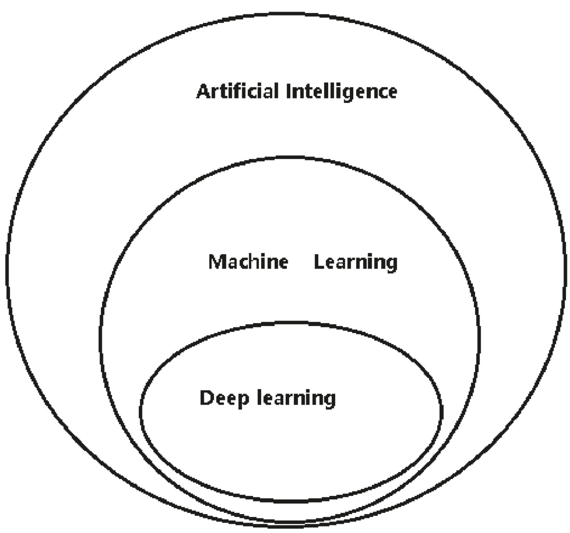


FIGURE 1.1 Deep Learning Family [**16**].

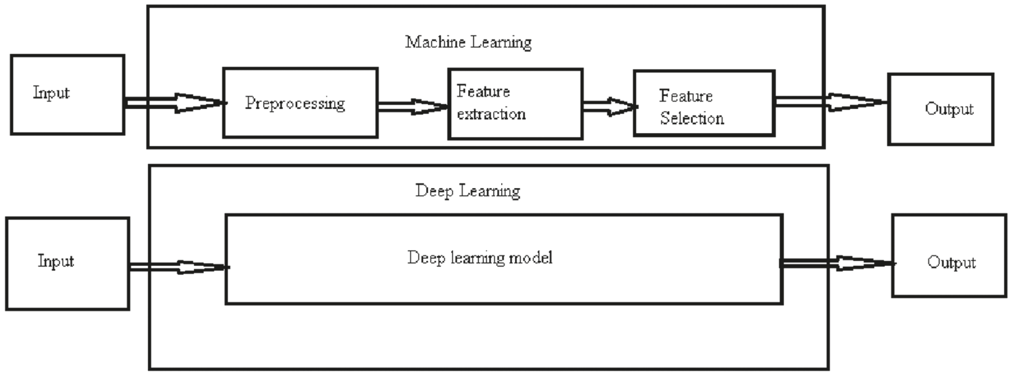


FIGURE 1.2 DL versus Traditional ML [**18**].

and implementation to solve classification issues. Attribute mixes have huge impacts on how well machine learning techniques work as well.

Inaccurate class distinctions may result from neutral selection. Deep learning can learn strategies for many tasks, in contrast to conventional machine learning techniques [18]. With DL, learning and categorization can be achieved in one pass (Figure 1.2). DL has gained popularity as a machine learning algorithm recently [15] as a result of the enormous growth and evolution of big data. It has not yet aided development in many ML jobs' [19] new performance in many areas, including picture resolution, object detection, and image recognition. Performance on tasks like picture categorization has recently been surpassed by deep learning. This technology has had an impact on virtually every branch of science. Due to the use of DL, the majority of enterprises and sectors have already been impacted [20].

Global businesses and technology companies are focusing on competition to advance deep learning. Even now, people's level of expertise and performance capacity fall short of DLs in a number of categories, including predicting rating, choosing a cutoff to assess loan demand, and calculating truck duration. The 2019 Nobel Prize winners – also referred to as the Turing Prize – were three deep learning pioneers [20]. Even though many goals have been achieved; the DL field is still developing. DL has the power to improve people's lives by providing more diagnosis, such as predicting natural disasters, discovering new drugs, and testing for cancer. Deep learning is capable of recognising ailments based on dermatologist suggestions using 129,450 pictures of 2032 disorders. Additionally, GoogleAI [21] outperformed these professionals in the US Pathology Board's estimated accuracy test for cancer diagnosis, scoring 70% versus 61%. For the detection of COVID-19, a brand-new coronavirus, in 2020, DL is essential [22]. In numerous clinics across the globe where chest X-rays or other types of imaging is used; deep learning has emerged as a key tool for classifying and detecting COVID-19. To finish, the application of deep learning is capable of anything, according to AI pioneer Geoffrey Hinton, who famously said.

1.3 APPLICATIONS OF DEEP LEARNING

The fact that machine intelligence is effective in many contexts and can sometimes perform as well as or better than human specialists suggests that deep learning has addressed the following issues without knowledge. Situations in which individuals have difficulty in explaining decisions made employing their cognitive abilities (linguistic comprehension, medical decision-making, and language skills) are:

1. Universal Learning Approach: Because deep learning can be applied to almost any application.
2. Robust: Deep learning is typically not needed to finish features. Instead, as might be predicted, optimized characteristics are automatically learnt about the task. This offers robustness against a wide range of input data fluctuations.
3. Generalization: It is possible to apply the same DL methodology to a variety of materials or applications. Insufficient data issues can also be solved using this technique.
4. Scalability: It is very easy to scale deep learning. With 1202 layers and widespread use in supercomputing, ResNet was created by Microsoft. Similar steps have been conducted by the important network evolution business Lawrence Livermore National Laboratory (LLNL), which has produced hundreds of results.

Numerous DL applications are currently accessible everywhere. These applications, include those for the healthcare industry, social analytics, voice and speech (including augmentation and recognition), visualization of data (including data analysis and computational science), and NLP (interpretation and sentence categorization). These programs can be divided into five groups: segmentation, recording, location, discovery, and classification. The idea of classification is the division of data into categories. Finding relevant objects in an image is achieved via detection, which takes the background into consideration. In the search, there are numerous items that may be from various classes that are enclosed by linked boxes. Finding things inside a bounding box can be achieved using the localization technique. Objects are still surrounded by identified contours during segmentation (semantic segmentation). Fitting a picture into another picture, which could be in 2D or 3D, is referred to as noun. The application and significance of DL in the healthcare industry cannot be overstated. This study is important because it has a significant impact on people's lives. In the area of medicine, deep learning has also shown potential. We demonstrate this by providing a brief overview of the DL application used in medical picture analysis as an example.

1.3.1 Localization

Doctors typically have an interest in the natural body position, although bodyworkers use it more often. Even though electronic images at a regional center are examined and determined without human assistance, they can still be used in end-to-end technological applications. Deep learning recognises malignant spots in X-ray pictures used in non-invasive radiation therapy. Both the spatial and temporal aspects are included when examining hierarchical traits. According to Organs, this method has an accuracy range of 62 to 79%. For the diagnosis of pulmonary and local diseases, two convolution networks – Ret Net and Mask R-CNN – are employed. Detection An additional method for detection is computer-aided detection (CADe). A wound that is ignored might have immediate negative effects on the patient and the doctor. As a result, research is a discipline that demands accuracy and precision. a thorough investigation into diseases using the idea of adaptive learning. Their approach had a 96.4% accuracy rate and a 99.62% success rate in recovering deleted data. Numerous neural network techniques that work well for automatic X-ray image detection have been proposed in the fields of COVID-19 and pneumonia.

1.3.2 Detection

Another method of detection is computer-aided detection. Ignoring an inflammation might have negative implications on both the patient and the doctor. Because of this, detection is a subject that calls for both sensitivity and precision. A cutting-edge learning system will apply the concept of transferred learning to identify pneumonia. Their method had a 99.62% call rate and a 96.4% accuracy rating for unobserved data. For automated identification from X-ray pictures of COVID-19 and pulmonary illness, a number of convolution neural network techniques have been presented, and they have demonstrated great performance.

1.3.3 Segmentation

Many MRI and CT scan segmentation studies have focused on the brain, particularly tumors, despite the fact that other organs like the liver, prostate, and knee cartilage have also been included. This problem is essential in surgical planning to obtain a clean tumor for small surgery. Surgery that removes too much brain tissue can cause brain damage that can impair memory, cause depression, and cause loss of mobility. Tracing lines particularly from layer to layer on a CT or MRI set has historically been the method used by doctors to manually segment clinical anatomical structures. This difficult task is best handled by automated solutions. Automated identification of the covid-19 virus from CT images has just been implemented in order to assist in the teaching of trans disciplinary studies.

1.3.4 Registration

The basic stages of the unique process for registration work are generally given two input photos, used as follows:

Product selection: Following the first input picture, characteristics of subsequent input pictures must continue to be true.
Feature extraction: This determines the characteristics that were taken for each of the input pictures.
Characteristic harmonizing: This makes it possible to compare previously acquired features.
Exposure Optimization: This reduces the level of difference between the two input images. The resultant statistical renovation (such as transformation, rotary motion, degree, and so on.) and a close distance between them are the outcomes of the registration operation. The levels of overlap are good.

1.4 COMPUTATIONAL METHODS

Complex ML and DL approaches are extensively functional in a variety of industries and have swiftly emerged as the most valuable methods for data processing. The creation and advancement of algorithms, along with the effectiveness of mathematics and the usage of large data, have made it possible to implement several applications that were either too complex or difficult to imagine beforehand. There are now a number of common (Deep Neural Network) DNN configurations available. The primary distinction between these two approaches is the link pattern between layers and all tiers. During DNN training, several optimisation approaches are employed to obtain the updates, but the (Stochastic Gradient Descent) SGD procedure is utilised to fit (or not fit) the weights. The waste management social network should develop together with increased output. For instance, it takes between 30 and 40 thousand iterations for the training method using the extensive ImageNet data set (more than 14 million pictures) and the ResNet network model to arrive at a fixed solution: frozen. The total calculation time of the high-level approach is expected to be greater than 1020 hops as exercise locate mass in addition to neural network involvement amplification. By 2009, the GPU could be used to advance training to a satisfactory level. Even with GPU help, training often takes a few days or weeks. For instance, numerous reduction methods have been developed that greatly cut down on training time. It is thought that as DNNs scale in complexity and size, so do their computing requirements. Memory throughput and capacity are calculated for the entire line and have less of an impact than the installation cost. In particular, there is a large amount of data recovery, parameters are not consistently allocated throughout the initial data levels, and computing several layers in a network only yields a tiny computer-to-bandwidth ratio. If there is no classification, multiplexed data, on the other hand, has very little expense and a very low computational bandwidth ratio for additional Fully Connected (FC) processing. Although maximum Graphical Processing Unit (GPU) presentation cannot be achieved as well as the inclusion of numerous ideas or models that are bandwidth-dependent, these networks are better able to solve computational issues thanks to the GPU performance.

The worst-case GPU efficiency ranges from 15% to 20% of the theoretical maximum performance. To solve this problem, the memory bandwidth must be increased using high-bandwidth cluster memory. Then, various techniques based on central processing units, graphical processing units, and field programmable gate arrays will be thoroughly explained.

1.4.1 Central processing unit-based approach

A CPU-based concert of central processing unit nodes primarily supports huge memory, network connectivity, and storage capacity. Despite being more prevalent than (Field Processing Gate Array) FPGA or GPU nodes, CPU nodes require more space and memory because they cannot manage with limited computing resources.

1.4.2 GPU-based approach

The GPU is a good fit for several essential DL ideas, including parallel operations such as activation, matrix multiplication, and convolution. Because High Bandwidth Memory (HBM) stacked memory has been integrated into these new GPU models, they provide increased bandwidth. This improvement enables several cores to fully leverage the GPU's capabilities. Heavy linear algebra operations usually result in a 10–20:1 speed advantage for the GPU over the CPU. The original GPU programming paradigm was built on the idea of increasing parallel processing. For instance, a single GPU has a maximum of 64 units. With 16 processing lines per Single Instruction Multiple Data (SIMD) unit, there are four SIMD processing units. 25 T hops (fp16) and 10 T hops (fp32) operate best when the operational percentage is near to 100%. If addition and subtraction for vectors are combined with internal manufacturing rules for comparing operations requiring matrix operations, further GPU performance can be attained. In general, GPUs are thought to be well-designed for DNN training and also offer improved performance for inference operations.

1.4.3 FPGA-based approach

Deep learning is just one application of FPGAs. Oftentimes, FPGAs employ inference accelerators. Inefficient functionality or overheads related to GPU systems can be reduced by optimizing FPGAs. Poor access point performance and restricted computation are FPGAs' main drawbacks in comparison to GPUs. The key characteristic of FPGAs is their capacity to configure an array by design utilizing a variety of existing headers or brand-new ones, as well as to alter its properties in real time. For DL inference workloads, as was already established, FPGAs outperform GPUs and CPUs in terms of computation speed and latency per watt. These three elements – reduced arithmetic, network integration, and efficient usage of high-performance devices – allow FPGAs to leverage DL algorithms to support FPGAs at this level. Long Short-Term Memories (LSTM)s, on the other hand, commonly use pruning techniques. Using MultiLayer Perceptron (MLP) neural processing, the size of the model can be reduced to 20, which has significant benefits when using efficient methods.

According to recent studies on the usage of fixed content and custom control content, 8-bit reduction is not only very effective but also helps as an FPGA technology advance for the best DNN model performance.

1.5 SUMMARY AND CONCLUSION

After compiling all the data related to this research, a brief discussion is warranted. The information is broken down into its component parts for explanation and advice on where to go next. Large volumes of complicated data require simultaneous modeling via deep learning, which is challenging. Multimodal DL is yet another strategy used in current DL development. In the future, the development of DL apps should heavily rely on cloud-based platforms. Cloud computing can be used to handle massive amounts of data with efficient solutions. Moreover, it lowers expenses while boosting efficiency. For deep learning training, it also offers flexibility. New developments in computing hardware, such as neural network processors and mobile GPUs, have improved deep learning applications with transferable approach. DL user determination does this more simply. Several adaptive learning techniques are intended to address the problem of a lack of training data, including the training of the deep learning model on a sizable dataset of images that are unlabeled, prior to applying it to the task of training well-known DL models on a small number of images. As a description for the DL community who are interested in the DL space, this area serves as a starting point. Additionally, researchers will be able to choose the best lines of inquiry so they bring more detailed options to the field.

REFERENCES

1. Rozenwald, Michal, et al. "A machine learning framework for the prediction of chromatin folding in Drosophila using epigenetic features." *PeerJ Computer Science* 6 (2020): e307.
2. Amrit, Chintan, Tim Paauw, Robin Aly, and Miha Lavric. "Identifying child abuse through text mining and machine learning." *Expert Systems with Applications* 88 (2017): 402–418.
3. Hossain, Eklas, et al. "Application of big data and machine learning in smart grid, and associated security concerns: A review." *IEEE Access* 7 (2019): 13960–13988.
4. Crawford, Michael, et al. "Survey of review spam detection using machine learning techniques." *Journal of Big Data* 2, no. 1 (2015): 1–24.
5. Deldjoo, Yashar, et al. "Content-based video recommendation system based on stylistic visual features." *Journal on Data Semantics* 5 (2016): 99–113.
6. Al-Dulaimi, Khamael et al. "Benchmarking HEp-2 specimen cells classification using linear discriminant analysis on higher order spectra features of cell shape." *Pattern Recognition Letters* 125 (2019): 534–541.
7. Liu, Weibo, et al. "A survey of deep neural network architectures and their applications." *Neurocomputing* 234 (2017): 11–26.
8. Onyelowe, Kennedy, et al. "Selected AI optimization techniques and applications in geotechnical engineering." *Cogent Engineering* 10, no. 1 (2023): 2153419.
9. Alom, MdZahangir, et al. "A state-of-the-art survey on deep learning theory and architectures." *Electronics* 8, no. 3 (2019): 292.
10. Potok, Thomas E., et al. "A study of complex deep learning networks on high-performance, neuromorphic, and quantum computers." *ACM Journal on Emerging Technologies in Computing Systems (JETC)* 14, no. 2 (2018): 1–21.
11. Adeel, Ahsan, Mandar Gogate, and Amir Hussain. "Contextual deep learning-based audio-visual switching for speech enhancement in real-world environments." *Information Fusion* 59 (2020): 163–170.
12. Tian, Haiman, Shu-Ching Chen, and Mei-Ling Shyu. "Evolutionary programming based deep learning feature selection and network construction for visual data classification." *Information Systems Frontiers* 22 (2020): 1053–1066.

