Artificial Intelligence

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ARTIFICIAL INTELLIGENCE

Technologies, Applications, and Challenges

Edited by
Lavanya Sharma
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A CHAPMAN & HALL BOOK

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Dedicated to My Dada Ji (Late. Shri Ram Krishan Choudhary Ji)
Ek prerna mayeh Vyaktitavh

Dr. Lavanya Sharma

Dedicated to my Parents (late Shri Ramgopal Garg and Late Smt. Urmila Garg)

Prof. Pradeep K. Garg

Contents

Section III Artificial Intelligence–Based Real-Time Applications

Preface

This book provides an overview of the basic concept of artificial intelligence tools from historical background to real-time applications domains, related technologies, and their possible solutions to take up future challenges. It offers detailed descriptions with practical ideas of using AI to deal with the dynamics, the ecosystem, and challenges involved in surpassing diversified field, image processing, communications, integrity, and security aspects. The AI, in combination for outdoor and indoor scenarios, proved to be most advantageous for the companies and organizations to efficiently monitor and control their day-to-day processes such as design, production, transportation, maintenance, implementation, and distribution of their products.

This book consists of four important parts that provide an overview of artificial intelligence, critical applications domains, tools, and technologies. In addition, it provides insights to undertake the research work in future challenging areas. Overall, this publication would help the readers understand the needs of artificial intelligence for individuals as well as organizations.

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I am especially grateful to *my dada ji*, *my parents*, *my husband*, and *my beautiful family* for their continuous support and blessings. I would like to thank my husband *Dr. Mukesh (general and laparoscopic surgeon)* for his continuous motivation and support throughout this project. Apart from his busy schedule, he always motivated and supported me.

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Above all, I express my heartiest thanks to God (The One to Whom We Owe Everything) *Sai Baba of Shirdi* for all blessings, guidance, and help by you and only you. I would like to thank God for believing in me and being my defender. Thank you, God Almighty.

Dr. Lavanya Sharma

I am extremely grateful to my family Mrs. Seema Garg, Dr. Anurag Garg, Dr. Garima Garg, Mr. Hansraj Aggrawal, Ms. Pooja Aggrawal, and Master Avyukt Garg, and all relatives and friends for their understanding, continuous encouragement, moral support, and well wishes. Above all, I express my gratitude to Almighty God for offering all blessings and giving me enough strength to work hard to complete the book on time, as planned.

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Prof. Pradeep K. Garg

Editors

Dr. Lavanya Sharma completed her M.Tech (Computer Science and Engineering) in 2013 from Manav Rachna College of Engineering, affiliated with Maharshi Dayanand University, Haryana, India. She completed her Ph.D. from Uttarakhand Technical University, India, as a full-time Ph.D. scholar in the field of digital image processing and computer vision in April 2018, and received a TEQIP scholarship for the same. Her research work is on motion-based object detection using background subtraction technique for smart video surveillance. She received several prestigious awards during her academic career.

She is the recipient of several prestigious awards during her academic career and qualified certification courses from ISRO Dehradun unit, India. She has 40+ research papers to her credit, including Elsevier (SCI Indexed), Inderscience, IGI Global, IEEE Explore, and many more. She has published three books and two books with Taylor & Francis, CRC Press in 2019 and 2020. She also has two patents in her account on object detection in visual surveillance. She has also contributed as an Organizing Committee member of Springer's ICACDS conferences 2016, Springer's ICACDS 2018, Springer's ICACDS 2019, Springer's ICACDS 2020, ICRITO 2021, and Springer's ICACDS 2021. Presently, she is the editorial member/reviewer of various journals of repute and active program committee member of various IEEE and Springer conferences also. Her primary research interests are Digital Image Processing and Computer Vision, Artificial Intelligence, Machine learning, deep learning, and Internet of Things. Her vision is to promote teaching and research, providing a highly competitive and productive environment in academic and research areas with tremendous growing opportunities for the society and her country.

Professor Pradeep Kumar Garg has worked as the Vice-Chancellor, Uttarakhand Technical University, Dehradun (2015–2018). Presently, he is working as a professor in the Department of Civil Engineering, IIT Roorkee. He completed B.Tech (Civil Engineering) in 1980 and M.Tech (Civil Engineering) in 1982, both from the University of Roorkee (now IIT Roorkee). He is a recipient of the Gold Medal at IIT Roorkee for securing the highest marks during the M.Tech program, the Commonwealth Scholarship Award for doing Ph.D. from University of Bristol (UK), and the Commonwealth Fellowship Award to carry out post-doctoral research work at the University of Reading (UK). He joined the Department of Civil Engineering at IIT Roorkee in 1982, and gradually advancing his career, rose to the position of Head of the Department in 2015 at IIT Roorkee.

Professor Garg has published more than 310 technical papers in national and international conferences and journals. He has undertaken 27 research projects and provided technical services to 85 consultancy projects on various aspects of Civil Engineering, generating funds for the Institute. He has authored five textbooks on (Remote Sensing, Geomatics Engineering, Digital Soil Mapping, UAV, and Digital Surveying Methods), and edited two books on Environmental Monitoring and Video Surveillance. He has developed several new courses and practical exercises in geomatics engineering. Besides supervising a large number of undergraduate projects, he has guided about 72 M.Tech and 26 Ph.D. theses. He is instrumental in prestigious Ministry of Human Resource Development (MHRD)-funded projects on e-learning, Development of Virtual Labs, Pedagogy, and courses under the National Programme on Technology Enhanced Learning (NPTEL). He has served as an expert on various national committees, including Ministry of Environment and Forests, National Board of Accreditation (All India Council of Technical Education), and Project Evaluation Committee, Department of Science and Technology, New Delhi.

Professor Garg has reviewed a large number of papers for national and international journals. Considering the need to train the human resources in the country, he has successfully organized 40 programs in advanced areas of surveying, photogrammetry, remote sensing, geographic information system (GIS), and global positioning system (GPS). He has successfully organized ten conferences and workshops. He is a life member of 24 professional societies, out of which, he is a fellow member of eight societies. For academic work, Professor Garg has travelled widely, nationally and internationally.

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Section I

Introduction to Artificial Intelligence

1

Overview of Artificial Intelligence

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CONTENTS

1.1 Introduction

Since the invention of computers, humans have been developing various approaches to increase operational speed and decrease physical size in diverse types of hardware and applications. While expanding the uses of computer systems, humans were interested in exploring whether a machine can think, work and behave like a human (McCarthy, 2019). This curiosity gave rise to the growth of artificial intelligence (AI), creating computer-controlled machines (e.g., robot) almost as intelligent as human beings. AI can be defined as "a science and a set of computational techniques that are inspired by the way in which human beings use their nervous system and their body to feel, learn, reason, and act" (McCarthy, 2019, pp. 1, 2–10).

AI is composed of two words, "artificial" and "intelligence," where "artificial" stands for "human-created' and "intelligence" stands for "thinking power." In other words, AI is "*a man-made object with thinking power'*. The intelligence is intangible which may be described as "the ability of a system to calculate, reason, perceive relationships and analogies, learn from experience, store and retrieve information from memory, solve problems, comprehend complex ideas, use natural language fluently, classify, generalize, and adapt new situations" (Iyer, 2018).

AI allows machines or computers to perform in an intelligent manner. For AI to work, availability of "data" is the main key (Joshi, 2020). Humans need some device or software that can process and handle the large amounts of data with minimum effort and speed. This handling of data and processing is known as data science. Data science can be defined as the "scientific study of data, that stores, records and analyses data for the benefits of society" (Joshi, 2020, pp. 1–5). Humans can learn faster and process certain things faster even with a limited amount of data, but AI-based systems need massive amounts of data to generate any useful inferences. The answers are present in the data, which can be obtained by applying AI to get them out. The AI techniques speed up the implementation of the complex programs. AI is currently

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being applied in a variety of fields, ranging from playing chess and music to making complex decisions, creating models, predicting patterns, and even self-driving cars (Iyer, 2018).

1.2 Definitions of AI

According to the father of AI, John McCarthy, artificial intelligence is "the science and engineering of making intelligent machines, especially intelligent computer programs" (McCarthy 2019, pp. 1–2). In other words, AI can be defined as "a branch of computer science by which we create intelligent machines which can think like human, act like human, and able to make decisions like human" (McCarthy, 2019, pp. 2–3). AI in a sense is the simulation/replication of intelligence processes by computer systems that can think and act rationally in the way similar to humans. There are many definitions and explanation available in literature about AI, as summarized in Table 1.1.