13. Young, Tom, Devamanyu Hazarika, Soujanya Poria, and Erik Cambria. “Recent trends in deep learning based natural language processing.” *IEEE Computational Intelligence Magazine* 13, no. 3 (2018): 55–75.
14. Koppe, Georgia, Andreas Meyer-Lindenberg, and Daniel Durstewitz. “Deep learning for small and big data in psychiatry.” *Neuropsychopharmacology* 46, no. 1 (2021): 176–190.
15. Dalal, Navneet, and Bill Triggs. “Histograms of oriented gradients for human detection.” In *2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR’05)*, vol. 1, pp. 886–893. IEEE, 2005.
16. Lowe, David G. “Object recognition from local scale-invariant features.” In *Proceedings of the Seventh IEEE International Conference on Computer Vision*, vol. 2, pp. 1150–1157. IEEE, 1999.
17. Y. Lv, J. Zhang, Y. Dai, A. Li, N. Barnes and D. -P. Fan, "Toward Deeper Understanding of Camouflaged Object Detection," in *IEEE Transactions on Circuits and Systems for Video Technology*, vol. 33, no. 7, pp. 3462-3476, July 2023.
18. Krishnamurthy, Gangeshwar, et al. “A deep learning approach for multimodal deception detection.” In *Computational Linguistics and Intelligent Text Processing: 19th International Conference, CICLing 2018, Hanoi, Vietnam, March 18–24, 2018, Revised Selected Papers, Part I*, pp. 87–96. Cham: Springer Nature Switzerland, 2023.
19. Wang, Kunyu, Xianguo Wu, Limao Zhang, and Xieqing Song. “Data-driven multi-step robust prediction of TBM attitude using a hybrid deep learning approach.” *Advanced Engineering Informatics* 55 (2023): 101854.
20. Chen, Xudong, Zhun Wei, Maokun Li, and Paolo Rocca. “A review of deep learning approaches for inverse scattering problems (invited review).” *Progress in Electromagnetics Research* 167 (2020): 67–81.
21. Haque, Intisar Rizwan I., and Jeremiah Neubert. “Deep learning approaches to biomedical image segmentation.” *Informatics in Medicine Unlocked* 18 (2020): 100297.
22. Stokes, Yang, et al. “ A deep learning approach to antibiotic discovery.” *Cell* 180, no. 4 (2020): 688–702.

Deep Learning

Rozenwald, Michal , et al. “A machine learning framework for the prediction of chromatin folding in Drosophila using epigenetic features.” PeerJ Computer Science 6 (2020): e307.

Amrit, Chintan , Tim Paauw , Robin Aly , and Miha Lavric . “Identifying child abuse through text mining and machine learning.” Expert Systems with Applications 88 (2017): 402–418.

Hossain, Eklas , et al. “Application of big data and machine learning in smart grid, and associated security concerns: A review.” IEEE Access 7 (2019): 13960–13988.

Crawford, Michael , et al. “Survey of review spam detection using machine learning techniques.” Journal of Big Data 2, no. 1 (2015): 1–24.

Deldjoo, Yashar , et al. “Content-based video recommendation system based on stylistic visual features.” Journal on Data Semantics 5 (2016): 99–113.

Al-Dulaimi, Khamael et al. “Benchmarking HEp-2 specimen cells classification using linear discriminant analysis on higher order spectra features of cell shape.” Pattern Recognition Letters 125 (2019): 534–541.

Liu, Weibo , et al. “A survey of deep neural network architectures and their applications.” Neurocomputing 234 (2017): 11–26.

Onyelowe, Kennedy , et al. “Selected AI optimization techniques and applications in geotechnical engineering.” Cogent Engineering 10, no. 1 (2023): 2153419.

Alom, MdZahangir , et al. “A state-of-the-art survey on deep learning theory and architectures.” Electronics 8, no. 3 (2019): 292.

Potok, Thomas E ., et al. “A study of complex deep learning networks on high-performance, neuromorphic, and quantum computers.” ACM Journal on Emerging Technologies in Computing Systems (JETC *)* 14, no. 2 (2018): 1–21.

Adeel, Ahsan , Mandar Gogate , and Amir Hussain . “Contextual deep learning-based audio-visual switching for speech enhancement in real-world environments.” Information Fusion 59 (2020): 163–170.

Tian, Haiman , Shu-Ching Chen , and Mei-Ling Shyu . “Evolutionary programming based deep learning feature selection and network construction for visual data classification.” Information Systems Frontiers 22 (2020): 1053–1066.

Young, Tom , Devamanyu Hazarika , Soujanya Poria , and Erik Cambria . “Recent trends in deep learning based natural language processing.” IEEE Computational Intelligence Magazine 13, no. 3 (2018): 55–75.

Koppe, Georgia , Andreas Meyer-Lindenberg , and Daniel Durstewitz . “Deep learning for small and big data in psychiatry.” Neuropsychopharmacology 46, no. 1 (2021): 176–190.

Dalal, Navneet , and Bill Triggs . “Histograms of oriented gradients for human detection.” In 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR’05), vol. 1, pp. 886–893. IEEE, 2005.

Lowe, David G . “Object recognition from local scale-invariant features.” In Proceedings of the Seventh IEEE International Conference on Computer Vision, vol. 2, pp. 1150–1157. IEEE, 1999.

Y. Lv , J. Zhang , Y. Dai , A. Li , N. Barnes and D. -P. Fan , "Toward Deeper Understanding of Camouflaged Object Detection," in IEEE Transactions on Circuits and Systems for Video Technology, vol. 33, no. 7, pp. 3462-3476, July 2023.

Krishnamurthy, Gangeshwar , et al. “A deep learning approach for multimodal deception detection.” In Computational Linguistics and Intelligent Text Processing: 19th International Conference, CICLing 2018, Hanoi, Vietnam, March 18–24, 2018, Revised Selected Papers, Part I, pp. 87–96. Cham: Springer Nature Switzerland, 2023.

Wang, Kunyu , Xianguo Wu , Limao Zhang , and Xieqing Song . “Data-driven multi-step robust prediction of TBM attitude using a hybrid deep learning approach.” Advanced Engineering Informatics 55 (2023): 101854.

Chen, Xudong , Zhun Wei , Maokun Li , and Paolo Rocca . “A review of deep learning approaches for inverse scattering problems (invited review).” Progress in Electromagnetics Research 167 (2020): 67–81.

Haque, Intisar Rizwan I ., and Jeremiah Neubert . “Deep learning approaches to biomedical image segmentation.” Informatics in Medicine Unlocked 18 (2020): 100297.

Stokes, Yang , et al. “ A deep learning approach to antibiotic discovery.” Cell 180, no. 4 (2020): 688–702.

Deep Learning Impacts in the Field of Artificial Intelligence

Adnan, N ., Khalid, W. B. , Umer, F . An artificial intelligence model for instance segmentation and tooth numbering on orthopantomograms. Int J Comput Dent. 2023 Nov 28;26(4):301-309.

Aisen, A. M. , Rodrigues, P. S. Deep Learning to Detect Pancreatic Cancer at CT: Artificial Intelligence Living Up to Its Hype. Radiology. 2023 Jan; 306(1):183-185.

Alghamdi, Salem Saeed . (2023). The Application of Artificial Intelligence in Detecting Breast Lesions with Medical Imaging: A Literature Review. In International Journal of Biomedicine (Vol. 13, Issue 1).

Ali, Rafia , Mehala Balamurali , and Pegah Varamini . (2022). Deep Learning-Based Artificial Intelligence to Investigate Targeted Nanoparticles' Uptake in TNBC Cells. International Journal of Molecular Sciences, 23(24).
Al-Tameemi, Maad Issa , Ammar A. Hasan , and Bashra Kadhim Oleiwi . (2023). "Design and Implementation Monitoring Robotic System Based on You Only Look Once Model Using Deep Learning Technique." IAES International Journal of Artificial Intelligence, 12(1): 106.
Bastidas, S. E. C. , Porras, A. M. , Gómez, A. P. , García, I.M. , and González, L . (2023). Elderly, Their Emotions and Deep Learning Techniques to Help Their Dignified and Positive Aging. Lecture Notes in Networks and Systems, 594 LNNS.
Benayad, Anass , et al. (2022). High-Throughput Experimentation and Computational Freeway Lanes for Accelerated Battery Electrolyte and Interface Development Research. In Advanced Energy Materials (Vol. 12, Issue 17).
Buhmann, Alexander , and Christian Fieseler . (2023). "Deep Learning Meets Deep Democracy: Deliberative Governance and Responsible Innovation in Artificial Intelligence." Business Ethics Quarterly, 33(1): 146–79.
Case, James A. (2022). Deep Learning and Artificial Intelligence: What Does the Cardiologist Really Need to Know? In Circulation: Cardiovascular Imaging (Vol. 15, Issue 9).
Chakraborty, Shouvik , and Kalyani Mali . (2023). "An Overview of Biomedical Image Analysis from the Deep Learning Perspective." Research Anthology on Improving Medical Imaging Techniques for Analysis and Intervention, 43–59.
Chen, Tzeng-Ji . 2023. "ChatGPT and Other Artificial Intelligence Applications Speed up Scientific Writing." Journal of the Chinese Medical Association, 10.
Chou, Wei-Chun , and Zhoumeng Lin . (2023). "Machine Learning and Artificial Intelligence in Physiologically Based Pharmacokinetic Modeling." Toxicological Sciences, 191(1): 1–14.
Dayı, Burak , Hüseyin Üzen , İpek Balıkçı Çiçek , and Şuayip Burak Duman . (2023). "A Novel Deep Learning-Based Approach for Segmentation of Different Type Caries Lesions on Panoramic Radiographs." Diagnostics, 13(2): 202.
Deng, Wen , Guangjun Liang , Chenfei Yu , Kefan Yao , Chengrui Wang , and Xuan Zhang . (2023). An Early Warning Model of Telecommunication Network Fraud Based on User Portrait. Computers, Materials and Continua, 75(1).
Du, Jian , et al. (2023). "A Theory-Guided Deep-Learning Method for Predicting Power Generation of Multi-Region Photovoltaic Plants." Engineering Applications of Artificial Intelligence 118: 105647.
Gombolay, G.Y. , Gopalan, N ., Bernasconi, A ., Nabbout, R ., Megerian, J.T. , Siegel, B.I. , Hallman-Cooper, J ., Bhalla, S ., & Gombolay, M.C. (2023). Review of Machine Learning and Artificial Intelligence (ML/AI) for the Pediatric Neurologist. Pediatric neurology, *141* , 42-51.
Gore, Sayali V ., et al. (2023). Zebrafish Larvae Position Tracker (Z-LaP Tracker): A High-Throughput Deep-Learning Behavioral Approach for the Identification of Calcineurin Pathway-Modulating Drugs Using Zebrafish Larvae. Scientific Reports, 13(1).
Greffier, Joël , et al. (2023). "Improved Image Quality and Dose Reduction in Abdominal CT with Deep-Learning Reconstruction Algorithm: A Phantom Study." European Radiology, 33(1): 699–710.
Gronwald, K.-D. (2023). Machine Learning, Deep Learning und Artificial Intelligence. In Globale Kommunikation und Kollaboration.
Gu, Shangzhi , et al. (2023). Detection of Sarcopenia Using Deep Learning-Based Artificial Intelligence Body Part Measure System (AIBMS). Frontiers in Physiology, 14.
Gupta, Lav Kumar , Deepika Koundal , and Shweta Mongia . (2023). "Explainable Methods for Image-Based Deep Learning: A Review." Archives of Computational Methods in Engineering, 1–16.
Huang, Chun-Chao , et al. (2023). Using Deep-Learning-Based Artificial Intelligence Technique to Automatically Evaluate the Collateral Status of Multiphase CTA in Acute Ischemic Stroke. Tomography, 9(2).
Hughes, H ., M. O'Reilly , N. McVeigh , and R. Ryan . (2023). "The Top 100 Most Cited Articles on Artificial Intelligence in Radiology: A Bibliometric Analysis." Clinical Radiology, 78 (2): 99–106.
Ishii, Euma , et al. (2023). "Development, Validation, and Feature Extraction of a Deep Learning Model Predicting in-Hospital Mortality Using Japan's Largest National ICU Database: A Validation Framework for Transparent Clinical Artificial Intelligence (CAI) Development." Anaesthesia Critical Care & Pain Medicine, 42(2): 101167.
Jia, Tianlong , et al. (2023). "Deep Learning for Detecting Macroplastic Litter in Water Bodies: A Review." Water Research, 119632.
Jin, Xiaoxue , Xiufeng Wang , Xingiang Cao , and Chaohua Xue . (2023). Construction and Recognition of Acoustic ID of Ancient Coins Based on Deep Learning of Artificial Intelligence for Audio Signals. Heritage Science, 11(1).
Kavitha, R ., et al. (2023). "Ant Colony Optimization-Enabled CNN Deep Learning Technique for Accurate Detection of Cervical Cancer." BioMed Research International 2023.
Khan, Mohd Imran , Subharthi Sarkar , and Rajib Maity . (2023). "Artificial Intelligence/Machine Learning Techniques in Hydroclimatology: A Demonstration of Deep Learning for Future Assessment of Stream Flow under Climate Change." In Visualization Techniques for Climate Change with Machine Learning and Artificial Intelligence, pp. 247–73. Elsevier.

Krentzel, D ., Shorte, S. L. , & Zimmer, C . (2023). Deep learning in image-based phenotypic drug discovery. Trends in cell biology, *33* (7), 538–554.
Lan, Chou-Chin , et al. (2022). Deep Learning-based Artificial Intelligence Improves Accuracy of Error-prone Lung Nodules. International Journal of Medical Sciences, 19(3).
Lee, Jaekyu , and Sangyub Lee . (2023). “Construction Site Safety Management: A Computer Vision and Deep Learning Approach.” Sensors, 23(2): 944.
Lei, Shijun , and Huiming Liu . (2022). Deep Learning Dual Neural Networks in the Construction of Learning Models for Online Courses in Piano Education. Computational Intelligence and Neuroscience, 2022.
Li, Hengyi , et al. (2023). “An Architecture-Level Analysis on Deep Learning Models for Low-Impact Computations.” Artificial Intelligence Review, 56(3): 1971–2010.
Li, Weiyan . (2022). Analysis of Piano Performance Characteristics by Deep Learning and Artificial Intelligence and Its Application in Piano Teaching. Frontiers in Psychology, 12.
Lin, Dana J ., Sven S. Walter , and Jan Fritz . (2023). “Artificial Intelligence–Driven Ultra-Fast Superresolution MRI: 10-Fold Accelerated Musculoskeletal Turbo Spin Echo MRI Within Reach.” Investigative Radiology, 58(1): 28–42.
Liu, Chi-Yun , and Jui-Sheng Chou . (2023). “Bayesian-Optimized Deep Learning Model to Segment Deterioration Patterns underneath Bridge Decks Photographed by Unmanned Aerial Vehicle.” Automation in Construction 146: 104666.
Liu, L . (2023). Study on the Influence of Deep Learning and Artificial Intelligence on Transportation and Mobility Industry and Corporations. In Proceedings of the 2022 2nd International Conference on Business Administration and Data Science (BADS 2022).
Mehralivand, Sherif , et al. (2022). Deep Learning-Based Artificial Intelligence for Prostate Cancer Detection at Biparametric MRI. Abdominal Radiology, 47(4).
Minaee, S ., Abdolrashidi, A ., Su, H ., Bennamoun, & Zhang, D . (2023). Biometrics recognition using deep learning: a survey. Artificial Intelligence Review, *56* , 8647-8695.
Mughaid, Ala , et al. (2023). “Improved Dropping Attacks Detecting System in 5g Networks Using Machine Learning and Deep Learning Approaches.” Multimedia Tools and Applications, 82(9): 13973–95.
Novakovsky, Gherman , et al. (2023). “Obtaining Genetics Insights from Deep Learning via Explainable Artificial Intelligence.” Nature Reviews Genetics, 24(2): 125–37.
Park, Seungman , Anna L. Chien , Beiyu Lin , and Keva Li . (2023). “FACES: A Deep-Learning-Based Parametric Model to Improve Rosacea Diagnoses.” Applied Sciences, 13(2): 970.
Pico, Lilia Edith Aparicio , Oscar Julián Amaya Marroquín , and Paola Andrea Devia . (2023). “Application of Deep Learning for the Identification of Surface Defects Used in Manufacturing Quality Control and Industrial Production: A Literature Review.” Reproduction, e18934.
Rodrigues, Terrance , and Rajesh Keswani . (2023). “Endoscopy Training in the Age of Artificial Intelligence: Deep Learning or Artificial Competence?” Clinical Gastroenterology and Hepatology, 21(1): 8–10.
Sardanelli, Francesco , et al. (2023). “Artificial Intelligence (AI) in Biomedical Research: Discussion on Authors’ Declaration of AI in Their Articles Title.” European Radiology Experimental, 7(1): 2.
Schmitt, Marc . (2023). “Deep Learning in Business Analytics: A Clash of Expectations and Reality.” International Journal of Information Management Data Insights, 3(1): 100146.
Serey, Joel , et al. (2023). Pattern Recognition and Deep Learning Technologies, Enablers of Industry 4.0, and Their Role in Engineering Research. In *Symmetry* (Vol. 15, Issue 2).
Shafik, Wasswa , and Mojtaba S. Matinkhah . (2021). “Unmanned Aerial Vehicles Analysis to Social Networks Performance.” The CSI Journal on Computer Science and Engineering, 18(2): 24-31.
Shafik, Wasswa , Mojtaba Matinkhah , and Mamman Nur Sanda . (2020). “Network Resource Management Drives Machine Learning: A Survey and Future Research Direction.” Journal of Communications Technology, Electronics and Computer Science, 2020: 1-15.
Shafik, Wasswa , Mojtaba S. Matinkhah , Mamman Nur Sanda , and Fawad Shokoor . (2021). “Internet of Things-Based Energy Efficiency Optimization Model in Fog Smart Cities.” JOIV: International Journal on Informatics Visualization, 5(2): 105-112.
Shafik, Wasswa . (2023). “Cyber Security Perspectives in Public Spaces: Drone Case Study.” In Handbook of Research on Cybersecurity Risk in Contemporary Business Systems, pp. 79-97. IGI Global.
Shokoor, Fawad , Wasswa Shafik , and Mojtaba S. Matinkhah . (2022). “Overview of 5G & Beyond Security.” EAI Endorsed Transactions on Internet of Things 8(30).
Shuaib, M ., J. Jaafar , M. Faizuddin , and S. Musa . (2022). Review on Recent Trends and Challenges in Deep Learning and Artificial Intelligence. AIP Conference Proceedings, 2617.
Shubham, Shubham , et al. (2023). Identify Glomeruli in Human Kidney Tissue Images using a Deep Learning Approach. Soft Computing, 27(5).
Soori, Mohsen , Behrooz Arezoo , and Roza Dastres . (2023). “Machine Learning and Artificial Intelligence in CNC Machine Tools, A Review.” Sustainable Manufacturing and Service Economics, 100009 : 1-12.
Sujith, A. V. L. N. , et al. (2022). Systematic Review of Smart Health Monitoring using Deep Learning and Artificial Intelligence. Neuroscience Informatics, 2(3).

Surendiran, R ., M. Thangamani , S. Monisha , and P. Rajesh . (2022). Exploring the Cervical Cancer Prediction by Machine Learning and Deep Learning with Artificial Intelligence Approaches. International Journal of Engineering Trends and Technology, 70(7).
Tang, A ., Tian, L ., Gao, K ., Liu, R ., Hu, S ., Liu, J ., Xu, J ., Fu, T ., Zhang, Z ., Wang, W ., Zeng, L ., Qu, W ., Dai, Y ., Hou, R ., Tang, S ., & Wang, X . (2023). Contrast-enhanced harmonic endoscopic ultrasound (CH-EUS) MASTER: A novel deep learning-based system in pancreatic mass diagnosis. Cancer medicine, *12* (7), 7962–7973.
Thurzo, Andrej , et al. (2023). “Impact of Artificial Intelligence on Dental Education: A Review and Guide for Curriculum Update.” Education Sciences, 13(2): 150.
Turkbey, Baris , and Masoom A. Haider . (2022). Deep learning-Based Artificial Intelligence Applications in Prostate MRI: Brief Summary. In British Journal of Radiology (Vol. 95, Issue 1131).
Vahadane, Abhishek , et al. (2023). “Development of an Automated Combined Positive Score Prediction Pipeline Using Artificial Intelligence on Multiplexed Immunofluorescence Images.” Computers in Biology and Medicine, 152: 106337.
Wang, Yu . (2022). Safety Production Supervision of Industrial Enterprises Based on Deep Learning and Artificial Intelligence. Mobile Information Systems, 2022.
Wu, Fei , Yu Chen , and Dan Han . (2022). Development Countermeasures of College English Education Based on Deep Learning and Artificial Intelligence. Mobile Information Systems, 2022.
Wu, L ., Pei, J ., Tang, J ., Xia, Y ., & Guo, X . (2023). Deep Learning on Graphs: Methods and Applications (DLG-KDD2023). Proceedings of the 29th ACM SIGKDD Conference on Knowledge Discovery and Data Mining.
Wu, Qingjie , et al. (2023). Application of Deep-Learning–Based Artificial Intelligence in Acetabular Index Measurement. Frontiers in Pediatrics, 10.
Yao, Jun , Alisa Craig , Wasswa Shafik , and Lule Sharif . (2021). “Artificial Intelligence Application in Cybersecurity and Cyberdefense.” Wireless Communications & Mobile Computing (Online) 2021: 1-10.
Yu, Haiyun , et al. (2023). A Deep-Learning-Based Artificial Intelligence System for the Pathology Diagnosis of Uterine Smooth Muscle Tumor. Life, 13(1).
Zhang, Bo , Jun Zhu , and Hang Su . (2023). “Toward the Third Generation Artificial Intelligence.” Science China Information Sciences, 66 (2): 1–19.
Zhao, Liguo , et al. (2022). “Artificial Intelligence Analysis in Cyber Domain: A Review.” International Journal of Distributed Sensor Networks, 18 (4): 15501329221084882.
Zhu, Qinlei , and Hao Zhang . (2022). Teaching Strategies and Psychological Effects of Entrepreneurship Education for College Students Majoring in Social Security Law Based on Deep Learning and Artificial Intelligence. Frontiers in Psychology, 13.

Deep Learning is a State-of-the-Art Approach to Artificial Intelligence

LeCun, Y . et al., “Gradient-Based Learning Applied to Document Recognition,” Proceedings of the IEEE, vol. 86, no. 11, pp. 2278–2324, Nov. 1998.
Krizhevsky, A . et al., “ImageNet Classification with Deep Convolutional Neural Networks,” in Advances in Neural Information Processing Systems (NIPS), 2012.
He, K . et al., “Deep Residual Learning for Image Recognition,” in IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2016.
Sutskever, I . et al., “Sequence to Sequence Learning with Neural Networks,” in Advances in Neural Information Processing Systems (NIPS), 2014.
Socher, R . et al., “Recursive Deep Models for Semantic Compositionality Over a Sentiment Treebank,” in Proceedings of the 2013 Conference on Empirical Methods in Natural Language Processing (EMNLP), 2003.
Graves, A . et al., “Speech Recognition with Deep Recurrent Neural Networks,” in IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), 2003.
Vaswani, A . et al., “Attention Is All You Need,” in Advances in Neural Information Processing Systems (NIPS), 2017.
See, A . et al., “Get To The Point: Summarization with Pointer-Generator Networks,” in Proceedings of the 55th Annual Meeting of the Association for Computational Linguistics (ACL), 2017.
Devlin, J . et al., “BERT: Pre-training of Deep Bidirectional Transformers for Language Understanding,” in Proceedings of the 2019 Conference of the North American Chapter of the Association for Computational Linguistics (NAACL), 2019.
Vinyals, O . et al., “A Neural Conversational Model,” in Proceedings of the 32nd International Conference on Machine Learning (ICML), 2015.
Hochreiter, S . and Schmidhuber, J . “Long Short-Term Memory,” Neural Computation, vol. 9, no. 8, pp. 1735–1780, Nov. 1997.

Hannun, A . et al., “Deep Speech: Scaling Up End-to-End Speech Recognition,” arXiv preprint arXiv:1412.5567, 2014.
Hinton, G . et al.., “Deep Neural Networks for Acoustic Modeling in Speech Recognition,” IEEE Signal Processing Magazine, vol. 29, no. 6, pp. 82–97, Nov. 2012.
He, Y . et al., “Neural Collaborative Filtering,” in Proceedings of the 26th International Conference on World Wide Web (WWW), 2017.
Koren, Y . et al., “Matrix Factorization Techniques for Recommender Systems,” IEEE Computer, vol. 42, no. 8, pp. 30–37, Aug. 2009.
Bojarski, M . et al., “End to End Learning for Self-Driving Cars,” arXiv preprint arXiv:1604.07316, 2016.
Chen, Y . et al., “DeepDriving: Learning Affordance for Direct Perception in Autonomous Driving,” in IEEE International Conference on Computer Vision (ICCV), 2015.
Esteva, A . et al., “Dermatologist-level Classification of Skin Cancer with Deep Neural Networks,” Nature, vol. 542, no. 7639, pp. 115–118, Feb. 2017.
Rajkomar, A . et al., “Scalable and Accurate Deep Learning for Electronic Health Records,” NPJ Digital Medicine, vol. 1, no. 1, pp. 18, 2018.
Poplin, R . et al., “Prediction of Cardiovascular Risk Factors from Retinal Fundus Photographs via Deep Learning,” Nature Biomedical Engineering, vol. 2, no. 3, pp. 158–164, Mar. 2018.
Graves, A . et al., “Towards End-to-End Speech Recognition with Recurrent Neural Networks,” in IEEE International Conference on Machine Learning (ICML), 2014.
Mitchell, M . et al., “Model Cards for Model Reporting,” in Proceedings of the Conference on Neural Information Processing Systems (NeurIPS), 2018.
Bolukbasi, T . et al., “Man is to Computer Programmer as Woman is to Homemaker? Debiasing Word Embeddings,” in Proceedings of the Conference on Neural Information Processing Systems (NeurIPS), 2016.
Goodfellow, I. J. et al., “Deep Learning,” Nature, vol. 521, no. 7553, pp. 436–444, May 2015.
Jouppi, J . et al., “In-Datacenter Performance Analysis of a Tensor Processing Unit,” in Proceedings of the 44th Annual International Symposium on Computer Architecture (ISCA), 2017.
Abadi, M . et al., “TensorFlow: A System for Large-Scale Machine Learning,” in Proceedings of the 12th USENIX Symposium on Operating Systems Design and Implementation (OSDI), 2016.
Paszke, A . et al.., “PyTorch: An Imperative Style, High-Performance Deep Learning Library,” in Advances in Neural Information Processing Systems (NIPS), 2019.
Selvaraju, V . et al., “Grad-CAM: Visual Explanations from Deep Networks via Gradient-Based Localization,” in Proceedings of the IEEE International Conference on Computer Vision (ICCV), 2017.
Ribeiro, M. T. et al., “Why Should I Trust You? Explaining the Predictions of Any Classifier,” in Proceedings of the ACM SIGKDD International Conference on Knowledge Discovery and Data Mining (KDD), 2016.
Mnih, V . et al., “Human-level Control through Deep Reinforcement Learning,” Nature, vol. 518, no. 7540, pp. 529–533, Feb. 2015.
LeCun, Y . et al., “Deep Learning,” Nature, vol. 521, no. 7553, pp. 436–444, May 2015.
Goodfellow, I. J. et al., “Generative Adversarial Nets,” in Advances in Neural Information Processing Systems (NIPS), 2014.
Bengio, Y . “Deep Learning of Representations: Looking Forward,” in Proceedings of the International Joint Conference on Artificial Intelligence (IJCAI), 2003.
Finn, C . et al., “Model-Agnostic Meta-Learning for Fast Adaptation of Deep Networks,” in Proceedings of the International Conference on Machine Learning (ICML), 2017.
Li, Z . and Hoiem, D . “Learning Without Forgetting,” IEEE Transactions on Pattern Analysis and Machine Intelligence (TPAMI), vol. 40, no. 12, pp. 2935–2947, Dec. 2018.
Mitchell, T . et al., “Artificial Intelligence: A Report of the 2019 AAAI/ACM Conference on AI, Ethics, and Society,” ACM SIGAI Ethics and Artificial Intelligence, vol. 1, no. 1, Article 8, Jan. 2020.
LeCun, Y . et al., “Gradient-Based Learning Applied to Document Recognition,” Proceedings of the IEEE, vol. 86, no. 11, pp. 2278–2324, Nov. 1998.
Krizhevsky, A . et al., “ImageNet Classification with Deep Convolutional Neural Networks,” in Advances in Neural Information Processing Systems (NIPS), 2012.
He, K . et al., “Deep Residual Learning for Image Recognition,” in IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2016.
Everingham, M . et al.., “The PASCAL Visual Object Classes Challenge: A Retrospective,” International Journal of Computer Vision, vol. 111, no. 1, pp. 98–136, Jan. 2015.
Hochreiter, S . and Schmidhuber, J . “Long Short-Term Memory,” Neural Computation, vol. 9, no. 8, pp. 1735–1780, Nov. 1997.
Cho, K . et al., “Learning Phrase Representations using RNN Encoder-Decoder for Statistical Machine Translation,” in Proceedings of the Conference on Empirical Methods in Natural Language Processing (EMNLP), 2014.
Goodfellow, I . et al., “Generative Adversarial Networks,” in Advances in Neural Information Processing Systems (NIPS), 2014.