1.3 History of AI

The concept of inanimate constructs that can operate independently of humans is not new; in fact, it has been known since ancient times. The Greek god Hephaestus has been depicted forging robot-like servants out of gold. The modern computers were developed in the late nineteenth and early twentieth centuries. With the advent of modern, high-speed computers, it became possible to develop and test the ideas of machine intelligence. The pioneer project was conceived back in the 1950s. Since then, every industry has been trying to develop and/or make use of AI. Table 1.2 summarizes the systematic development of AI tools and technology.

TABLE 1.1
Various Definitions of Artificial Intelligence

S. No.	Authors	Definitions/Explanation
1	Bellman (1978)	"The automation of activities that we associate with human thinking, activities such as decision making, problem solving, learning."
2	Charniak and McDermott (1985)	"The study of mental faculties through the use of computational models."
3	Haugeland (1985)	"The exciting new effort to make computers think machines with minds, in the full and literal sense."
4	Schalkoff (1990)	"A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes."
5	Kurzweil (1990)	"The art of creating machines that perform functions that require intelligence when performed by people."
6	Rich and Knight (1991)	"The study of how to make computers do things at which, at the moment, people are better."
7	Winston (1992)	"The study of the computations that make it possible to perceive, reason, and act."
8	Luger and Stubblefield (1993)	"The branch of computer science that is concerned with the automation of intelligent behavior."
9	Dean et al. (1995)	"The design and study of computer programs that behave intelligently. These programs are constructed to perform as would a human or an animal whose behavior we consider intelligent."
10	Nilsson (1998)	"Many human mental activities, such as writing computer programs, doing mathematics, engaging in common sense reasoning, understanding language, and even driving an automobile, are said to demand intelligence. We might say that (these systems) exhibit artificial intelligence."

TABLE 1.2

Summary of Developments in AI

Activity	Year	Particulars
First computer-related developments	1836	Charles Babbage, mathematician at Cambridge University, and Augusta Ada Byron first developed a programmable machine.
	1923	Karel Čapek's play *Rossum's Universal Robots* opened in London, where the word "**robot**" was used first time.
	1940s	John Von Neumann, mathematician at Princeton University, conceived the architecture for a computer that included a program and its processed data that can be stored in the computer's memory.
Maturation of Artificial Intelligence	1943	Warren McCulloch and Walter Pits carried out the first work that is now known as AI. They suggested a model of **artificial neurons**. The foundation for neural networks was laid out.
	1945	Isaac Asimov, a Columbia University alumnus, coined a term "**robotics.**"
	1949	Donald Hebb developed a new rule, called **Hebbian learning**, for modifying the strength between neurons.
	1950	Alan Turing, a British mathematician, World War II code-breaker, and a pioneer in machine learning, published ***Computing Machinery and Intelligence***. He introduced the **Turing Test** for evaluation of intelligent behavior of the machines equivalent to human intelligence. Claude Shannon published ***Detailed Analysis of Chess Playing***.
The birth of artificial intelligence	1955	Allen Newell and Herbert A. Simon developed the **first artificial intelligence program**, naming it the "**Logic Theorist**." This program was capable of proving 38 out of 52 mathematics theorems, as well as develop new proofs for several problems.
	1956	American computer scientist John McCarthy at the Dartmouth College Conference first used the term "**artificial intelligence**." During that time, computer languages, such as FORTRAN, LISP, and COBOL, were invented. Demonstration of the first running AI program was done at Carnegie Mellon University. It attracted lot of government and industry support.
The golden years – early enthusiasm	1965	Robinson's complete algorithm for logical reasoning was introduced.
	1966	Algorithms for solving mathematical problems were developed. Same year, Joseph Weizenbaum created the first **chatbot**, named **ELIZA,** which laid the foundation for the chatbots used today.
	1969	**Shakey**, a robot having locomotion, perception, and problem-solving capabilities, was developed by Stanford Research Institute.
	1972	The first intelligent humanoid robot, named **WABOT-1**, was built in Japan.
	1973	Edinburgh University's robot, called **Freddy**, could use vision technology to locate and assemble models.
The first AI winter	1974	The beginning of a period, which would last until the end of the decade, during which computer developers experienced a severe shortage of government fund for research work, leading to a decrease in interest in AI.
	1979	**Stanford Cart**, the first computer-controlled autonomous vehicle, was built.
A boom of AI	1980	AI came back using new techniques of deep learning, including Edward Feigenbaum's **Expert Systems** that replicated the decision-making capability of human experts. That year, the American Association of Artificial Intelligence organized its first national conference at Stanford University.
	1985	**Aaron**, the drawing program, was created by Harold Cohen.
	1986	Popularity of neural networks.
The second AI winter	1987	Private investment and government funding for AI research dry out once again due to huge costs and not enough return on investment. However, the **XCON** Expert System proved very cost effective.
	1990	Many advances in AI took place, such as machine learning, Web crawler, scheduling, data mining, multi-agent planning, natural language understanding and translation, case-based reasoning, games, vision, and virtual reality.
	1991	AI logistics planning and scheduling program that involved up to 50,000 vehicles, cargo, and people was adopted by US forces during the First Gulf War.

(*Continued*)

TABLE 1.2 (*Continued*)

Summary of Developments in AI

Activity	Year	Particulars
The emergence of intelligent agents	1995	The emergence of intelligent agents.
	1997	**IBM Deep Blue** defeated world chess champion **Gary Kasparov**, the first computer to defeat a human world chess champion.
	2000	Interactive robot pets developed. **Kismet**, a robot with a face capable of expressing emotions, was developed by researchers at MIT. Another robot, called **Nomad** was used to explore remote areas of Antarctica and located meteorites.
	2002	For the first time, AI **Roomba**, a vacuum cleaner, found application in the home.
	2006	AI used by business firms such as Facebook, Twitter, and Netflix.
Deep learning, big data, and artificial general intelligence	2011	IBM's **Watson**, a program capable of understand natural language and solving complex questions quickly, ultimately won **Jeopardy**, a quiz show.
	2012	An Android app, called **Google now**, was launched, which could be used as a prediction tool.
	2014	The **Eugene Goostman**, a chatbot, won a competition in the infamous **Turing test**.
	2018	**Project Debater** developed by IBM could be used to debate complicated topics with two master debaters, and outperformed them. Google developed a virtual assistant, **Duplex**, which made a call to book hairdresser appointment, with a human receptionist on the other end of the line not realizing she was talking to a computer program.
	Present	Increased computational power and volume of available data has increased the use of AI in the late 1990s, and this trend is accelerating. AI has enhanced the use of natural language processing, computer vision, robotics, machine learning, deep learning, etc. AI is useful in controlling vehicles, diagnosing diseases, and predicting behaviors. Recently, the 18-times historic defeat of World Go champion Lee Sedol by Google DeepMind's **AlphaGo** has proved the capabilities of intelligent machines.

1.4 The Importance of AI

AI can automate repetitive learning through the datasets. But AI has some basic differences from hardware-driven automation, as it can perform continuous, large-volume tasks reliably (Iyer, 2018). For such automation, some human intervention is still required to initialize the system. Automation, communication platforms, and machines can be integrated together with massive data to apply to several new applications. Given that AI adds intelligence to existing processes, it cannot be viewed as an independent application. For example, in new-generation Apple products, the Siri is included as a useful feature.

AI uses progressive learning algorithms that allow the data to carry out the programming. It can find structure and irregularities in the data to be used in classification and/or a prediction. For example, the AI-based program can teach itself to playing chess, and it can also be used to recommend the next product for online buyers. In the same way the models continue to adapt with the input of new data. The back-propagation technique allows the algorithm to refine itself, with the help of training data and new data, if the predicted results are not accurate. AI can analyze large data with hidden layers of neural networks. It can obtain higher accuracy through deep neural networks (https://www.javatpoint.com). The DL models require Big Data to train, as they learn directly from a dataset. The more data is fed to models, the more accurately they predict the results. For example, Alexa, Google Search, and Google Photos are all using the DL approach; the more we utilize them, the more accurate they become. In the medical field, AI-based DL, image classification, and object recognition techniques can be employed to possibly detect the disease on MRIs with almost as much reliability as when it's done by trained radiologists.