Mnih, V . et al., “Human-level Control through Deep Reinforcement Learning,” Nature, vol. 518, no. 7540, pp. 529–533, Feb. 2015.
Silver, D . et al.., “Mastering the Game of Go with Deep Neural Networks and Tree Search,” Nature, vol. 529, no. 7587, pp. 484–489, Jan. 2016.
Vaswani, A . et al., “Attention Is All You Need,” in Advances in Neural Information Processing Systems (NIPS), 2017.
LeCun, Y . et al., “Gradient-Based Learning Applied to Document Recognition,” Proceedings of the IEEE, vol. 86, no. 11, pp. 2278–2324, Nov. 1998.
Vaswani, A . et al., “Attention Is All You Need,” in Advances in Neural Information Processing Systems (NIPS), 2017.
Hinton, G . et al., “Deep Neural Networks for Acoustic Modeling in Speech Recognition: The Shared Views of Four Research Groups,” IEEE Signal Processing Magazine, vol. 29, no. 6, pp. 82–97, Nov. 2012.
Cheng, H . et al., “Wide & Deep Learning for Recommender Systems,” in Proceedings of the ACM Conference on Recommender Systems (RecSys), 2016.
LeCun, Y . et al., “Gradient-Based Learning Applied to Document Recognition,” Proceedings of the IEEE, vol. 86, no. 11, pp. 2278–2324, Nov. 1998.
Hochreiter, S . and Schmidhuber, J . “Long Short-Term Memory,” Neural Computation, vol. 9, no. 8, pp. 1735–1780, Nov. 1997.
Vaswani, V . et al.., “Attention Is All You Need,” in Advances in Neural Information Processing Systems (NIPS), 2017.
Chen, J . et al., “Big Self-Supervised Models Are Strong Semi-Supervised Learners,” in Advances in Neural Information Processing Systems (NIPS), 2020.
Bengio, Y . “Deep Learning of Representations: Looking Forward,” in Statistical Language and Speech Processing, Lecture Notes in Computer Science, 2003.
Doshi-Velez, F . and Kim, B . “Towards a Rigorous Science of Interpretable Machine Learning,” arXiv preprint arXiv:1702.08608, 2017.
Bolukbasi, T . et al., “Man is to Computer Programmer as Woman is to Homemaker? Debiasing Word Embeddings,” in Proceedings of the Conference on Neural Information Processing Systems (NeurIPS), 2016.
Goodfellow, I. J. et al., “Deep Learning,” Nature, vol. 521, no. 7553, pp. 436–444, May 2015.
Redmon, J . and Farhadi, A . “YOLO9000: Better, Faster, Stronger,” in Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2017.
Lakkaraju, H . et al., “Identifying Unknown Unknowns in the Open World: Representations and Policies for Guided Exploration,” in Proceedings of the AAAI Conference on Artificial Intelligence (AAAI), 2017.
Selvaraju, V . et al., “Grad-CAM: Visual Explanations from Deep Networks via Gradient-Based Localization,” in Proceedings of the IEEE International Conference on Computer Vision (ICCV), 2017.
Mnih, V . et al., “Human-level Control through Deep Reinforcement Learning,” Nature, vol. 518, no. 7540, pp. 529–533, Feb. 2015.
Goodfellow, I . et al., “Generative Adversarial Networks,” in Advances in Neural Information Processing Systems (NIPS), 2014.
Pearl, J. M. “Reasoning with Cause and Effect,” in Proceedings of the AAAI Conference on Artificial Intelligence (AAAI), 2018.
Topol, E . “High-performance Medicine: The Convergence of Human and Artificial Intelligence,” Nature Medicine, vol. 25, no. 1, pp. 44–56, Jan. 2019.

Unleashing the Power

Alzubaidi, Laith, Jinglan Zhang, Amjad J. Humaidi, Ayad Al-Dujaili, Ye Duan, Omran Al-Shamma, J. Santamaría, Mohammed A. Fadhel, Muthana Al-Amidie, and Laith Farhan. 2021. “Review of deep learning: Concepts, CNN architectures, challenges, applications, future directions.” Journal of Big Data 8. Accessed June 6, 2023.
Antoniadis, Panagiotis. 2016. Using GANs for Data Augmentation. March 23. Accessed June 6, 2023. www.baeldung.com/cs/ml-gan-data-augmentation
Boesch, Gaudenz. n.d. Deep Neural Network: The 3 Popular Types (MLP, CNN and RNN). https://viso.ai/deep-learning/deep-neural-network-three-popular-types/
Brownlee, Jason. 2019. 18 Impressive Applications of Generative Adversarial Networks (GANs). June 14. Accessed June 6, 2023. https://machinelearningmastery.com/impressive-applications-of-generative-adversarial-networks/
Donges, Niklas. 2023. A Guide to Recurrent Neural Networks: Understanding RNN and LSTM Networks. February 28. Accessed June 2, 2023. https://builtin.com/data-science/recurrent-neural-networks-and-lstm
Gavrilova, Yulia. 2020. An Overview of Machine Learning Optimization Techniques. December 2. Accessed June 6, 2023. https://serokell.io/blog/ml-optimization

Gupta, Sakshi. 2021. How Deep Learning Revolutionized NLP. January 24. Accessed June 2, 2023. www.springboard.com/blog/data-science/nlp-deep-learning/
Gurucharan, M. K. 2022. Basic CNN Architecture: Explaining 5 Layers of Convolutional Neural Network. July 28. Accessed June 6, 2023. www.upgrad.com/blog/basic-cnn-architecture/#:~:text=CNNs%20are%20a%20class%20of,vision%20and%20natural%20language%20processing
Hung, Che-Lun. 2023. "Deep learning in biomedical informatics." Intelligent Nanotechnology 307-329. Accessed June 2, 2023.
Janiesch, Christian, Patrick Zschech, and Kai Heinrich. 2021. "Machine learning and deep learning." Electronic Markets 31: 685-695. Accessed June 2, 2023.
Jayawardhana, Santhoopa. 2020. Sequence Models & Recurrent Neural Networks (RNNs). July 27. Accessed June 6, 2023. https://towardsdatascience.com/sequence-models-and-recurrent-neural-networks-rnns-62cadeb4f1e1
Johnson, Daniel. 2023. Back Propagation in Neural Network: Machine Learning Algorithm. May 6. Accessed 6 6, 2023. www.guru99.com/backpropogation-neural-network.html
Kumar, Ajitesh. 2021. Real-world Applications of Convolutional Neural Network (CNN). November 6. Accessed June 6, 2023. https://vitalflux.com/real-world-applications-of-convolutional-neural-networks/
Liu, Di, Hao Kong, Xiangzhong Luo, Weichen Liu, and Ravi Subramaniam. 2022. "Bringing AI to edge: From deep learning's perspective." Neurocomputing 485: 297-320. Accessed June 2, 2023.
Madan, Piyush. 2020. An Introduction to Deep Learning. March 2. Accessed June 2, 2023. https://developer.ibm.com/articles/an-introduction-to-deep-learning/
Menzli, Amal. 2023. Graph Neural Network and Some of GNN Applications: Everything You Need to Know. April 26. Accessed June 6, 2023. https://neptune.ai/blog/graph-neural-network-and-some-of-gnn-applications
Nabriya, Pratik. 2021. Perceptron: Building Block of Artificial Neural Network. October 21. Accessed June 2, 2023. www.analyticsvidhya.com/blog/2021/10/perceptron-building-block-of-artificial-neural-network/
Saha, Sumit. 2018. A Comprehensive Guide to Convolutional Neural Networks — the ELI5 Way. December 15. Accessed June 2, 2023. https://saturncloud.io/blog/a-comprehensive-guide-to-convolutional-neural-networks-the-eli5-way/
Sarker, Iqbal H. 2021. "Deep Learning: A Comprehensive overview on techniques, taxonomy, applications and research directions." SN Computer Science 2. Accessed June 2, 2023.
Saxena, Shipra. 2021. Introduction to The Architecture of Alexnet. March 19. Accessed June 2, 2023. www.analyticsvidhya.com/blog/2021/03/introduction-to-the-architecture-of-alexnet/#:~:text=Alexnet%20won%20the%20Imagenet%20large,Alex%20Krizhevsky%20and%20his%20colleagues
Sharma, Prashant. 2022. Feedforward Neural Network: Its Layers, Functions, and Importance. January 18. Accessed June 2, 2023. www.analyticsvidhya.com/blog/2022/01/feedforward-neural-network-its-layers-functions-and-importance/
Thomas, Christopher. 2019. Recurrent Neural Networks and Natural Language Processing. June 9. Accessed June 6, 2023. https://towardsdatascience.com/recurrent-neural-networks-and-natural-language-processing-73af640c2aa1
Vaseekaran, Varatharajah. 2022. GANs for Synthetic Data Generation. August 2. Accessed June 6, 2023. https://towardsai.net/p/l/gans-for-synthetic-data-generation
Vaswani, Ashish, Noam Shazeer, Niki Parmar, Jakob Uszkoreit, Llion Jones, Aidan N. Gomez, Łukasz Kaiser, and Illia Polosukhin. 2017. "Attention Is All You Need." Edited by I. Guyon, U. Von Luxburg, S. Bengio, H. Wallach, R. Fergus, S. Vishwanathan and R. Garnett. NeurIPS Proceedings. Accessed June 6, 2023. https://papers.nips.cc/paper_files/paper/2017/hash/3f5ee243547dee91fbd053c1c4a845aa-Abstract.html
West, Darrell M., and John R. Allen. 2018. "How artificial intelligence is transforming the world." Accessed June 2, 2023. www.brookings.edu/research/how-artificial-intelligence-is-transforming-the-world/

Deep Learning for ECG Classification

Burak Tasci . "Automated ischemic acute infarction detection using pre-trained CNN models' deep features." Biomedical Signal Processing and Control, 2023.
Jianwei Zheng , et al. "A 12-lead electrocardiogram database for arrhythmia research covering more than 10,000 patients." Scientific Data, 2020: 1–8.
Laith Alzubaidi , et al. "Review of deep learning: Concepts, CNN architectures, challenges, applications, future directions." Journal of Big Data, 2021: 1–74.
Muthulakshmi, M. , Kavitha, G . "Deep CNN with LM learning Based Myocardial Ischemia Detection in Cardiac Magnetic Resonance Images." 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC). IEEE, 2019.

Neptune.AI. n.d. https://neptune.ai/blog/performance-metrics-in-machine-learning-complete-guide
Parul Madan , et al. “A hybrid deep learning approach for ECG-based Arrhythmia classification.” Bioengineering, 2022: 152–157.
Qing Pan , Xinyi Li , & Luping Fang . “Data augmentation for deep learning-based ECG analysis.” Feature Engineering and Computational Intelligence in ECG Monitoring, 2020: 91–111.
Shraddha Singha , Saroj Kumar Pandeyb , Urja Pawarc , & Rekh Ram Jangheld . “Classification of ECG Arrhythmia using Recurrent Neural Networks.” International Conference on Computational Intelligence and Data Science. Elsevier, 2018. 1290–1297.
Shubhojeet Chatterjee , et al. “Review of noise removal techniques in ECG signals.” IET Signal Processing, 2020: 569–692.
Sucharita Mitra Sarkar , & Priyanka Samanta . “Performance evaluation of a modified ECG De-noising.” Journal of Electrical and Electronic Engineering, 2023: 89–98.
Sujadevi, V. G. , Soman, K. P. , & Vinayakumar, R .. “Real-time detection of Atrial fibrillation from short time single lead ECG traces using recurrent neural networks.” Intelligent Systems Technologies and Applications, 2017: 212–221.

Social Distancing Detection System Using Single Shot Detection (SSD) and Neural Networks

Information regarding covid-19 pandemic [online] Available at https://en.wikipedia.org/wiki/COVID-19
Preventive measures and guidelines declared by WHO for covid-19 [online] Available at: www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public
Zhao, L. , and Li, S . “Object detection algorithm based on improved YOLOv3”, Electronics, vol. 9, no. 3, MDPI AG, Mar. 2020, pp. 537. Crossref.
Li, Z ., Dong, Y ., Wen, Y ., Xu, H ., and Wu, J . “A deep pedestrian tracking SSD-based model in the sudden emergency or violent environment”, Journal of Advanced Transportation, vol. 2021, 2021, pp. 13, Article ID 2085876.
Mathurkar, G. , Parkhi, C. , Utekar, M ., and Chitte, P. Ms. “Ensuring social distancing using machine learning”, ITM Web of Conferences, vol. 40, 2021, pp. 03049, ICACC-2021.
Saponara, S. , Elhanashi, A. , and Qinghe, Z . “ Developing a real-time social distancing detection system based on YOLOv4-tiny and bird-eye view for COVID-19“, Journal of Real-Time Image Processing, vol. 19, 2022, pp. 1-13.
Naqiyuddin, F. A. A. , Mansor, W ., Sallehuddin, N. M. , Mohd Johari, M. N. S. , Shazlan, M. A. S. , and Bakar, A. N. “Wearable Social Distancing Detection System,” 2020 IEEE International RF and Microwave Conference (RFM), Kuala Lumpur, Malaysia, 2020, pp. 1-4.
Jia, S ., Diao, C ., Zhang, G ., Dun, A ., Sun, Y ., Li, X ., and Zhang, X . Object Detection Based on the Improved Single Shot MultiBox Detector. In Proceedings of the International Symposium on Power Electronics and Control Engineering (ISPECE), Xi’an, China, December 2018, pp. 28–30.
SSD object detection: Single Shot MultiBox Detector for real-time processing [online] Available at: https://jonathan-hui.medium.com/ssd-object-detection-single-shot-multibox-detector-for-real-time-processing-9bd8deac0e06
SSD: Single Shot Detector for object detection using MultiBox [online] Available at: https://towardsdatascience.com/ssd-single-shot-detector-for-object-detection-using-multibox-1818603644ca
Object detection using multibox detector [online] Available at: https://cv-tricks.com/object-detection/single-shot-multibox-detector-ssd/
Calculating Manhattan Distance [online] Available at: www.omnicalculator.com/math/manhattan-distance
www.youtube.com/watch?v=XgAcTEjDHnA
www.pexels.com/video

Recognition of Voice and Speech Using NLP Techniques

Kumar Mr , & Ekta Walia . “Analysis of Various Biometric Techniques”, (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 2, Issue 4, 2011, pp. 1595-1597.
Bansal, Mohit , & K. Thivakaran . “Analysis of Speech Recognition using Convolutional Neural Network”, Journal of Engineering Sciences”, Vol. 11, Issue 1, Jan 2020.
Sanjay, Krishna , Gouda Kanetkar Salil , Vrindavan Harrison , & Manfred Warmuth . “Speech Recognition: Key Word Spotting through Image Recognition”, 2020.

Kulkarni, Nidhi A . & Satish P. Deshpande . “Speech Recognition using Convolutional Network”, 2019.
Dr. Jaydeep Patil , Atharva Shewale , Ekta Bhushan , Alister Fernandes , & Rucha Khartadkar . “ A Voice Based Assistant Using Google Dialogflow and Machine Learning”, International Journal of Scientific Research in Science and Technology(IJSRST), Vol. 8, Issue 3, May-June-2021, pp. 06–17. Print ISSN: 2395-6011, Online ISSN: 2395-602X
Sunitha, C ., & Chandra, Evania . “Speaker Recognition using MFCC and Improved Weighted Vector Quantization Algorithm”, International Journal of Engineering and Technology, Vol. 7, 2015, pp. 1685–1692.
Suksri, S ., & T. Yingthawornsuk . “Speech Recognition using MFCC”, 2012.
Ibrahim, H ., & A. Varol . “A Study on Automatic Speech Recognition Systems,” 2020 8th International Symposium on Digital Forensics and Security (ISDFS), Beirut, Lebanon, 2020, pp. 1–5.
Djuraev, O . U., Khamdamov , S. Muminkhodjaeva , U. Abdullaev , & K. Akhmedova . “An In-Depth Analysis of Automatic Speech Recognition System,” 2021 International Conference on Information Science and Communications Technologies (ICISCT), Tashkent, Uzbekistan, 2021, pp. 1–5.
Pala, Mahesh . “A New Human Voice Recognition System.” AJSAT, Vol. 5, 2016, pp. 23-30.
www.mathworks.com/help/audio/ug/speaker-identification-using-pitch-and-mfcc.html
Indolia, Sakshi , Anil Kumar Goswami , S. P. Mishra , & Pooja Asopa . Conceptual Understanding of Convolutional Neural Network- A Deep Learning Approach, Procedia Computer Science, Vol. 132, 2018, pp. 679–688. ISSN 1877-0509.
Reynolds, D . Gaussian Mixture Models. In: Li, S.Z. , Jain, A . (eds) Encyclopedia of Biometrics. Springer, Boston, MA., 2009.
https://raw.githubusercontent.com/NVIDIA/NeMo/$BRANCH/scripts/dataset_processing/process_speech_commands_data.py
Jadhav, Dipti , & Udhav Bhosle . Video summarisation based on motion estimation using speeded up robust features, International Journal of Computational Vision and Robotics(IJCVR), Vol. 9, Issue 6, 2019.

Transfer Learning with Joint Fine-Tuning for Multimodal Sentiment Analysis

Medhat, W. , Hassan, A. , & Korashy, H . Sentiment analysis algorithms and applications: A survey. Ain Shams Engineering Journal. 2014 Dec 1;5(4), 1093–113.
Zhang, L. , Wang, S. , & Liu, B . Deep learning for sentiment analysis: A survey. Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery. 2018 Jul;8(4), e1253.
Hussein, D. M. A survey on sentiment analysis challenges. Journal of King Saud University-Engineering Sciences. 2018 Oct 1;30(4), 330–8.
Prabowo, R. , & Thelwall, M . Sentiment analysis: A combined approach. Journal of Informetrics. 2009 Apr 1;3(2), 143–57.
Gonçalves, P. , Araújo, M. , Benevenuto, F. , & Cha, M . (2013 Oct 7). Comparing and combining sentiment analysis methods. In Proceedings of the first ACM conference on Online social networks (pp. 27–38).
Whitelaw, C. , Garg, N. , & Argamon, S . (2005 Oct 31). Using appraisal groups for sentiment analysis. In Proceedings of the 14th ACM international conference on Information and knowledge management (pp. 625–631).
Tan, S , & Zhang, J . An empirical study of sentiment analysis for Chinese documents. Expert Systems with Applications. 2008 May 1;34(4), 2622–9.

Machine Learning for Traffic Flow Prediction Addressing Congestion Challenges

Bishop, C. M. (2006). Pattern Recognition and Machine Learning. Springer.
Chen, S ., et al. (2018). Short-term traffic flow prediction with long short-term memory network. IEEE Transactions on Intelligent Transportation Systems, 19(2), 570–579.
Chen, X ., Xu, H ., Liu, Y ., Cao, D ., & Zhao, H . (2021). Adaptive traffic flow prediction based on self-attention mechanism and local trend. IET Intelligent Transport Systems, 15(5), 590–600.
Hastie, T ., Tibshirani, R ., & Friedman, J . (2009). The Elements of Statistical Learning. Springer.
He, J ., Zhang, M ., Ding, Z ., & Zhao, D . (2019). ST-MetaNet: Learning to predict spatiotemporal properties of traffic flow with deep meta-learning. IEEE Transactions on Intelligent Transportation Systems, 21(10), 4428–4438.
Hu, X ., et al. (2019). Traffic flow prediction using a hybrid clustering and recurrent neural network approach. IEEE Transactions on Intelligent Transportation Systems, 20(6), 2132–2142.
Jain, A. K. , et al. (1999). Data clustering: A review. ACM Computing Surveys (CSUR), 31(3), 264–323.

Jain, A. K. , et al. (1999). Data clustering: A Review. ACM Computing Surveys (CSUR), 31(3), 264–323.
James, G ., et al. (2013). An Introduction to Statistical Learning. Springer.
Kaelbling, L. P. , Littman, M. L. , & Moore, A. W. (1996). Reinforcement Learning: A Survey. Journal of Artificial Intelligence Research, 4, 237–285.
Liu, X ., Wang, L ., & Lv, Y . (2020). Traffic flow prediction with multi-granularity temporal correlation learning. IEEE Transactions on Intelligent Transportation Systems, 22(4), 2194–2204.
Lv, Y ., Duan, Y ., Kang, W ., & Li, L . (2014). Traffic flow prediction with spatiotemporal correlations using big data. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 7(6), 1814–1823.
Lv, Y ., Wang, L ., Li, L ., & Lv, Q . (2020). Traffic flow prediction with multi-channel graph convolutional networks. IEEE Transactions on Intelligent Transportation Systems, 22(7), 4389–4399.
Ma, W ., et al. (2015). Traffic flow prediction with big data: A deep learning approach. IEEE Transactions on Intelligent Transportation Systems, 16(2), 865–873.
Ma, Y ., & Hu, S . (2015). A review on the prediction of traffic flow pattern using machine learning techniques. Journal of Traffic and Transportation Engineering (English Edition), 2(3), 157–164.
Mitchell, T . (1997). Machine Learning. McGraw-Hill.
Mnih, V ., et al. (2015). Human-level control through deep reinforcement learning. Nature, 518(7540), 529–533.
Qi, Y ., et al. (2017). Traffic flow prediction with spatial-temporal correlation in big data environment. IEEE Transactions on Intelligent Transportation Systems, 18(11), 2965–2974.
Russell, S. J. , & Norvig, P . (2016). Artificial Intelligence: A Modern Approach (3rd ed.). Pearson.
Silver, D ., et al. (2016). Mastering the game of go with deep neural networks and tree search. Nature, 529(7587), 484–489.
Sutton, R. S. , & Barto, A. G. (2018). Reinforcement Learning: An Introduction (2nd ed.). MIT Press.
Tang, J ., et al. (2019). Spatiotemporal traffic flow prediction based on long short-term memory neural networks with a novel attention mechanism. Transportation Research Part C: Emerging Technologies, 107, 129–142.
Wang, D ., Liu, Y ., Xie, K ., Zhang, Z ., & Yan, X . (2019). Urban traffic flow prediction using a spatiotemporal graph convolutional neural network. Sensors, 19(16), 3561.
Wang, Z ., et al. (2020). Traffic flow prediction via hybrid deep learning: A survey. IEEE Transactions on Intelligent Transportation Systems, 21(1), 427–439.
Xu, Y ., Wu, S ., & Zhang, S . (2020). Short-term traffic flow prediction based on long short-term memory neural network with historical data augmentation. IEEE Access, 8, 12404–12415.
Yin, H ., et al. (2018). Short-term traffic flow prediction with a hybrid model combining LSTM and ARIMA. Transportation Research Part C: Emerging Technologies, 89, 110–124.
Yu, H ., Wang, X ., & Yin, B . (2017). Traffic flow prediction using LSTM recurrent neural networks. IEEE Access, 5, 20551–20559.
Zhang, X ., et al. (2016). Short-term traffic flow prediction: A spatiotemporal graph convolutional neural network approach. Transportation Research Part C: Emerging Technologies, 72, 74–93.
Zheng, S ., Lv, Y ., & Yang, Q . (2019). Traffic flow prediction with graph convolutional neural networks. IEEE Transactions on Intelligent Transportation Systems, 20(3), 1018–1030.
Zheng, Y ., et al. (2017). Traffic flow prediction with big data: A deep learning approach. IEEE Transactions on Intelligent Transportation Systems, 16(2), 865–873.

Enhancing Autistic Spectrum Disorder Diagnosis Using ML Techniques

Akyol, K., Gultepe, Y., and Karaci, A. 2018. “A Study on Autistic Spectrum Disorder for Children Based on Feature Selection and Fuzzy.” International Congress on Engineering and Life Science, 804–7.
Diabat, M. Al, and Al-Shanableh, N. 2019. “Ensemble Learning Model For Screening.” International Journal of Computer Science & Information Technology (IJCSIT) 11 (2): 13–14.
Lang, S., Bravo-Marquez, F., Beckham, C. and Hall, M. 2019. “WekaDeeplearning4j: A Deep Learning Package for Weka Based on DeepLearning4j.” no. May.
Lecun, Y., Bengio, Y., and Hinton, G. 2015. “Deep Learning.”
Misman, M. F., et al. 2019. “Classification of Adults with Autism Spectrum Disorder Using Deep Neural Network.” University of Edinburgh. Downloaded on June 14, 2020, at 19:47:17 UTC from IEEE Xplore.
Mohanty, A. S., Parida, P., and Patra, K. C. 2021. “ASD Classification for Children Using Deep Neural Network.” Global Transitions Proceedings 2 (2): 461–66.
Sahu, S. K., and Shrivas, A. K. 2020. “Comparative Study of Classification Models with Genetic Search Based Feature Selection Technique.” Cognitive Analytics, 773–83.
Sahu, S. K., and Verma, P. 2022. “Classification of Autistic Spectrum Disorder Using Deep Neural Network with Particle Swarm Optimization.” International Journal of Computer Vision and Image Processing (IJCVIP) 12 (1): 1–11.

Srivastava, N., Hinton, G., Krizhevsky, A., Sutskever, I., and Salakhutdinov, R. 2014. “Dropout: A Simple Way to Prevent Neural Networks from Overfitting.” Journal of Machine Learning Research 15: 1929–58.
Thabtah, F. 2017. “Autism Spectrum Disorder Screening: Machine Learning Adaptation and DSM-5 Fulfillment.” 1–6.
Thabtah, F, and Peebles, D. 2020. “A New Machine Learning Model Based on Induction of Rules for Autism Detection.” Health Informatics Journal 26 (1): 265–86.
Tripathi, N., Goshisht, M. K., Sahu, S. K., and Arora, C. 2021. “Applications of Artificial Intelligence to Drug Design and Discovery in the Big Data Era: A Comprehensive Review.” Molecular Diversity 25 (3): 1643–64.
Vaishali, R., and Sasikala, R. 2017. “A Machine Learning Based Approach to Classify Autism with Optimum Behaviour Sets.” International Journal of Engineering & Technology 5 (x): 1–6.
Verma, P. , Awasthi, V. K. , Sahu, S. K. , and Shrivas, A. K. 2022. “Coronary Artery Disease Classification Using Deep Neural Network and Ensemble Models Optimized by Particle Swarm Optimization.” International Journal of Applied Metaheuristic Computing (IJAMC *)* 13: 1–25.
Verma, P. , Awasthi, V. K. , Shrivas, A. K. , and Sahu, S. K. 2022. “Stacked Generalization Based Ensemble Model for Classification of Coronary Artery Disease.” In Internet of Things and Connected Technologies (Lecture Notes in Networks and Systems 340), edited by Rajiv Misra , Nishtha Kesswani , Muttukrishnan Rajarajan , Veeravalli Bharadwa , and Ashok Patel , Vol. 340, 1: 57–65. Springer International Publishing Cham.
Verma, P., Awasthi, V. K., and Sahu, S. K. 2021a. “A Novel Design of Classification of Coronary Artery Disease Using Deep Learning and Data Mining Algorithms.” Revue d ’ Intelligence Artificielle 35 (3): 209–15.
Verma, P., Awasthi, V. K., and Sahu, S. K. 2021b. “An Ensemble Model with Genetic Algorithm for Classification of Coronary Artery Disease.” International Journal of Computer Vision and Image Processing 11 (3): 70–83.
Wan, L., Zeiler, M., Zhang, S., LeCun, Y. and Fergus, R. 2013. “Generalizing Pooling Functions in CNNs: Mixed, Gated, and Tree.” In 30th International Conference on Machine Learning, Atlanta, Georgia, USA, 2013, 40: 863–75.
Wang, H., Li, L. , Chi, L., and Zhao, Z. 2019. “Autism Screening Using Deep Embedding Representation.” In Lecture Notes in Computer Science, Springer, Cham.
Zhao, R., Yan, R., Chen, Z., Mao, K., Wang, P., and Gao, R. X. 2019. “Deep Learning and Its Applications to Machine Health Monitoring.” Mechanical Systems and Signal Processing 115: 213–37.

Deep Learning: A State-Of-The-Art Approach To Artificial Intelligence “AI”

Goodfellow, I ., Bengio, Y ., & Courville, A . (2016). Deep Learning. MIT Press.
He, K ., Zhang, X ., Ren, S ., & Sun, J . (2015). Delving deep into rectifiers: Surpassing human-level performance on ImageNet classification. In Proceedings of the IEEE international conference on computer vision (pp. 1026–1034).
Huang, G ., Liu, Z ., Van Der Maaten, L ., & Weinberger, K. Q. (2017). Densely connected convolutional networks. In Proceedings of the IEEE conference on computer vision and pattern recognition (pp. 4700–4708).
LeCun, Y ., Bengio, Y ., & Hinton, G . (2015). Deep learning. Nature, 521(7553), 436–444.
Schmidhuber, J . (2015). Deep learning in neural networks: An overview. Neural Networks, 61, 85–117.
Dai, J ., Li, Y ., He, K ., & Sun, J . (2016). R-FCN: Object detection via region-based fully convolutional networks. In Advances in neural information processing systems (pp. 379–387).
Krizhevsky, A ., Sutskever, I ., & Hinton, G. E. (2012). ImageNet classification with deep convolutional neural networks. In Advances in neural information processing systems (pp. 1097–1105).
He, K ., Zhang, X ., Ren, S ., & Sun, J . (2016). Deep residual learning for image recognition. In Proceedings of the IEEE conference on computer vision and pattern recognition (pp. 770–778).
Siddiqui, S. A. , Yadav, A. K. , & Anwar, S . (2019). Deep learning-based prediction models for stock market forecasting: A survey. Expert Systems with Applications, 115, 419–435.
Szegedy, C ., et al. (2015). Going deeper with convolutions. In Proceedings of the IEEE conference on computer vision and pattern recognition (pp. 1–9).
Simonyan, K ., & Zisserman, A . (2014). Very deep convolutional networks for large-scale image recognition. arXiv preprint arXiv:1409.1556
Vaswani, A .et al. (2017). Attention is all you need. In Advances in neural information processing systems (pp. 5998–6008).
Bahdanau, D ., Cho, K ., & Bengio, Y . (2014). Neural machine translation by jointly learning to align and translate. arXiv preprint arXiv:1409.0473
Silver, D ., et al. (2016). Mastering the game of Go with deep neural networks and tree search. Nature, 529(7587), 484–489.
Mnih, V ., et al. (2015). Human-level control through deep reinforcement learning. Nature, 518(7540), 529–533.