AI is not going to replace humans, but it supplements human abilities so they can be performed better. As AI algorithms learn entirely differently from humans, they ought to perceive things differently, and can easily visualize the relationships and patterns that cannot be seen by humans (McCarthy, 2019; Joshi, 2020). Thus the human–AI partnership can offer many opportunities:

(i) It can provide further support to our existing abilities, and allow for better perception and understanding.
(ii) It can introduce analytics to industries in which AI is currently being used.
(iii) It can be used to improve the analytic technologies such as computer vision, time-series analysis, etc.
(iv) It can bridge the economic, language, and translation barriers.
(v) It provides know-how of ML to be used to build predictive models for AI.
(vi) It can learn how software is to be utilized to process, analyze, and derive meanings from natural language.
(vii) It can process images and videos for several real-time applications.
(viii) It can build intelligent systems to provide interactive communications between humans and AI systems.

1.5 Processes Involved with AI

The AI programs will have cognitive skills: reasoning, problem solving, learning, perception, and self-correction, as given below (McCarthy, 2019):

1. **Reasoning process:** The AI program here focuses on selecting the most appropriate algorithm to achieve the required results. It is the process that is used for making judgments, decisions, and predictions. Reasoning processes are mainly categorized as inductive reasoning and deductive reasoning.
2. **Learning process**: Its function is acquiring data and creating rules in order to devise actionable information from data. Learning improves understanding of the subjects under study. The rules, also called algorithms, help provide sequences of instructions to perform a task using computing devices. It involves acquiring knowledge by way of study, practice, and gaining experience. Humans, some animals, and AI-based systems have the ability to learn (Rouse, 2020).
3. **Problem-solving process**: It is used to get the required solution from the current situation by taking another approach. Problem solving may include decision-making, i.e., selecting the best out of several possible alternatives to get the objectives.
4. **Perception process**: It includes selecting, acquiring, interpreting, and ultimately analyzing the information. In case of humans, perception is supported by sensory organs. Perception mechanisms in AI place the sensors data together in a useful manner.
5. **Self-correction process**: It is designed to continually refine the algorithm so that it determines the most accurate results.

1.6 AI as an Interdisciplinary Tool

AI is a technology that encompasses many areas including computer science, biology, psychology, sociology, philosophy, mathematics, and neuron science. One or more areas may be required to create an AI system. From an interdisciplinary perspective, the AI domains include explicit knowledge, language aptitude, verbal and numerical reasoning, creative and critical thinking, as well as working memory, as shown in Figure 1.1.

AI today is one of the growing technologies in computer science or data science, which has created a revolution globally by developing intelligent machines and tools (Shankar, 2020). AI is developed in a way similar to the operation of a human brain, specifically the way a human learns, decides, and works while attempting to solve a problem, and then using this outcome to develop intelligent machines and software. AI includes the use of expert systems, machine learning (ML), deep learning (DL), natural language processing (NLP), neural network, and fuzzy logic, as shown in Figure 1.2.

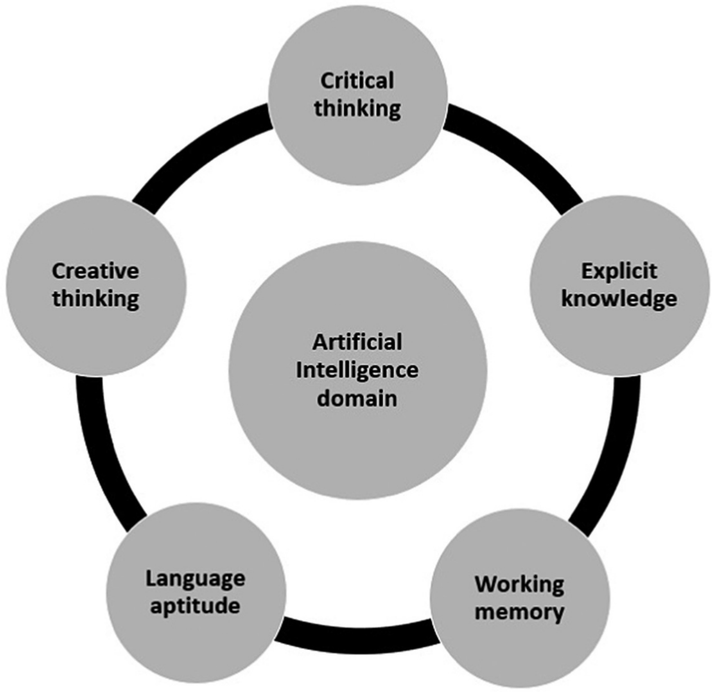

FIGURE 1.1 Various interdisciplinary domains of AI.

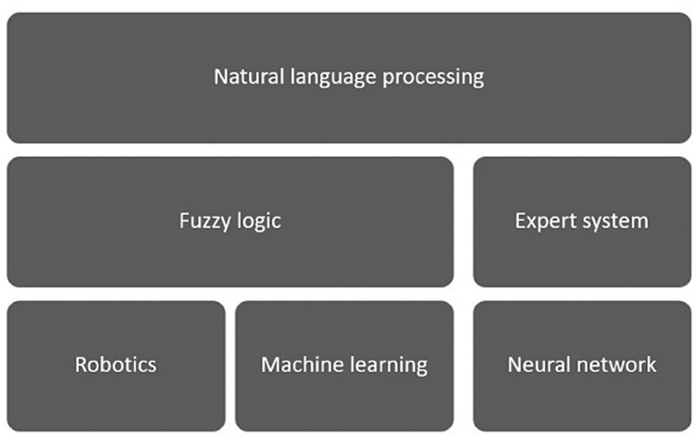

FIGURE 1.2 Various technologies used in AI.

The ML is about instructing a computer by providing it with data so it learns several things on its own, even when it has not been explicitly programmed. It is part of the expanding collection of AI tools that helps people make smarter, more logical decisions. The ultimate aim of ML is to allow independent decision-making by machines. The ML-based AI has several applications in education, medicine, search engine results, digital marketing, and more. Such AIs have a big demand in businesses, as they utilize ML to enhance users' experience, like for Amazon and Flipkart. The ML techniques have made significant progress in the past, and the commonly used are: (i) supervised learning, (ii) unsupervised learning, and (iii) reinforcement learning (Tutorials Point, 2021).

Robotics, a subset of AI, includes different fields of engineering and sciences, which involve design and manufacture of robots as well as their applications. They are often used to undertake difficult tasks that are not possible for humans, or to perform repetitive work. The AI-based robots work by studying the objects in their surroundings and by taking relevant actions. The automation tools with AI technologies can be used for repetitive work, as well as rule-based data processing tasks that are usually done by humans. For example, robots can be used in production of goods or for moving, spraying, painting, precision checking, drilling, cleaning, coating, carving, surgery, nursing, etc. (Shankar, 2020).

The ML-based AI applications can take large volumes of data and quickly transform them into actionable information. The robots combined with the ML can automate larger jobs and respond to process about the changes. The ML is also used to develop robots that are used to interact in social settings. Artificial neural networks (ANN) and DL technologies are also gaining popularity, as AI can process huge amounts of data more quickly and make more accurate predictions than humans can possibly do (Rouse, 2020). Some neural networks based applications include recognition of pattern, face, character, and handwriting. They can be used to manage the real-world problems and devise their solutions quickly.

An expert system can mimic the decision-making capability of humans. Expert systems integrate software, machine, reasoning, explanation, and actions to the users. Table 1.3 presents a scenario comparing programming without AI and programming with AI. The examples of expert systems include flight-tracking systems, predicting systems, clinical systems, etc.

Fuzzy logic approach can be used to compute based on "degrees of truth" rather than "true or false" (1 or 0) Boolean logic, on which the modern computers are based. The binary logic is not able to solve complex problems. Most of the processes are nonlinear in nature, and no specific model would be suitable to every situation. Fuzzy logic controllers are popular globally, especially with unstructured information (Shankar, 2020). The examples include consumer electronics and automobiles, among others.

The NLP requires AI methods that analyze the natural human languages to derive useful insights to solve problems. Existing approaches to the NLP are using ML. The NLP may include sentiment analysis, speech recognition, and text translation (Tucci, 2020). A well-known example of NLP is spam detection, which can interpret the subject title and body of an e-mail to determine the presence of "junk" content. Virtual assistants such as Alexa and Siri are good examples of computer applications helping people with daily tasks. These assistants can ask a few questions from the user to know what he/she wants, instead of analyzing huge amounts of data to understand a request, therefore drastically reducing the time to get the desired answer.

A correlation between AI, ML, ANN, and DL is shown in Figure 1.3. The broad differences are given in Table 1.4.