Arjovsky, M ., Chintala, S ., & Bottou, L . (2017). Wasserstein generative adversarial networks. In International conference on machine learning (pp. 214–223).
Radford, A ., Metz, L ., & Chintala, S . (2015). Unsupervised representation learning with deep convolutional generative adversarial networks. arXiv preprint arXiv:1511.06434
Goodfellow, I ., et al. (2014). Generative adversarial nets.
Singh, D ., & Ghosh, P . (2019). Deep learning techniques for sentiment analysis: A review. International Journal of Information Management, 49, 427–436.
Kaiming, H ., Zhang, X ., Ren, S ., & Sun, J . (2016). Identity mappings in deep residual networks. In European conference on computer vision (pp. 630–645).
Kingma, D. P. , & Ba, J . (2014). Adam: A method for stochastic optimization. arXiv preprint arXiv:1412.6980
Kingma, D. P. , & Ba, J . (2014). Adam: A method for stochastic optimization. arXiv preprint arXiv:1412.6980
Abadi, M ., et al. TensorFlow: A system for large-scale machine learning. In 12th {USENIX} Symposium on Operating Systems Design and Implementation ({OSDI} 16) (pp. 265–283).
Redmon, J ., Divvala, S ., Girshick, R ., & Farhadi, A . (2016). You only look once: Unified, real-time object detection. In Proceedings of the IEEE conference on computer vision and pattern recognition (pp. 779–788).
Liu, W ., Anguelov, D ., Erhan, D ., Szegedy, C ., Reed, S ., Fu, C. Y. , & Berg, A. C. (2016). SSD: Single shot multibox detector. In European conference on computer vision (pp. 21–37).
Szegedy, C ., Ioffe, S ., Vanhoucke, V ., & Alemi, A. A. (2017). Inception-v4, Inception-ResNet and the impact of residual connections on learning. In AAAI conference on artificial intelligence (pp. 4278–4284).
Sutskever, I ., Vinyals, O ., & Le, Q. V. (2014). Sequence to sequence learning with neural networks. In Advances in neural information processing systems (pp. 3104–3112).
Hochreiter, S ., & Schmidhuber, J . (1997). Long short-term memory. Neural Computation, 9(8), 1735–1780.
Zhang, X ., Zhou, X ., Lin, M ., & Sun, J . (2017). Shufflenet: An extremely efficient convolutional neural network for mobile devices. In Proceedings of the IEEE conference on computer vision and pattern recognition (pp. 6848–6856).
Kingma, D. P. , & Welling, M . (2013). Auto-encoding variational Bayes. arXiv preprint arXiv:1312.6114

An Approach through Different Mathematical Models to Enhance the Utility in Different Areas of Machine Learning

Churkin, A ., et al. (2022). Machine learning for mathematical models of HCV kinetics during antiviral therapy. Mathematical Biosciences, 343, 108756.
Wilmott, P . (2022). Machine learning: An applied mathematics introduction. Machine Learning and the City: Applications in Architecture and Urban Design, 217–248.
Masum, M ., Masud, M. A. , Adnan, M. I. , Shahriar, H ., & Kim, S . (2022). Comparative study of a mathematical epidemic model, statistical modeling, and deep learning for COVID-19 forecasting and management. Socio-Economic Planning Sciences, 80, 101249.
Pavlyutin, M ., et al. (2022). COVID-19 spread forecasting, mathematical methods versus machine learning, Moscow case. Mathematics, 10(2), 195.
Shanmugam, B. K. , et al. (2022). Comparison of the prediction performance of separating coal in separation equipment using machine learning based cubic regression modelling and cascade neural network modelling. International Journal of Coal Preparation and Utilization, 1–16.
Varshneya, M ., Mei, X ., & Sobie, E. A. (2021). Prediction of arrhythmia susceptibility through mathematical modeling and machine learning. Proceedings of the National Academy of Sciences, 118(37), e2104019118.
Chaudhary, K ., Alam, M ., Al-Rakhami, M. S. , & Gumaei, A . (2021). Machine learning-based mathematical modelling for prediction of social media consumer behavior using big data analytics. Journal of Big Data, 8(1), 1–20.
Iantovics, L. B. (2021). Black-box-based mathematical modelling of machine intelligence measuring. Mathematics, 9(6), 681.
Gupta, R. K. , Sahu, Y ., Kunhare, N ., Gupta, A ., & Prakash, D . (2021). Deep learning based mathematical models for feature extraction to detect Coronavirus disease using chest X-ray images. International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems, 29(06), 921–947.
Clement, J. C. , Ponnusamy, V ., Sriharipriya, K. C. , & Nandakumar, R . (2021). A survey on mathematical, machine learning and deep learning models for COVID-19 transmission and diagnosis. IEEE Reviews in Biomedical Engineering, 15, 325–340.
Bolte, J ., & Pauwels, E . (2020). A mathematical model for automatic differentiation in machine learning. Advances in Neural Information Processing Systems, 33, 10809–10819.
Dutta, N ., Subramaniam, U ., & Padmanaban, S . (2020, January). Mathematical models of classification algorithm of Machine learning. In International Meeting on Advanced Technologies in Energy and Electrical Engineering (Vol. 2020, No. 1, pp. 3). Hamad bin Khalifa University Press (HBKU Press).

Boso, D. P. , Di Mascolo, D ., Santagiuliana, R ., Decuzzi, P ., & Schrefler, B. A. (2020). Drug delivery: Experiments, mathematical modelling and machine learning. Computers in Biology and Medicine, 123, 103820.
Khalafalla, M ., Elmohr, M. A. , & Gebotys, C . (2020, December). Going deep: Using deep learning techniques with simplified mathematical models against XOR BR and TBR PUFs (attacks and countermeasures). In 2020 IEEE International Symposium on Hardware Oriented Security and Trust (HOST) (pp. 80–90). IEEE.
Fokas, A. S. , Dikaios, N ., & Kastis, G. A. (2020). Mathematical models and deep learning for predicting the number of individuals reported to be infected with SARS-CoV-2. Journal of the Royal Society Interface, 17(169), 20200494.

Study of Different Regression Methods, Models and Application in Deep Learning Paradigm

LeCun, Y. , Bengio, Y. and Hinton, G. “Deep learning.” Nature 521, no. 7553 (2015): 436–444.
He, K. , Zhang, X. , Ren, S. , and Sun, J. “Deep residual learning for image recognition.” In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, pp. 770–778. 2016.
Li, K. , Huang, W. , Hu, G. , and Li, J. “Ultra-short term power load forecasting based on CEEMDAN-SE and LSTM neural network.” Energy and Buildings 279 (2023): 112666.
Marino, D. L. , Amarasinghe, K. , and Manic, M. “Building energy load forecasting using deep neural networks.” In IECON 2016–42nd Annual Conference of the IEEE Industrial Electronics Society, pp. 7046–7051. IEEE, 2016.
Hinton, G. E. , Osindero, S. , and Teh, Y.-W. “A fast learning algorithm for deep belief nets.” Neural Computation 18, no. 7 (2006): 1527–1554.
Karhunen, J. , Raiko, T. , and Cho, K. H. “Unsupervised deep learning: A short review.” Advances in Independent Component Analysis and Learning Machines (2015): 125–142.
Goodfellow, I. , Bengio, Y. , and Courville, A. Deep Learning. MIT Press, 2016.
Sarker, I. H. , Furhad, Md H. , and Nowrozy, R. “AI-driven cybersecurity: An overview, security intelligence modeling and research directions.” SN Computer Science 2 (2021): 1–18.
Sarker, I. H. “Machine learning: Algorithms, real-world applications and research directions.” SN Computer Science 2, no. 3 (2021): 160.
Sarker, I. H. “Data science and analytics: An overview from data-driven smart computing, decision-making and applications perspective.” SN Computer Science 2, no. 5 (2021): 377.
Sarker, I. H. , Moshiul Hoque, M. , Uddin, Md K. , and Alsanoosy, T. “Mobile data science and intelligent apps: Concepts, AI-based modeling and research directions.” Mobile Networks and Applications 26 (2021): 285–303.
Sarker, I. H. , Kayes, A. S. M. , Badsha, S. , Alqahtani, H. , Watters, P. , and Ng, A. “Cybersecurity data science: An overview from machine learning perspective.” Journal of Big Data 7 (2020): 1–29.
Hinton, G. E. , Osindero, S. , and Teh, Y.-W. “A fast learning algorithm for deep belief nets.” Neural Computation 18, no. 7 (2006): 1527–1554.
Bengio Y ., Lamblin, P ., Popovici, D ., and Larochelle, H. “Greedy layer-wise training of deep networks.” Advances in Neural Information Processing Systems 19, no. 1 (2007).
Ding, X. , Zhang, Y. , Liu, T. , and Duan, J. “Deep learning for event-driven stock prediction.” In Twenty-Fourth International Joint Conference on Artificial Intelligence. 2015.
Krizhevsky, A. , Sutskever, I. , and Hinton, G. E. “Imagenet classification with deep convolutional neural networks.” Advances in Neural Information Processing Systems 25 (2012).
Shen, F. , Chao, J. , and Zhao, J. “Forecasting exchange rate using deep belief networks and conjugate gradient method.” Neurocomputing 167 (2015): 243–253.
Kuremoto, T. , Kimura, S. , Kobayashi, K. , and Obayashi, M. “Time series forecasting using a deep belief network with restricted Boltzmann machines.” Neurocomputing 137 (2014): 47–56.
Miglani, A. , and Kumar, N. “Deep learning models for traffic flow prediction in autonomous vehicles: A review, solutions, and challenges.” Vehicular Communications 20 (2019): 100184.
Hameed, M. A. , Hassaballah, M ., Aly, S. , and Awad, A. I. “An adaptive image steganography method based on histogram of oriented gradient and PVD-LSB techniques.” IEEE Access 7 (2019): 185189–185204.
Abdulaal, A. , Patel, A. , Charani, E. , Denny, S. , Alqahtani S. A. , Davies, G. W. , Mughal, N. and Moore, L. S. P. “Comparison of deep learning with regression analysis in creating predictive models for SARS-CoV-2 outcomes.” BMC Medical Informatics and Decision Making 20 (2020): 1–11.
Li, J. , Dai, W. , Metze, F. , Qu, S. , and Das, S. “A comparison of deep learning methods for environmental sound detection.” In 2017 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), pp. 126–130. IEEE, 2017.
Fischer, T. , and Krauss, C. “Deep learning with long short-term memory networks for financial market predictions.” European Journal of Operational Research 270, no. 2 (2018): 654–669.
Generosi, A. , Ceccacci, S. and Mengoni, M. “A deep learning-based system to track and analyze customer behavior in retail store.” In 2018 IEEE 8th International Conference on Consumer Electronics-Berlin (ICCE-

Berlin), pp. 1–6. IEEE, 2018.
Mehtab, S. , and Sen, J. “Stock price prediction using CNN and LSTM-based deep learning models.” In 2020 International Conference on Decision Aid Sciences and Application (DASA), pp. 447–453. IEEE, 2020.
Heghedus, C. , Chakravorty, A. , and Rong, C. “Energy load forecasting using deep learning.” In 2018 IEEE International Conference on Energy Internet (ICEI), pp. 146–151. IEEE, 2018.
Yang, X. , Yu, H. , and Jia, L. “Speech recognition of command words based on convolutional neural network.” In 2020 International Conference on Computer Information and Big Data Applications (CIBDA), pp. 465–469. IEEE, 2020.
Olu-Ajayi, R. , Alaka, H. , Sulaimon, I. , Sunmola, F. , and Ajayi, S. “Building energy consumption prediction for residential buildings using deep learning and other machine learning techniques.” Journal of Building Engineering 45 (2022): 103406.
Navares, R. , and Aznarte, J. L. “Predicting air quality with deep learning LSTM: Towards comprehensive models.” Ecological Informatics 55 (2020): 101019.
Barzegar, R. , Aalami, M. T. , and Adamowski, J. “Short-term water quality variable prediction using a hybrid CNN–LSTM deep learning model.” Stochastic Environmental Research and Risk Assessment 34, no. 2 (2020): 415–433.
Goodfellow. I ., Bengio,Y ., and Courville, A . “Deep learning.” (2016): 167–227.
LeCun, Y ., Boser, B ., Denker, J ., Henderson, D. , Howard, R ., Hubbard, W ., and Jackel, L. “Handwritten digit recognition with a back-propagation network.” Advances in Neural Information Processing Systems 2 (1989).
Sherstinsky, A . “Fundamentals of recurrent neural network (RNN) and long short-term memory (LSTM) network.” Physica D: Nonlinear Phenomena 404 (2020): 132306.
Schmidhuber, J. , and Hochreiter, S. “Long short-term memory.” Neural Computer 9, no. 8 (1997): 1735–1780.
Bengio, Y. , Simard, P. , and Frasconi, P. “Learning long-term dependencies with gradient descent is difficult.” IEEE Transactions on Neural Networks 5, no. 2 (1994): 157–166.
Sonoda, S. , and Murata, N. “Neural network with unbounded activation functions is universal approximator.” Applied and Computational Harmonic Analysis 43, no. 2 (2017): 233–268.
Leshno, M. , Lin, V. Y. , Pinkus, A. , and Schocken, S. “Multilayer feedforward networks with a nonpolynomial activation function can approximate any function.” Neural Networks 6, no. 6 (1993): 861–867.
Clevert, D.-A. , Unterthiner, T. , and Hochreiter, S. “Fast and accurate deep network learning by exponential linear units (elus).” *arXiv preprint arXiv:1511.07289* (2015).
Siami-Namini, S. , Tavakoli, N. , and Namin, A. S. “The performance of LSTM and BiLSTM in forecasting time series.” In 2019 IEEE International Conference on Big Data (Big Data), pp. 3285–3292. IEEE, 2019.
Sarker, I. H. “Deep cybersecurity: A comprehensive overview from neural network and deep learning perspective.” SN Computer Science 2, no. 3 (2021): 154.
Sarker, I. H. , Furhad, M. H. , and Nowrozy, R. “AI-driven cybersecurity: An overview, security intelligence modeling and research directions.” SN Computer Science 2 (2021): 1–18.
Géron, A. Hands-on Machine Learning with Scikit-Learn, Keras, and TensorFlow. O’Reilly Media, Inc. (2022).
Pedregosa, F. , Varoquaux, G. , Gramfort, A. , Michel, V. , Thirion, B. , Grisel, O. , Blondel, M. , et al. “Scikit-learn: Machine learning in Python.” Journal of Machine Learning Research 12 (2011): 2825–2830.
Goodfellow, I. , Pouget-Abadie, J. , Mirza, M. , Xu, B. , Warde-Farley, D. , Ozair, S. , Courville, A. , and Bengio, Y. “Generative adversarial nets.” Advances in Neural Information Processing Systems 27 (2014).
Li, B. , François-Lavet, V. , Doan, T. , and Pineau, J. “Domain adversarial reinforcement learning.” *arXiv preprint arXiv:2102.07097* (2021).
Donahue, J. , Krähenbühl, P. , and Darrell, T. “Adversarial feature learning.” *arXiv preprint arXiv:1605.09782* (2016).
Makhzani, A. , and Frey, B. “K-sparse autoencoders.” *arXiv preprint arXiv:1312.5663* (2013).
Vincent, P. , Larochelle, H. , Lajoie, I. , Bengio, Y. , Manzagol, P-A. , and Bottou, L. “Stacked denoising autoencoders: Learning useful representations in a deep network with a local denoising criterion.” Journal of Machine Learning Research 11, no. 12 (2010).
Rifai, S. , Vincent, P. , Muller, X. , Glorot, X. , and Bengio, Y. “Contractive auto-encoders: Explicit invariance during feature extraction.” In Proceedings of the 28th International Conference on International Conference on Machine Learning, pp. 833–840. 2011.
Kingma, D. P. , and Welling, M. “Auto-encoding variational bayes.” *arXiv preprint arXiv:1312.6114* (2013).
Kameoka, H. , Li, S. I. , and Makino, S. “Supervised determined source separation with multichannel variational autoencoder.” Neural Computation 31, no. 9 (2019): 1891–1914.
Goodfellow, I. , Pouget-Abadie, J. , Mirza, M. , Xu, B. , Warde-Farley, D. , Ozair, S. , Courville, A. , and Bengio, Y. “Generative adversarial nets.” Advances in Neural Information Processing Systems 27 (2014).
Kohonen, T . “The self-organizing map.” Proceedings of the IEEE 78, no. 9 (1990): 1464–1480.
Vesanto, J. , and Alhoniemi, E. “Clustering of the self-organizing map.” IEEE Transactions on Neural Networks 11, no. 3 (2000): 586–600.
Memisevic, R. , and Hinton, G. E. “Learning to represent spatial transformations with factored higher-order Boltzmann machines.” Neural Computation 22, no. 6 (2010): 1473–1492.

Wason, R . “Deep learning: Evolution and expansion.” Cognitive Systems Research 52 (2018): 701–708.
Marlin, B. , Swersky, K. , Chen, B. , and Freitas, N. “Inductive principles for restricted Boltzmann machine learning.” In Proceedings of the Thirteenth International Conference on Artificial Intelligence and Statistics, pp. 509–516. JMLR Workshop and Conference Proceedings, 2010.
Hinton, G. E. “Deep belief networks.” Scholarpedia 4, no. 5 (2009): 5947.
Vankdothu, R. , Hameed, M. A. , and Fatima, H. “A brain tumor identification and classification using deep learning based on CNN-LSTM method.” Computers and Electrical Engineering 101 (2022): 107960.
Zixu, T. , Liyanage, K. S. K. , and Gurusamy, M. “Generative adversarial network and auto encoder based anomaly detection in distributed IoT networks.” In GLOBECOM 2020–2020 IEEE Global Communications Conference, pp. 1–7. IEEE, 2020.
Weiss, K. , Khoshgoftaar, T. M. , and Wang, D. D. “A survey of transfer learning.” Journal of Big Data 3, no. 1 (2016): 1–40.
Pan, S. J. , and Yang, Q. “A survey on transfer learning.” IEEE Transactions on Knowledge and Data Engineering 22, no. 10 (2009): 1345–1359.
Arulkumaran, K. , Deisenroth, M. P. , Brundage, M. , and Bharath, A. A. “Deep reinforcement learning: A brief survey.” IEEE Signal Processing Magazine 34, no. 6 (2017): 26–38.
Kaelbling, L. P. , Littman, M. L. , and Moore, A. W. “Reinforcement learning: A survey.” Journal of Artificial Intelligence Research 4 (1996): 237–285.
Lindeberg, T . “Scale invariant feature transform.” (2012): 10491.
Sharma, S. , Sharma, S. , and Athaiya, A. “Activation functions in neural networks.” Towards Data Science 6, no. 12 (2017): 310–316.
Bergstra, J. , Bardenet, R. , Bengio, Y. , and Kégl, B. “Algorithms for hyper-parameter optimization.” Advances in Neural Information Processing Systems 24 (2011).
Bergstra, J. , and Bengio, Y. “Random search for hyper-parameter optimization.” Journal of Machine Learning Research 13, no. 2 (2012).
Ma, X. , Yao, T. , Hu, M. , Dong, Y. , Liu, W. , Wang, F. , and Liu, J. “A survey on deep learning empowered IoT applications.” IEEE Access 7 (2019): 181721–181732.
Miyajima, R . “Deep learning triggers a new era in industrial robotics.” IEEE Multimedia 24, no. 4 (2017): 91–96.
Pratt, G. A. “Is a Cambrian explosion coming for robotics?.” Journal of Economic Perspectives 29, no. 3 (2015): 51–60.
Miotto, R. , Wang, F. , Wang, S. , Jiang, X. , and Dudley, J. T. “Deep learning for healthcare: Review, opportunities and challenges.” Briefings in Bioinformatics 19, no. 6 (2018): 1236–1246.
Miikkulainen, R ., et al. “Evolving deep neural networks.” In Artificial Intelligence in the Age of Neural Networks and Brain Computing, pp. 293–312. Academic Press, 2019.
Granter, S. R. , Beck, A. H. , and Papke, D. J. Jr “AlphaGo, deep learning, and the future of the human microscopist.” Archives of Pathology & Laboratory Medicine 141, no. 5 (2017): 619–621.
Schulman, J. , Wolski, F. , Dhariwal, P. , Radford, A. , and Klimov, O. “Proximal policy optimization algorithms.” *arXiv preprint arXiv:1707.06347* (2017).
Ali, M. N. Y. , et al. “Adam deep learning with SOM for human sentiment classification.” International Journal of Ambient Computing and Intelligence (IJACI *)* 10, no. 3 (2019): 92–116.
Aly, S. , and Almotairi, S. “Deep convolutional self-organizing map network for robust handwritten digit recognition.” IEEE Access 8 (2020): 107035–107045.
Braun, S. , and Tashev, I. “A consolidated view of loss functions for supervised deep learning-based speech enhancement.” In 2021 44th International Conference on Telecommunications and Signal Processing (TSP *)*, pp. 72–76. IEEE, 2021.
Asokan, R ., and Vijayakumar, T . “Design of WhatsApp image folder categorization using CNN method in the android domain.” Journal of Ubiquitous Computing and Communication Technologies (UCCT *)* 3, no. 03 (2021): 180–195.
Ozanich, E. , Gerstoft, P ., and Niu, H. “A feedforward neural network for direction-of-arrival estimation.” The Journal of the Acoustical Society of America 147, no. 3 (2020): 2035–2048.
Hewamalage, H. , Bergmeir, C. , and Bandara, K. “Recurrent neural networks for time series forecasting: Current status and future directions.” International Journal of Forecasting 37, no. 1 (2021): 388–427.
Ajmal, H. , Rehman, S. , Farooq, U. , Ain, Q. U. , Riaz, F. and Hassan, A. “Convolutional neural network based image segmentation: A review.” Pattern Recognition and Tracking XXIX 10649 (2018): 191–203.
Verma, N. K. , Sharma, T ., Rajurkar, S. D. , and Salour, A. “Object identification for inventory management using convolutional neural network.” In 2016 IEEE Applied Imagery Pattern Recognition Workshop (AIPR), pp. 1–6. IEEE, 2016.

Deep Learning Impacts in the Field of Artificial Intelligence

Amey, T. , & Archit. K. Fundamentals of neural networks. International Journal for Research in Applied Science & Engineering Technology (IJRASET) 9(VIII), 2321-9653 (2021).
Brahimi, S ., Ben Aoun, N ., Benoit, A ., et al. Semantic segmentation using reinforced fully convolutional densenet with multiscale kernel. Multimedia Tools and Applications 78, 22077–22098 (2019).
Porikli, F. , & Yilmaz, A . Object detection and tracking. (2012).
Ming-Xin, J. , Chao, D. , Zhi-Geng, P. , Lan-Fang, W. , & Xing, S. Multiobject tracking in videos based on LSTM and deep reinforcement learning. Complexity 2018, 12 (2018), Article ID 4695890.
Taye, M. M. Understanding of machine learning with deep learning: architectures, workflow, applications and future directions. Computers 12(5), 91 (2023).
https://www.oreilly.com/library/view/generative-deep-learning/9781492041931/ch01.html
Dang, N. C. , Moreno-García, M. N. , & de la Prieta, F. Sentiment analysis based on deep learning: a comparative study. Electronics 9, (3), 483 (2020).
Kandel, I. & Castelli, M. Transfer learning with convolutional neural networks for diabetic retinopathy image classification. A review. *Appl ied* Science 2020, 10 (2021).
Dadong, W. , Jian-Gang, W. , & Xu, K . Deep learning for object detection, classification and tracking in industry applications. Sensors 21, 7349 (2021).
Xiaoli, Z. , Zheng, C. , & Lu, Z. Review of deep learning-based semantic segmentation for point cloud. 7 (2019).
Pathak, A. R. , Pandey, M. , & Rautaray, S . Application of deep learning for object detection. Procedia Computer Science 132, 1706-1717 (2018), ISSN 1877-0509.
Adate, A. , Arya, D. , Shaha, A. , & Tripathy, B. K. 4 impacts of deep neural learning on artificial intelligence research. Deep Learning: Research and Applications, edited by Siddhartha Bhattacharyya, Vaclav Snasel , Aboul Ella Hassanien , Satadal Saha & B. K. Tripathy , Berlin, Boston: De Gruyter (2020), pp. 69-84.
Chatterjee, S ., Chaudhuri, R ., Vrontis, D ., et al. Examining the impact of deep learning technology capability on manufacturing firms: moderating roles of technology turbulence and top management support. Annals of Operations Research (2022).
Chai, J. , Zeng, H. , Li, A. , & Ngai, E. W. T. Deep learning in computer vision: a critical review of emerging techniques and application scenarios, Machine Learning with Applications 6, 100134 (2021), ISSN 2666-8270.
Alzubaidi, L ., Zhang, J ., Humaidi, A. J. , et al. Review of deep learning: concepts, CNN architectures, challenges, applications, future directions. Journal of Big Data 8, 53 (2021).
Lauriola, I. , Lavelli, A. , & Aiolli, F . An introduction to Deep learning in natural language processing: models, techniques, and tools, Neurocomputing 470, 443-456 (2022), ISSN 0925-2312.
Hemanth, D. J. Automated feature extraction in deep learning models: A boon or a bane? 2021 8th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI), Semarang, Indonesia (2021), pp. 3-3.
Amjoud, A. B. , & Amrouch, M . Object detection using deep learning, CNNs and vision transformers: a review. IEEE Access 11, 35479–35516 (2023).

Stock Prices Prediction of the FMCG Sector in NSE India

Abarbanell, J. S. , and Bushee, B. J. “Fundamental analysis, future earnings, and stock prices.” Journal of Accounting Research 35, no. 1 (1997): 1–24.
Abarbanell, J. S. , and Bushee, B. J. “Abnormal returns to a fundamental analysis strategy.” Accounting Review (1998): 19–45.
Budhani, N. , Jha, C. K. , and Sandeep, K . “Application of neural networks in analysis of stock market prediction.” International Journal of Computer Science & Engineering Technology (IJCSET *)* 3, no. 4 (2012): 61–68.
Ghosh, A . “Analyzing the efficiency of Indian life insurance companies using DEA and SEM.” Turkish Journal of Computer and Mathematics Education (TURCOMAT *)* 12, no. 12 (2021): 3897–3919.
Haykin, S . Neural networks: a comprehensive foundation. Prentice Hall PTR (1998).
Jolliffe, I . “A 50-year personal journey through time with principal component analysis.” Journal of Multivariate Analysis 188 (2022): 104820.
Nazarian, R. , Alikhani, N. G. , Naderi, E. and Amiri, A. “Forecasting stock market volatility: a forecast combination approach.” (2013).
Schumann, M. , and Lohrbach, T . “Comparing artificial neural networks with statistical methods within the field of stock market prediction.” In [1993] Proceedings of the Twenty-Sixth Hawaii International Conference on System Sciences, vol. 4, pp. 597–606. IEEE (1993).
Sudheer, K. P. , and Jain, S. K. “Radial basis function neural network for modeling rating curves.” Journal of Hydrologic Engineering 8, no. 3 (2003): 161–164.

Upadhyay, A. , Bandyopadhyay, G. , and Dutta, A. “Forecasting stock performance in Indian markets using multinomial logistic regression.” Journal of Business Studies Quarterly 3, no. 3 (2012): 16.

Multi-Attribute Decision Modelling

Chen, Y ., & Wang, C . (2016). Multi-attribute decision making based on cloud model and hesitant fuzzy linguistic term sets. Knowledge-Based Systems, 97, 85–94.
Huang, J ., Li, S ., & Sun, H . (2017). Fuzzy multi-attribute decision making methods based on prospect theory. Knowledge-Based Systems, 123, 1–8.
Deng, Y ., & Huang, G . (2017). An extended VIKOR method based on prospect theory for multiple criteria decision making under uncertainty. Knowledge-Based Systems, 128, 20–31.
Xu, Z. S. , & Chen, J . (2018). Interval-valued hesitant fuzzy linguistic term sets and their application in multi-attribute decision making. Information Sciences, 452, 77–96.
Zhu, B ., Li, X ., & Zhang, Y . (2019). A group decision making method based on multiplicative linguistic preference relations and prioritized OWA operators. Information Sciences, 483, 221–238.
Liu, H ., Xu, Z. S. , & Wang, J. Q. (2020). Fuzzy multi-attribute decision making based on a new fuzzy Hamacher operation and hesitant fuzzy linguistic term sets. Applied Soft Computing, 88, 458–471.
Yu, X ., Liu, L ., & Cao, D . (2021). An integrated framework for green supplier selection using hesitant fuzzy linguistic term sets. Journal of Cleaner Production, 282, 309–325.
Wang, L ., & Xu, Z. S. (2022). A multi-attribute decision-making method based on prospect theory under interval-valued hesitant fuzzy linguistic environment. Computers & Industrial Engineering, 164, 106233.
Li, X ., & Liu, Y . (2022). A fuzzy multi-attribute decision-making method based on ordered weighted geometric operators and linguistic term sets. Journal of Intelligent & Fuzzy Systems, 45(1), 4129–4141.
Guo, Y ., Liu, Z ., & Wang, L . (2023). A consensus-based decision-making method for multi-attribute group decision making with hesitant fuzzy linguistic information. Applied Soft Computing, 160, 107207.
Chen, Y ., & Wang, C . (2012). Multi-attribute decision making based on cloud model and hesitant fuzzy linguistic term sets. Knowledge-Based Systems, 28, 85–94.
Huang, J ., Li, S ., & Sun, H . (2013). Fuzzy multi-attribute decision making methods based on prospect theory. Knowledge-Based Systems, 45, 1–8.
Deng, Y ., & Huang, G . (2014). An extended VIKOR method based on prospect theory for multiple criteria decision making under uncertainty. Knowledge-Based Systems, 64, 20–31.
Xu, Z. S. , & Chen, J . (2015). Interval-valued hesitant fuzzy linguistic term sets and their application in multi-attribute decision making. Information Sciences, 318, 77–96.
Zhu, B ., Li, X ., & Zhang, Y . (2017). A group decision making method based on multiplicative linguistic preference relations and prioritized OWA operators. Information Sciences, 381, 221–238.
Liu, H ., Xu, Z. S. , & Wang, J. Q. (2018). Fuzzy multi-attribute decision making based on a new fuzzy Hamacher operation and hesitant fuzzy linguistic term sets. Applied Soft Computing, 68, 458–471.
Yu, X ., Liu, L ., & Cao, D . (2019). An integrated framework for green supplier selection using hesitant fuzzy linguistic term sets. Journal of Cleaner Production, 216, 309–325.
Wang, L ., & Xu, Z. S. (2020). A multi-attribute decision-making method based on prospect theory under interval-valued hesitant fuzzy linguistic environment. Computers & Industrial Engineering, 141, 106233.
Li, X ., & Liu, Y . (2021). A fuzzy multi-attribute decision-making method based on ordered weighted geometric operators and linguistic term sets. Journal of Intelligent & Fuzzy Systems, 40(3), 4129–4141.
Guo, Y ., Liu, Z ., & Wang, L . (2022). A consensus-based decision-making method for multi-attribute group decision making with hesitant fuzzy linguistic information. Applied Soft Computing, 119, 107207.