TABLE 1.3

Programming without AI and with AI

S. No.	Programming not using AI	Programming using AI
1	Without AI, any computer program may be able to answer only the *specific* questions.	With AI, any computer program may be able to answer the *generic* questions.
2	Modifications in the program would require changes in its basic structure.	AI programs can easily adapt new changes by having independent modules together, so any module can be modified without changing its basic structure.
3	Changes in the program are time-consuming, and may affect the program entirely.	Modification in the program is quick and easy.

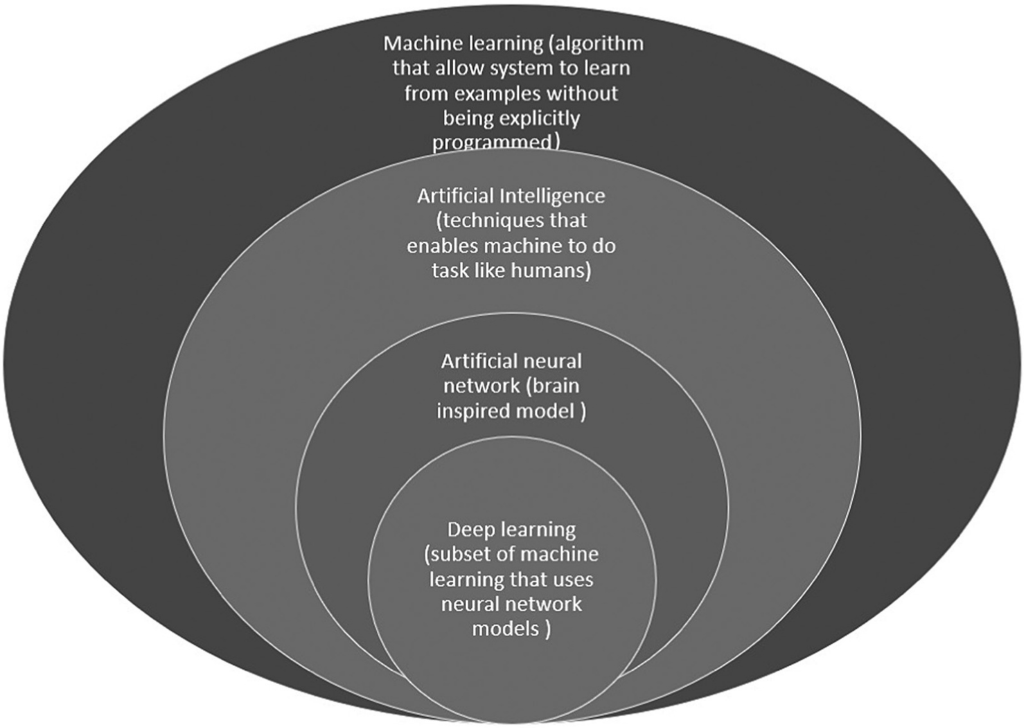

FIGURE 1.3 Relationship between AI, ML, ANN, and DL.

TABLE 1.4

Major Difference between AI, ML, ANN, and DL

AI	ML	ANN	DL
It originated around the 1950s	It originated around the 1960s	It originated around the 1950s	It originated around the 1970s
It is a subset of data science	It is a subset of data science and AI	It is a subset of data science, AI, and ML	It is a subset of data science, AI, and ML
It represents simulated intelligence in machines, and its aim is to build machines that can think like humans.	Computer can work/act without programming. Its aim is to make machines learn through data so that they can solve problems	These are the set of algorithms, modeled just like the human brain Their objective is to tackle complex problems	It is the process of automation of predictive analytics. It uses neural networks to automatically identify the patterns for feature extraction.
	Google search engine is used for speech recognition, image search, translation, etc. For example, Amazon and Flipkart are providing personalized services to individuals based on their likes and dislikes.		Some deep learning examples include self-driven vehicles, face recognition on phone, computer vision, and tagging on Facebook.

1.7 Types of AI

AI can be classified into seven types depending on the performance of machines (https://www.javatpoint.com): reactive machines, limited memory machines, theory of mind, self-aware, ANI, AGI, and ASI, as briefly explained below (Rouse, 2020).

1. **Reactive machines**: Reactive machines are conventional types of AIs that possess only limited capability to simulate the ability of human mind. Reactive machines work without memory-based functionality, and so are unable to correct their present actions based on their past experiences. Therefore, these machines are not capable of "learning." They study the surroundings and select the best solution among the possible ones. A well-known example is Deep Blue, the IBM chess program that defeated Garry Kasparov in the 1990s (Joshi, 2020). The Deep Blue can recognize pawn on the chessboard to make a move, but it cannot retain any memory as well as incorporate past experiences for making present decisions.
2. **Limited memory**: As is clear from the name, these AI systems have a small amount of memory, and thus very limited capacity to apply past experiences to new decisions. This group includes, among others, chatbots, virtual assistants, and self-driving vehicles. Many existing applications fall under this category of AI. These machines can retain data for a short time, limited by the capacity of their memory. In addition to having the capabilities of reactive machines, limited memory machines are capable of learning from the historical data to make certain decisions. The AI systems using DL require large volumes of data for training, which they can store in their memory for solving the current/future problems. For example, an image recognition AI can be trained on a large number of images and their features to identify the objects it has scanned. Any new image will make use of the training images and, based on its "learning experience," would label the new image with better results. A self-driven vehicle constantly detects the movements of all other vehicles around it and adds them to its memory. It can store the speed and pattern of changing lanes, etc., of vehicles around it, and can safely navigate on the basis of these data.
3. **Theory of mind**: This is a psychology term. Theory of mind is the future AI systems that are presently planned to be developed (Tucci, 2020). When applied to AI, these systems are expected to have the social intelligence to understand emotions. The two types of AI mentioned previously comprise the majority of modern systems, with this type and self-aware type of AIs being developed as a concept, and the work is still in progress. The main purpose of building such an AI is to simulate human emotions and beliefs through computers that can impact future decisions. For example, if two individuals plan to work together, they should interact to work effectively.

   Various models are used to understand human behavior, but one with a mind of its own is yet to be created. These systems can understand human requirements and predict behavior. Such systems can assist in the future based on human expectations. Such AI will have the ability to understand humans by interacting with them and identifying their needs, emotions, and requirements. For example, Bellhop Robot is being developed for hotels, with the ability to assess the demands of people wishing to come stay at the hotel.
4. **Self-aware**: These AI systems have a sense of self and possess human-like consciousness and reactions. Machines with self-awareness will be able to understand their own current state, and thus be conscious about themselves, and will use information to infer the emotions of others. This is the expected next stage of AI development. It is believed that this type of AI will achieve the ultimate goal of AI development. It will have emotions, needs, beliefs, and potentially desires of its own. Such AI will operate like a human and start predicting its own needs and demands.

   The self-aware AI is expected to enhance the output many times, but it can also lead to disaster. Such AI would have dangerous ideas, like self-preservation, which may not always coincide with the wishes, or even the actual physical well-being, of humans. Such machines although will have the capability to develop self-driven actions. This is the type of AI associated with every apocalyptic prediction of the end of the human civilization.

5. **Artificial Narrow Intelligence (ANI)**: The ANI is also known as Weak AI, that is, the one designed and trained to undertake only one particular type of work (Rouse, 2020). This definition includes all the existing AIs, including the most complicated ones. Any AI that utilizes ML and DL to teach itself may be called an ANI. Since the ANI performs only a specific task autonomously due to its programming limitations, it has a very limited or narrow set of competencies. These systems correspond to all the reactive and limited memory AIs. Examples include industrial robots and virtual personal assistants, which use weak AI. Speech recognition AI is another example of a weak AI, which identifies spoken words and converts them into a machine-readable format.
6. **Artificial General Intelligence (AGI)**: The AGI is also known as Strong AI. Its program can replicate the cognitive abilities of the human brain. It can perform a variety of tasks, as well as learn and improve itself. It is a self-teaching system that can outperform humans in a large number of disciplines. It provides the ability to perceive, understand, learn, and function, just as human beings do. The AGI systems employ fuzzy logic to apply domain knowledge and find a solution automatically to an unknown task. Such systems are able to reduce substantially the time required for training. Examples include the Pillo Robot that can answer questions related to health, or AlphaGo, a computer program to play the board game Go, which has defeated Lee Sedol, a South Korean professional gamer.
7. **Artificial Super Intelligence (ASI)**: The ASI will probably be the future AI research area, as it would be the most capable intelligence in the world. The ASI will not only replicate the intelligence of human beings but also have much higher storage (i.e., memory), faster data analysis, and better decision-making powers. The capabilities of ASI are expected to supersede that of humans. The AGI and ASI are expected to create a big revolution in the future, but they also may threaten our way of life. An example of ASI includes the Alpha 2, which is the first humanoid ASI Robot (Rouse, 2020).

1.8 Advantages and Disadvantages of AI

Every technology has some merits and demerits (https://www.javatpoint.com; Tucci, 2020). AI has many more advantages than disadvantages, as discussed in the following section.

Advantages

1. **Better accuracy**: The AI-based machines help analyze patterns and trends by accurately assessing the needs of the users. An AI-enabled machine is responsible for selecting the input data and values as per past experience or information, reducing human error and providing high accuracy. For instance, if a firm is more dependent on the data that is fed to a system manually, the chances of 100% correctness of data entered into the system are lower than if the input is automated. By contrast, a machine that can analyze its surroundings to capture the data automatically into the system is considered to be more accurate, eliminating the possibility of a manual error.
2. **Higher speed**: The AI systems are very fast and can make predictions with a higher degree of accuracy than is possible for humans.
3. **Better decision-making**: Human perception, understanding, and decision-making are often affected by personal bias and current emotional state. Since the machines are not affected by bias or emotions, AI-enabled systems could provide the most optimal decisions and solutions without any personal prejudices. One of the first examples of this is the loss of Garry Kasparov – a chess grand champion but still prone to human error – to IBM's Deep Blue back in the 1990s.
4. **High reliability**: AI-equipped machines are capable of performing repeating actions with an unchangingly high degree of accuracy.
5. **Day-night working**: The AI systems can work continuously for long periods of time, without the need for break for sleep, food, elimination, or recreation, all of which humans need.

6. **Dealing with complexities**: While many people tout their ability to “multitask” on their resumes, it is actually impossible for humans to handle several tasks at the same time with the same degree of focus given to all of them. Machines, on the other hand, can process large amounts of data required for several tasks to be performed simultaneously, without any confusion and consequent errors.
7. **Working in risky areas**: AI-equipped machines are very useful in actions that are hazardous to humans, such as defusing a bomb, exploring the nuclear sites, cleaning up a toxic spill, and the like.
8. **Optimization of resources**: The AI systems have the capabilities to assess and interpret multiple data streams at the same time, from handling databases of products and customers to analyzing the patterns of purchase. Humans are not physically able to accomplish these multiple tasks simultaneously. Thus, these machines would help in the resource optimization.
9. **Digital assistant**: For example, the AI technology is used by various e-commerce companies to display the products per customer’s need.
10. **Working as a public utility**: AI is helpful in public utilities, self-driving cars, regulation of traffic, facial recognition, natural language processing, etc.

Disadvantages

1. **High cost**: An AI system consisiting of hardware and software is very costly, and it also requires recurring expenses for maintenance and upgrades to meet day-to-day needs. In addition, it may be costly to process the voluminous information required by AI programming.
2. **No original creativity**: Humans are always creative and full of new ideas, but AI machines are not creative and imaginative to beat the human intelligence.
3. **No out-of-box thinking**: Even smarter AI-based machines cannot think or work out of context, but will perform the task they have been trained on.
4. **No feelings and emotions**: Even the best-performing AI machines do not have feelings, so they fail to make any kind of emotional attachment with humans. These machines, in fact, may be harmful to users if they are not used properly.
5. **Dependency on machines**: With the advancements in technology, humans are becoming dependent on gadgets/devices/machines/software, and thus may not use much of their mental capabilities.

1.9 Some Examples of AI

Intelligent gadgets can make everyday tasks simple and fast. For example, Alexa is capable of keeping a record of our daily appointments, list of items to be purchased, play the desired music, read news, and play innovative games (Shankar, 2020). Some other examples include the following:

1. **Echo**: Echo, launched by Amazon, is a cloud-based voice assistant, Alexa. It is capable of hearing, comprehending, and responding to commands or questions of the users and offer possible solutions. For example, you can ask Alexa if you need an umbrella before going out, and it might suggest you take one, as it may to rain in the afternoon.
2. **Flipkart**: Flipkart, an e-commerce shopping platform, can be used to suggest items to its customers based on their past purchase or viewing history of items.
3. **Pandora**: The Pandora platform uses AI to determine the music the users require. It does not, however, provide any song choices.
4. **Netflix**: Netflix is the most popular Over The Top (OTT) platform today, and is also known as Other Than Television platform, among which are Amazon Prime, Hulu, and others. The OTT

platforms provide services that deliver content to its customers over the internet by paying a subscription fee. They also recommend additional content based on the user's previous choices.

5. **Siri**: Developed by Apple, Siri is a voice-activated interactive assistant. It uses ML technology to understand the ways the users are navigating through their phones, sending messages, and making phone calls. To use this feature, begin by saying, "Hello Siri," followed by an action request.

1.10 Applications of AI

AI has wide applications. More and more industries, such as education, health care, travel, entertainment, finance, and marketing, rely heavily on its ability to solve complex problems and perform complex functions efficiently (Sharma and Garg, 2020). It is also being used in military planning, intelligent vehicle movement, credit card transaction monitoring, robots, credit card fraud detection, automobiles, etc. (Tutorials Point, 2021; Tucci, 2020). The AI is trying to make users' daily lives much more easy and comfortable. The following are some areas having potential applications of AI:

1. **AI as a Service (AIaaS)**: The deployment of an AI platform may be expensive, as it involves the cost of hardware, software, and staff. Therefore, many firms are incorporating AI in their products to provide access to AIaaS platforms (Tucci, 2020). The AIaaS allows to experiment with various AI platforms for businesses and applications before investing heavily in an AI platform. Popular AI-based cloud offerings include IBM Watson Assistant, Amazon AI, Google AI, Microsoft Cognitive Services, etc.
2. **Automobiles**: Many automobile industries are providing AI-based virtual assistants to their users for better driving performance, such as TeslaBot by Tesla. The AI is now being applied toward development of driverless cars. These cars, with the help of AI systems would be able to apply brakes, change lanes, navigate, etc. Such cars will study the patterns of other surrounding cars moving on the road and implement the moves necessary for safe driving autonomously. Autonomous vehicles use computer vision, image recognition, and DL to navigate a vehicle in a given lane and at the same time avoid obstructions like dividers, pedestrians, light-poles, animals, etc.
3. **Agriculture**: The AI is emerging in the fields of agriculture, which requires various resources for obtaining the best yields. Agriculture robotics is being applied in agriculture for crop monitoring and predictive analysis to help farmers. The AI techniques for farming help increase productivity and yield.
4. **Banking**: Banks are using chatbots to provide services and offers to their customers, and to deal with the transactions without human involvement. The AI virtual assistants improve the services and cut down the costs of establishments. Financial organizations make use of AI to improve decision-making for loans, keep track of approved loans, set credit limits, as well as highlight the investment opportunities to their customers (Tucci, 2020).
5. **Business**: Business can use AI-based solutions to assess the weaknesses and strengths in order to improve its financial and customer relationship management (CRM), among other things. AI can help in automating the works, saving considerable time and manpower requirements. The ML algorithms that can better serve customers are integrated into analytics and CRM platforms to. Manufacturing units can improve the quantity and quality of its production by using AI required to assess the demand and supply, assembling the parts, etc.

   AI is being used in the e-commerce business in a big way to provide competition to e-commerce industry. It is helping its customers to find out the related products with suggested size, color, or brand. Chatbots are being used in websites of companies to provide almost instant customer service. For example, McDonald's has been using AI to analyze customers' ordering trends. Further, customers can place orders directly by using kiosks or interactive terminals instead of dealing with a live cashier; this has reduced order errors and increased sales.