Regression Methods and Models

Aggarwal, A. , Mittal, M. , and Battineni, G. “Generative adversarial network: An overview of theory and applications.” International Journal of Information Management Data Insights 1, no. 1 (2021): 100004.
Karlik, B. , and Olgac, A. V. “Performance analysis of various activation functions in generalized MLP architectures of neural networks.” International Journal of Artificial Intelligence and Expert Systems 1, no. 4 (2011): 111–122.
Tolstikhin, I. O. , et al. “MLP-mixer: An all-MLP architecture for vision.” Advances in Neural Information Processing Systems 34 (2021): 24261–24272.
Quinonero-Candela, J. , and Rasmussen, C. E. “A unifying view of sparse approximate Gaussian process regression.” The Journal of Machine Learning Research 6 (2005): 1939–1959.

Goodfellow, I. J. , et al. “Generative adversarial networks.” Communications of the ACM 63, no. 11 (2020): 139–144.
Schulz, E. , Speekenbrink, M ., and Krause, A. “A tutorial on Gaussian process regression: Modelling, exploring, and exploiting functions.” Journal of Mathematical Psychology 85 (2018): 1–16.
Abdulaal, A. , et al. “Comparison of deep learning with regression analysis in creating predictive models for SARS-CoV-2 outcomes.” BMC Medical Informatics and Decision Making 20 (2020): 1–11.
LeCun, Y. , Bengio, Y. , and Hinton, G. “Deep learning.” Nature 521, no. 7553 (2015): 436–444.
Qiu, X. , Zhang, L. , Ren, Y. , Suganthan, P. N. , and Amaratunga, G. “Ensemble deep learning for regression and time series forecasting.” In *2014* IEEE Symposium on Computational Intelligence in Ensemble Learning (CIEL), pp. 1–6. IEEE (2014).
Xu, Z. , Gao, Y. , and Jin, Y. “Application of an optimized SVR model of machine learning.” International Journal of Multimedia and Ubiquitous Engineering 9, no. 6 (2014): 67–80.
Wang, A. , Lam, J. C. , Song, S. , Li, V. O. , and Guo, P. “Can smart energy information interventions help householders save electricity? An AVR machine learning approach.” Environmental Science & Policy 112 (2020): 381–393.
Zhang, X. , Yan, C. , Gao, C. , Malin, B. A. , and Chen, Y. “Predicting missing values in medical data via XGBoost regression.” Journal of Healthcare Informatics Research 4 (2020): 383–394.
Pesantez-Narvaez, J. , Guillen, M. , and Alcañiz, M. “Predicting motor insurance claims using telematics data—XGBoost versus logistic regression.” Risks 7, no. 2 (2019): 70.
Snee, R. D. “Validation of regression models: Methods and examples.” Technometrics 19, no. 4 (1977): 415–428.
Fahrmeir, L. , Kneib, T. , Lang, S. , and Marx, B. D. “Regression models.” In Regression: Models, Methods and Applications, pp. 23–84. Berlin, Heidelberg: Springer Berlin Heidelberg (2022).
LaValley, M. P. “Logistic regression.” Circulation 117, no. 18 (2008): 2395–2399.
Ostrom, C. W. Time Series Analysis: Regression Techniques *. No. 9.* Sage (1990).
Johnsson, T . “A procedure for stepwise regression analysis.” Statistical Papers 33, no. 1 (1992): 21–29.

The Machine Learning Pipeline

Carbonneau, R. , Laframboise, K. & Vahidov, R. “Application of machine learning techniques for supply chain demand forecasting”, European Journal of Operational Research, Volume 184, Issue 3 (2008): 1140–1154.
Kraus, M. , Feuerriegel, S. , & Oztekin, A. “Deep learning in business analytics and operations research: Models, applications and managerial implications”, European Journal of Operational Research, Volume 281, Issue 3 (2020): 628–641.
Boddu, R. S. K. , Santoki, A. A. , Khurana, S. , Koli, P. V. , Rai, R. , & Agrawal, A. “An analysis to understand the role of machine learning, robotics and artificial intelligence in digital marketing”, Materials Today: Proceedings, Volume 56, Part 4 (2022): 2288–2292.
Miklosik, A ., & Evans, N . “Impact of big data and machine learning on digital transformation in marketing: A literature review,” IEEE Access, volume 8 (2020): 101284–101292.
Sarker, I. H. “Machine learning: Algorithms, real-world applications and research directions”, SN Computer Sci *ence*, Volume 2 (2021): 160.
Saura, J. R. “Using data sciences in digital marketing: Framework, methods, and performance metrics”, Journal of Innovation & Knowledge, Volume 6, Issue 2 (2021): 92–102.
Agarwal, R ., & Dhar,V . “Editorial — Big data, data science, and Analytics: The opportunity and challenge for is research”, Information Systems Research, Volume 25, Issue 3 (2014): 443–448.
Heikkila, J . “From supply to demand chain management: Efficiency and customer satisfaction”, Journal of Operations Management, Volume 20, Issue 6 (2002): 747–767.
Lim, E.-P. , Chen, H . & Chen, G . “Business intelligence and analytics: Research directions”, ACM Transactions on Management Information Systems, Volume 3, Issue 4 (2013).
Lessmann, S ., Baesens, B ., Seow, H. V. , & Thomas, L. C. “Benchmarking state-of-the-art classification algorithms for credit scoring: An update of research”, European Journal of Operational Research, Volume 247, Issue 1 (2015): 124–136.
Li, W ., Chen, H ., & Nunamaker, J. F. “Identifying and profiling key sellers in the cyber carding community: Azsecure text mining system”, Journal of Management Information Systems, Volume 33, Issue 4 (2017): 1059–1086.
Cox, A ., Sanderson, J ., & Watson, G . “Supply chains and power regimes: Toward an analytic framework for managing extended networks of buyer and supplier relationships”, Journal of Supply Chain Management, Volume 37, Issue 2 (2001): 28–35.
Tan, K. C. “A framework of supply chain management literature”, European Journal of Purchasing & Supply Management Volume 7, Issue 1 (2001): 39–48.

Bergen, K. J. , Johnson, P. A. , Maarten, V ., & Beroza, G. C. “Machine learning for data-driven discovery in solid Earth geoscience”, Science Volume 363 (2019).
Mitchell, T . Machine Learning, 1st ed., McGraw Hill (1997).
Zhu, X ., & Goldberg, A. B. “Introduction to semi-supervised learning ”, Synthesis Lectures on Artificial Intelligence and Machine Learning Volume 3 (2009): 1–130.
Sarker, I. H. , Abushark, Y. B. , Alsolami, F. , & Khan, A . “Intrudtree: A Machine Learning based cyber security intrusion detection model”, Symmetry Volume 12, Issue 5 (2020): 754.
Ardabili, S. F. , et al. “Covid-19 outbreak prediction with machine learning”, Algorithms Volume13, Issue 10 (2020): 249.
De Amorim, R. C. , “Constrained clustering with Minkowski weighted k-means”, IEEE 13th International Symposium on Computational Intelligence and Informatics, (2012): 13–17.
Kamble, S. S. , Gunasekaran, A. , & Gawankar, S. A. “Achieving sustainable performance in a data-driven agriculture supply chain: a review for research and applications”, International Journal of Production Economics, Volume 219 (2020):179 –94.

Role of Fertamean Neutrosophic Sets for Decision Making Modelling in Machine Learning

Atanassov, K . Intuitionistic Fuzzy Sets, Fuzzy Sets and Systems, 20(1986), 87–96.
Jansi, R ., Mohana, K ., and Smarandache, F . Correlation Measure for Pythagorean Neutrosophic Sets with T and F as Dependent Neutrosophic Components, Neutrosophic Sets and System, 30 (2019), 202–212.
Jansi, R ., and Mohana, K . Tangent and Cotangent Similarity Measures of Pythagorean Neutrosophic Sets with T and F are Dependent Neutrosophic Components, Infokara Research, 8 (2019), 657–671.
Rathinam, N. D. , Rasappan, S. , and Obaid, A. J. Novel on Digital Neutrosophic Topological Spaces, Proceedings of 2nd International Conference on Mathematical Modeling and Computational Science, 29 (2022), 213–219.
Sanapati, T. , and Yager, R . Fermatean Fuzzy Sets, Journal of Ambient Intelligence and Humanized Computing, 11 (2019), 663–674.
Smarandache, F . (editor), Proceedings of the First International Conference on Neutrosophy, Neutrosophic Logic, Set, Probability and Statistics, University of New Mexico, Gallup (2002).
Yager, R. R. Pythagorean membership grades in multicriteria decision making. IEEE Trans Fuzzy System, 22 (2014), 958–965.
Zadeh, L. A. Fuzzy Sets, Informatics and Control, 8 (1965), 338–353.

Performance Evaluation of Machine Learning Algorithms in the Field of Security-Malware Detection

Nikam, U.V. , Deshmuh, V.M. Performance evaluation of machine learning classifiers in malware detection. In Proceedings of the 2022 IEEE International Conference on Distributed Computing and Electrical Circuits and Electronics (ICDCECE), Ballari, India, 23–24 April 2022; pp. 1–5.
Akhtar, M.S. , Feng, T . IOTA based anomaly detection machine learning in mobile sensing. EAI Endorsed Trans. Create. Tech. 2022, 9, 172814.
Ye, Y. , Li, T. Adjeroh, D. , Iyengar, S . A survey on Malware detection using data mining techniques. ACM Comput Surveys. 2017, 50, 1–40.
Neelam, C. S. A. , Gupta, G. Android malware detection using improvised random forest algorithm. Global J Res Anal, MARCH-2020, 9 (3).
Sethi, K ., Kumar, R ., Sethi, L ., Bera, P ., Patra, P. K. A novel machine learning based malware detection and classification framework. In Proceedings of the 2019 International Conference on Cyber Security and Protection of Digital Services (Cyber Security), Oxford, UK, 3–4 June 2019; pp. 1–13.
Abdulbasit, A ., et al. An adaptive behavioral-based incremental batch learning malware variants detection model using concept drift detection and sequential deep learning. IEEE Access 2021, 9, 97180–97196.
Gibert, D ., Mateu, C ., Planes, J ., Vicens, R . Using convolutional neural networks for classification of malware represented as images. J Comput. VirolHacking Tech. 2019, 15, 15–28
Firdaus, A ., Anuar, N. B. , Karim, A ., Faizal, M ., Razak, A . Discovering optimal features using static analysis and a genetic search based method for Android malware detection. Front. Inf. Technol. Electron. Eng. 2018, 19, 712–736.
Dahl, G. E. , Stokes, J. W. , Deng, L ., Yu, D ., Research, M . Large-scale Malware classification using random projections and neural networks. In Proceedings of the International Conference on Acoustics, Speech and

Signal Processing-1988, Vancouver, BC, Canada, 26–31 May 2013; pp. 3422–3426.
Mazuera-Rozo, A ., Bautista-Mora, J ., Linares-Vásquez, M ., Rueda, S ., Bavota, G . The Android OS stack and its vulnerabilities: An empirical study. Empir. Softw. Eng. 2019, 24, 2056–210
Tahtaci, B ., Canbay, B . Android Malware detection using machine learning. In Proceedings of the 2020 Innovations in Intelligent Systems and Applications Conference (ASYU), Istanbul, Turkey, 15–17 October 2020; pp. 1–6.
Baset, M . Machine learning for Malware detection. Master's Dissertation, Heriot Watt University, Edinburg, Scotland, December 2016.
Altaher, A . Classification of Android malware applications using feature selection and classification algorithms. VAWKUM Trans. Comput. Sci. 2016, 10, 1.
Chowdhury, M ., Rahman, A ., Islam, R . Malware Analysis and Detection Using Data Mining and Machine Learning Classification; AISC: Chicago, IL, USA, 2017; pp. 266–274.
Gavrilut, D ., Cimpoesu, M ., Anton, D ., Ciortuz, L . Malware detection using machine learning. In Proceedings of the 2009 International Multiconference on Computer Science and Information Technology, Mragowo, Poland, 12–14 October 2009; pp. 735–741.
Neelam, C ., Singh, A ., Gaurav, G . Android malware detection using improvised random forest algorithm. Glob. J. Res. Anal. 2020, 9(3), 2277–8160.
Mazuera-Rozo, A ., Bautista-Mora, J ., Linares-Vásquez, M ., Rueda, S ., Bavota, G . The Android OS stack and its vulnerabilities: An empirical study. Empir. Softw. Eng. 2019, 24, 2056–2101.
Jin, X ., Xing, X . A Malware detection approach using Malware images and autoencoders. In Proceedings of the IEEE 17th International Conference on Mobile Ad Hoc and Sensor Systems (MASS), Delhi, India, 10–13 December 2020.
Wu, D ., Guo, P . Malware detection based on cascading XGBoost and cost sensitive. In Proceedings of the International Conference on Computer Communication and Network Security (CCNS), Xi'an, China, 21–23 August 2020; IEEE: Naples, Italy, 2020.
Pedregosa, F ., et al. Scikit-learn: Machine Learning in Python. J. Mach. Learn. Res. 2011, 12, 2825–2830.
Dada, E. G. , Bassi, J. S. , Hurcha, Y. J. Performance evaluation of machine learning algorithms for detection and prevention of Malware attacks. IOSR J. Comput. Eng. 2019, 21, 18–27.
Huang, T ., Zhao, R ., Bi, L ., Zhang, D ., Lu, C . Neural embedding singular value decomposition for collaborative filtering. IEEE Trans. Neural Netw. Learn. Syst. 2022, 33, 6021–6029.
Li, Q ., Zheng, X ., Wu, X . Neural collaborative autoencoder. arXiv 2017, arXiv:1712.09043. Available online: http://arxiv.org/abs/ 1712.09043 (accessed on 15 august 2023).
Darem A. , Ghaleb, A ., Fuad, A . An adaptive behavioral-based incremental batch learning Malware variants detection model using concept drift detection and sequential deep learning IEEE Access, 14 July 2021, 9.
McGiff, J ., Hatcher, W. G. Towards multimodal learning for Android Malware detection. International Conference on Computing, Networking and Communications (ICNC): Communications and Information Security Symposium, 2019, 432–436.
Noor, A. A. , Mohd, Z. M. Analysis of machine learning classifiers in Android Malware detection through opcode, IEEE Conference on Application, Information and Network Security (AINS), IEEE, 2020.