6. **Data security**: In digital worlds, cyberattacks are growing very fast, and the security of data has become crucial for all organizations. AI is being used to make this data safer and more secure. AI and ML in cybersecurity products are providing added value to identify malware attacks. The AI is capable of assessing new malware attacks much faster than the human operators. The AI-based security technology gives organizations advanced information to take precautions against threats before real damage occurs. The technology, such as AEG bot or AI2 platform, is playing an important role in helping organizations fight with cyberattacks; they can also be used to determine software bugs that allow cyberattacks to happen (McCarthy, 2019).
7. **Education**: AI can adapt the learning as required by each student, and deliver a good learning experience. In addition, it provides universal access to all students, as well as helps them work at their own pace. The system also automates examination grading systems by reducing the involvement of educators, providing them more time to teach. An AI chatbot, as a teaching assistant, can communicate effectively with students. An AI tutor can teach the subject as required by the students. The AI can work as a personal virtual tutor for students in future, which will be easily accessible to students at anywhere any time.
8. **Entertainment**: AI-based applications such as Netflix or Amazon are providing entertainment services all over the world. With the help of ML-based AI algorithms, these services also recommend specific programs or shows for its users.
9. **Finance**: Finance applications require collection of personal data of individuals and provide help, advice, and suggestions related with finances, and can even help doing securities trading. Today, trading on Wall Street is done through AI software (McCarthy, 2019). The finance industries are employing ML in the automation, chatbot, adaptive intelligence, algorithm trading, etc. into financial processes. The AI systems, such as Intuit Mint or TurboTax, are being used by financial institutions for personal financial applications, while other programs, such as IBM Watson, are being used to buy homes.
10. **Gaming**: AI can be used for gaming purpose to generate alternative solutions in a game based on decisions taken by the users in the game, such as player movements, pathfinding, etc. AI-based programming is used by many video games today, such as *Minecraft* and *Tom Clancy's Splinter Cell* (Tutorials Point, 2021). The AI machines can play crucial roles in games, such as poker, chess, etc.
11. **Government**: Governments are using AI to draw suitable policies and services, analyze road accidents, and find solutions for many other problems. The AI-based applications are reducing costs, minimizing errors, taking heavy workloads, and helping bust the backlogs.
12. **Health care**: AI is assisting doctors in many ways and providing faster recovery to the patients (Iyer, 2018). AI can help doctors and patients with diagnoses and inform the latest conditions to the patients, and, if the condition is serious, ensuring medical help reach patients faster. AI has several advantages and is expected to have a positive impact on the health care industry. The AI robots are being developed that will be able to care for the elderly and remind them to take their medicine and even locate the misplaced items like eyeglasses. Various AI applications may include use of online virtual health assistants and chatbots by the patients, collection of medical history, fixing of appointments, and helping with administrative tasks.

    The AI technologies are also helpful to understand pandemics, such as COVID-19. For example, BlueDot, a Canadian company, used AI technology to detect COVID-19 outbreak in Wuhan, China, soon after the first few cases were detected. The IBM Watson can understand the natural language and provide responses to the queries. The system can mine the data of patients to develop a framework for presenting the results with a relative score. But while the predictive algorithms could be helpful in controlling pandemics or other global threats, the ultimate impact of AI is impossible to predict (Tucci, 2020).

    It is known that robots are increasingly assisting the surgeons in an operating room. Specialized robots are being manufactured to carry out experimentation and provide life-like experiences without carrying out any hands-on experimentation on patients. For example, Gaumard, a health care education company, is now producing robots that can be used to perform various experiments by medical students and medical professionals to do practical learning. These life-like robots can interact with care providers and simulate facial expressions and other physical responses to the questions and actions of doctors or medical students when prompted, spoken to, or touched. Not only can medical professionals interact with the robots, but the robots also can be operated on to teach the procedure and also to take corrective steps if any errors are made during an operation. Using such AI-based system, medical students can easily make incisions, conduct surgeries, draw blood, monitor breathing, etc. (McCarthy, 2019).

13. **Law**: The use of AI is proving to be time-saving to automate the labor-intensive processes of the legal industry, and thus help improve the services of clients. Law firms and professionals make use of ML-based AI to analyze the data and predict the outcomes. In addition, computer vision is used to extract information and the NLP is used to interpret requests for information.
14. **Natural language processing**: The NLP utilizes the capabilities of machines to understand natural languages. Two of the most commonly used examples of NLPs, available in many smartphones and computer software, are spell check and autocorrect. In 2019, two AIs created by Alibaba and Microsoft defeated a team of persons in a Stanford reading-comprehension test (McCarthy, 2019). The algorithms could "read" a series of Wikipedia entries on the topic, and successfully answered a number of questions about the topic more precisely than the human participants could do.
15. **Personal assistant**: An AI-based personal assistant can perform several tasks based on verbal or written commands, such as navigating the records or assessing if some person suffered a heart attack during an emergency call services. This is a good example of weak AI, as the algorithm has been created to perform a specific task. The best-known examples of AI assistants are Google, Alexa, and Siri (Kowalewskisays, 2019). One of the most advantageous points about an AI assistant is that it serves as a great help in various applications of AI. As more and more consumers are using Virtual Personal Assistants, speech recognition has become essential in our lives. Phones, computers, and home appliances are increasing our dependence on AI and ML through voice. According to recent statistics, the AI assistant market is going to expand further and will become worth USD 25 billion by 2025 (Businesswire, 2019).
16. **Robotics**: AI has a remarkable role in robotics. Manufacturing industries are adapting to incorporate the use of robots into their workflows. Earlier, the industrial robots were separated from human workers and programmed to perform single tasks. Today industrial robots function as cobots, which are smaller and multitasking robots. Such cobots can be used to take up the jobs in warehouses, industries, and other workspaces. Normally, robots are programmed to perform tasks that are repetitive in nature, but AI-based robots are used to perform several tasks with their own previous experience, and even without preprogramming (Tutorials Point, 2021). Humanoid robots are best examples of AI-based intelligent robots; like Erica and Sophia can talk and behave like human-beings. Their sensors can detect physical data from the real world, such as light, sound, temperature, movement, and pressure, and these systems can learn from their past and apply that knowledge to the new environment (Tschopp, 2018).

    Industrial robots are used in the manufacturing fields as an alternative to humans. For example, such robots have been in use in the automobile manufacturing sector for quite some time, as some processes in car making may not be safe for humans. In 1961, Unimate, the first-ever industrial robot, was used by General Motors on an assembly line. Currently, the robots are used in warehouses for many other duties also (McCarthy, 2019). In 2014, Amazon has deployed Kiva robots in their centers' warehouses, which are helping employees to fill orders very quickly (15 minutes) that humans alone can manage (90 minutes). These robots can pick up the items and transport the inventory directly to human workers. Programmed with object detection technology, these robots can move freely throughout the warehouse, avoiding potential collisions with other Kiva robots or human workers.
17. **Social media**: AI can be used to organize and manage large volumes of data efficiently. Social media sites like Facebook, Twitter, and Snapchat may contain profiles of large number of users, which are required to be stored and managed efficiently. The AI can analyze this huge block of data to identify the latest trends, hashtags, and requirements, among other things, of different users.

18. **Supermarkets (retail)**: Some large industries in the retail sector have started using AI-based robots to handle the tasks previously carried out by human customer associates (Iyer, 2018). Stock inventories generally are time-consuming and require multiple employees to track items that need to be restocked so they can be reordered. Several supermarkets and other retail markets are now using robots to take stock inventory. For example, Walmart, a retail industry giant, and Bossa Nova, a robotics company, have teamed up to create a supermarket application. The Bossa Nova robot would be used to scan the shelves in real time to collect product data, doing so much faster than a human employee could. Such a robot aims to improve product availability, enhance customer experience, and reduce the workload of customer associates.
19. **Transportation and travel**: Demand for AI is also growing in travel industries. In addition to AI being used in autonomous vehicles, it is used to manage traffic, estimate flight delays, and many other tasks (Tucci, 2020). It is also used in the travel insurance sector to file claims faster and more efficiently after the accidents. The AI can be used for making travel arrangements and suggesting accommodations, flights and best routes to its customers. Travel companies are employing AI-powered chatbots for faster response and better service for their customers.
20. **Vision systems**: Vision based algorithms are being developed to predict future actions of individuals (Tutorials Point, 2021). Machine vision can capture and analyze visual information using a camera and video and digital signal processing. These systems can understand, interpret, analyze, and display visuals. For instance, doctors can utilize expert system to operate on patients. Police can use them to recognize the faces of criminals based on drawings done by a forensic artist.
21. **Speech recognition**: Some AI-based systems can be used for hearing and comprehending the sentences and their meanings while a person is talking. These systems are capable of handling a variety of accents, slang words, background noise, change in a person's voice due to an illness, and many more aspects.
22. **Handwriting recognition**: The algorithm is able to read the text written on paper using a pen or on screen using a stylus. In addition, it can also recognize letter shapes and convert them into editable text (Tutorials Point, 2021).

1.11 Summary

The AI is one of the important areas of computer/data science allowing a machine to perform tasks in a way similar to a human performing them. Its main goal is giving machines the ability to process information and make decisions based on that information, the same ways humans do. However, the science and the industry of AI are far from being fully explored and developed. In particular, AI/ML/DL possess significant potential to make human living safer and easier. It is implied that in the future, AI will help humans with many more tasks currently in infancy, such as, for example, space travel.

Robots nowadays are performing many tasks that in the past were done by humans. But robots cannot function without human cotrol, programming, debugging, and analysis. The AI-based robots would make human lives more comfortable, and soon they are going to be an essential part of our daily lives in the same way computers have been since the 1980s. Still, even though AI is becoming increasingly prevalent in many applications, it is not going to completely replace human operators. In the long run, AI is expected to enhance human abilities and be the dominant technology of the future.

REFERENCES

Bellman, R. (1978), *An introduction to artificial intelligence: Can computers think?* San Francisco: Boyd and Fraser Publishing Company.

Businesswire (2019), Global Intelligent Virtual Assistant (IVA) Market 2019–2025: Industry Size, Share & Trends-ResearchAndMarkets.com, https://www.businesswire.com/news/home/20190822005478/en/Global-Intelligent-Virtual-Assistant-IVA-Market-2019-2025

Charniak, E. and McDermott, D. (1985), *Introduction to artificial intelligence*. Reading: Addison-Wesley.

Dean, T., Allen, J. and Aloimonos, Y. (1995), *Artificial intelligence: Theory and practice*. New York: Benjamin Cummings.

Haugeland, J., (Ed.). (1985), *Artificial intelligence: The very idea*. Cambridge, MA: MIT Press.

History of Artificial Intelligence. Available at: https://www.javatpoint.com/history-of-artificial-intelligence [accessed on 23 April 2020a].

History of Artificial Intelligence. Available at: https://blog.solvatio.com/en/from-deep-blue-to-alexa-the-history-of-artificial-intelligence [accessed on 23 April 2020b].

History of Artificial Intelligence. Available at: https://blog.solvatio.com/en/from-deep-blue-to-alexa-the-history-of-artificial-intelligence [accessed on 23 April 2020c].

History of Artificial Intelligence. Available at: https://www.javatpoint.com/history-of-artificial-intelligence [accessed on 23 April 2020d].

Iyer, Ananth (2018), Artificial Intelligence, April 22, https://witanworld.com/article/2018/04/22/witan-sapience-artificial-intelligence/

Joshi, Navee (2020), Types of Artificial Intelligence, COGNITIVE WORLD, https://www.forbes.com/sites/cognitiveworld/2019/06/19/7-types-of-artificialintelligence/#3e68129b233e

Kowalewskisays, Michał (2019), 4 Amazing Ways AI Personal Assistants Can Impact Your Business, March, Artificial Intelligence, https://www.iteratorshq.com/

Kurzweil, R. (1990), *The age of intelligent machines*. Cambridge: MIT Press.

Luger, G. and Stubblefield, W. (1993), *Artificial intelligence: Structures and strategies for complex problem solving*. Redwood City: Benjamin/Cummings.

McCarthy, John (2019), Artificial Intelligence Tutorial – It's your time to innovate the future, Dataflair Team, November 27, https://data-flair.training/blogs/artificial-intelligence-ai-tutorial/

Nilsson, N.J. (1998), *Principles of artificial intelligence*. Palo Alto, CA: Tioga Publishing Company.

Rich, E. and Knight, T. (1991), *Artificial intelligence*. New York: McGraw-Hill.

Rouse, Margaret (2020), Artificial intelligence, https://searchenterpriseai.techtarget.com/definition/AI-Artificial-Intelligence

Schalkoff, R. (1990), *Artificial intelligence: An engineering approach*. New York: McGraw-Hill.

Shankar, Ramya (2020), Future of Artificial Intelligence, 9 April, https://hackr.io/blog/future-of-artificial-intelligence

Sharma, L. and Garg, P. (Ed.). (2020), *From visual surveillance to Internet of Things*. New York: Chapman and Hall/CRC, https://doi.org/10.1201/9780429297922

Tschopp, Marisa (2018), On Trust in AI – a systemic approach, August 28, https://medium.com/womeninai/on-trust-in-ai-a-systemic-approach-d1e1bd112532

Tucci, Linda (2020), Ultimate guide to artificial intelligence to enterprise, https://searchenterpriseai.techtarget.com/definition/AI-Artificial-Intelligence

Tutorials Point (2021), Artificial Intelligence: Intelligent Systems, https://www.tutorialspoint.com/artificial_intelligence/artificial_intelligence_overview.htm [accessed on April 20 2020]

Winston, P. (1992), *Artificial intelligence*. Reading: Addison-Wesley. [accessed on April 23 2020].

Overview of Artificial Intelligence

Bellman, R. (1978), An introduction to artificial intelligence: Can computers think? San Francisco: Boyd and Fraser Publishing Company.
Businesswire (2019), Global Intelligent Virtual Assistant (IVA) Market 2019–2025: Industry Size, Share & Trends-ResearchAndMarkets.com, https://www.businesswire.com/news/home/20190822005478/en/Global-Intelligent-Virtual-Assistant-IVA-Market-2019-2025
Charniak, E. and McDermott, D. (1985), Introduction to artificial intelligence. Reading: Addison-Wesley.
Dean, T. , Allen, J. and Aloimonos, Y. (1995), Artificial intelligence: Theory and practice. New York: Benjamin Cummings.
Haugeland, J. , (Ed.). (1985), Artificial intelligence: The very idea. Cambridge, MA: MIT Press.
History of Artificial Intelligence . Available at: https://www.javatpoint.com/history-of-artificial-intelligence [accessed on 23 April 2020a].
History of Artificial Intelligence . Available at: https://blog.solvatio.com/en/from-deep-blue-to-alexa-the-history-of-artificial-intelligence [accessed on 23 April 2020b].
History of Artificial Intelligence . Available at: https://blog.solvatio.com/en/from-deep-blue-to-alexa-the-history-of-artificial-intelligence [accessed on 23 April 2020c].
History of Artificial Intelligence . Available at: https://www.javatpoint.com/history-of-artificial-intelligence [accessed on 23 April 2020d].
Iyer, Ananth (2018), Artificial Intelligence, April 22, https://witanworld.com/article/2018/04/22/witan-sapience-artificial-intelligence/
Joshi, Navee (2020), Types of Artificial Intelligence, COGNITIVE WORLD, https://www.forbes.com/sites/cognitiveworld/2019/06/19/7-types-of-artificialintelligence/#3e68129b233e
Kowalewskisays, Michał (2019), 4 Amazing Ways AI Personal Assistants Can Impact Your Business, March, Artificial Intelligence, https://www.iteratorshq.com/
Kurzweil, R. (1990), The age of intelligent machines. Cambridge: MIT Press.
Luger, G. and Stubblefield, W. (1993), Artificial intelligence: Structures and strategies for complex problem solving. Redwood City: Benjamin/Cummings.
McCarthy, John (2019), Artificial Intelligence Tutorial – It's your time to innovate the future, Dataflair Team, November 27, https://data-flair.training/blogs/artificial-intelligence-ai-tutorial/
Nilsson, N.J. (1998), Principles of artificial intelligence. Palo Alto, CA: Tioga Publishing Company.
Rich, E. and Knight, T. (1991), Artificial intelligence. New York: McGraw-Hill.
Rouse, Margaret (2020), Artificial intelligence, https://searchenterpriseai.techtarget.com/definition/AI-Artificial-Intelligence
Schalkoff, R. (1990), Artificial intelligence: An engineering approach. New York: McGraw-Hill.
Shankar, Ramya (2020), Future of Artificial Intelligence, 9 April, https://hackr.io/blog/future-of-artificial-intelligence
Sharma, L. and Garg, P. (Ed.). (2020), From visual surveillance to Internet of Things. New York: Chapman and Hall/CRC, https://doi.org/10.1201/9780429297922
Tschopp, Marisa (2018), On Trust in AI – a systemic approach, August 28, https://medium.com/womeninai/on-trust-in-ai-a-systemic-approach-d1e1bd112532
Tucci, Linda (2020), Ultimate guide to artificial intelligence to enterprise, https://searchenterpriseai.techtarget.com/definition/AI-Artificial-Intelligence
Tutorials Point (2021), Artificial Intelligence: Intelligent Systems, https://www.tutorialspoint.com/artificial_intelligence/artificial_intelligence_overview.htm [accessed on April 20 2020]
Winston, P. (1992), Artificial intelligence. Reading: Addison-Wesley. [accessed on April 23 2020].

Knowledge Representation in Artificial Intelligence: An Overview

Artificial Intelligence : Available at: http://www.hbcse.tifr.res.in/jrmcont/notespart1/node38.html [accessed September 12, 2020].
Types of Techniques in Knowledge Representation : Available at: https://link.springer.com/chapter/10.1007/978-3-642-73402-1_13 html [accessed September 12, 2020].
Lavanya Sharma , P. Garg (Eds.). (2020). From Visual Surveillance to Internet of Things. New York: Chapman and Hall/CRC, https://doi.org/10.1201/9780429297922
Lavanya Sharma , "Introduction: From Visual Surveillance to Internet of Things," From Visual Surveillance to Internet of Things, Taylor & Francis Group, CRC Press, Vol. 1, pp. 14.
Lavanya Sharma , P. K. Garg , "Block based Adaptive Learning Rate for Moving Person Detection in Video Surveillance," From Visual Surveillance to Internet of Things, Taylor & Francis Group, CRC Press, Vol. 1, pp. 201.

L. Fogel , A. Owens , M. Walsh , “Artificial Intelligence Through a Simulation of Evolution,” in Biophysics and Cybernetic Systems Maxfield, Washington, DC: Spartan Books, 1965.
Suraj Makkar , Lavanya Sharma , “A Face Detection Using Support Vector Machine: Challenging Issues, Recent Trend, Solutions and Proposed Framework,” in Third International Conference on Advances in Computing and Data Sciences (ICACDS 2019, Springer), Inderprastha Engineering College, Ghaziabad, April12–13, 2019.
Lavanya Sharma , P. K. Garg , “IoT and Its Applications,” From Visual Surveillance to Internet of Things, Taylor & Francis Group, CRC Press, Vol. 1, pp. 29.
Lavanya Sharma , Annapurna Singh , Dileep Kumar Yadav , “Fisher’s Linear Discriminant Ratio based Threshold for Moving Human Detection in Thermal Video,” Infrared Physics and Technology, Elsevier, March 2016.
L. Sharma (Ed.). (2021). Towards Smart World. New York: Chapman and Hall/CRC. https://doi.org/10.1201/9781003056751
Lavanya Sharma , “Human Detection and Tracking Using Background Subtraction in Visual Surveillance,” Towards Smart World. New York: Chapman and Hall/CRC, https://doi.org/10.1201/9781003056751, pp. 317–328, December 2020.
N. Abramson , D. Braverman , G. Sebestyen , “Pattern recognition,” IEEE Transactions on Information Theory, vol. IT-9, pp. 257–261, 1963.
A. Newell , H. Simon , “The logic theory machine—a complex information processing system,” IRE Transactions on Information Theory, vol. IT-2, pp. 61–79, 1956.
G. Pask , “A Discussion of Artificial Intelligence and Self Organization,” in Advances in Computers, New York: Academic Press, vol. 5, pp. 110–218, 1964.
Lavanya Sharma , Birendra Kumar , “An Improved Technique for Enhancement of Satellite Images,” Journal of Physics: Conference Series, 1714, 012051, 2021.
Supreet Singh , Lavanya Sharma , Birendra Kumar , “A Machine Learning Based Predictive Model for Coronavirus Pandemic Scenario,” Journal of Physics: Conference Series, 1714, 012023, 2021.
B. Garcia-Garcia , T. Bouwmans , A. J. R. Silva , “Background Subtraction in Real Applications: Challenges, Current Models and Future Directions,” Computer Science Review, 35, 100204, 2020.
Knowledge Representation : Available at: https://www.javatpoint.com/propositional-logic-in-artificial-intelligence html [accessed September 12, 2020].
Akshit Anand , Vikrant Jha , Lavanya Sharma , “An Improved Local Binary Patterns Histograms Techniques for Face Recognition for Real Time Application,” International Journal of Recent Technology and Engineering, vol. 8, no. 2S7, pp. 524–529, 2019.
Lavanya Sharma , Dileep Kumar Yadav , “Histogram based Adaptive Learning Rate for Background Modelling and Moving Object Detection in Video Surveillance,” International Journal of Telemedicine and Clinical Practices, Inderscience, June 2016.
S. Shubham , V. Shubhankar , K. Mohit , Lavanya Sharma , “Use of Motion Capture in 3D Animation: Motion Capture Systems, Challenges, and Recent Trends,” in 1st IEEE International Conference on Machine Learning, Big Data, Cloud and Parallel Computing (Com-IT-Con), India, pp. 309–313, 14–16 February.
R. Faulk , “An Inductive Approach to Mechanical Translation,” Communications of the ACM, vol. 1, pp. 647–655, November 1964.
T. Evans , A Heuristic Program of Solving Geometric Analogy Problems, 1963.
Lavanya Sharma , Nirvikar Lohan , “Internet of things with object detection”, in Handbook of Research on Big Data and the IoT, IGI Global, pp. 89–100, March, 2019. (ISBN: 9781522574323, DOI: 10.4018/978-1-5225-7432-3.ch006).
T. Bouwmans , A. Sobral , S. Javed , S. K. Jung , E. H. Zahzah , “Decomposition into Low-Rank Plus Additive Matrices for Background/Foreground Separation: A Review for a Comparative Evaluation with a Large-Scale Dataset,” Computer Science Review, 23, 1–71, 2017.
Lavanya Sharma , Dileep Kumar Yadav , Sunil Kumar Bharti , “An Improved Method for Visual Surveillance using Background Subtraction Technique,” IEEE, 2nd International Conference on Signal Processing and Integrated Networks (SPIN-2015), Amity University, Noida, India, February 19–20, 2015.
Dileep Kumar Yadav , Lavanya Sharma , Sunil Kumar Bharti , “Moving Object Detection in Real-Time Visual Surveillance Using Background Subtraction Technique,” IEEE, 14th International Conference in Hybrid Intelligent Computing (HIS-2014), Gulf University for Science and Technology, Kuwait, December 14–16, 2014.
Lavanya Sharma , D. K. Yadav , Manoj Kumar , “A Morphological Approach for Human Skin Detection in Color Images,” 2nd National Conference on “Emerging Trends in Intelligent Computing & Communication”, GCET, Gr. Noida, India, April 26–27 2013.
Lavanya Sharma , Nirvikar Lohan , “Performance Analysis of Moving Object Detection using BGS Techniques,” *International Journal of Spatio-Temporal Data Science, Inderscience*, February 2019.
S. Amarel , “An Approach to Automatic Theory Formation,” in Principles of Self-Organization, New York: Pergamon Press, 1962.
Knowledge Representation : Available at: https://www.cs.utexas.edu/users/pclark/working_notes/010.pdf html [accessed September 12, 2020].

Lavanya Sharma , Nirvikar Lohan , “Performance Analysis of Moving Object Detection Using BGS Techniques in Visual Surveillance,” International Journal of Spatiotemporal Data Science, Inderscience, vol. 1, pp. 22–53, 2019.
T. Bouwmans , “Traditional and Recent Approaches in Background Modeling for Foreground Detection: An Overview,” Computer Science Review, 11, 31–66, 2014.
J. H. Giraldo , T. Bouwmans , GraphBGS: Background Subtraction via Recovery of Graph Signals. arXiv preprint arXiv:2001.06404, 2020.
T. Bouwmans , S. Javed , M. Sultana , S. K. Jung , “Deep Neural Network Concepts for Background Subtraction: A Systematic Review and Comparative Evaluation,” Neural Networks, 117, 8–66, 2019.

Programming Languages Used in AI

Artificial Intelligence . Available at: https://builtin.com/artificial-intelligence [accessed March 20, 2020].
Historical Background Artificial Intelligence . Available at: https://data-flair.training/blogs/history-of-artificial-intelligence/ [accessed March 20, 2020].
Historical Background Artificial Intelligence . Available at: https://www.javatpoint.com/history-of-artificial-intelligence [accessed March 20, 2020].
Programming language overview of Artificial Intelligence . Available at: https://www.zfort.com/blog/best-programming-language-for-ai#: [accessed March 20, 2020].
Realtime applications of AI . Available at: https://www.newgenapps.com/blog/the-role-of-ai-in-our-daily-lives/ [accessed March 20, 2020].
https://elearningindustry.com/ai-is-changing-the-education-industry-5-ways
Tyagi, S. , Sengupta, S. , Role of AI in Gaming and Simulation, Lecture Notes on Data Engineering and Communications Technologies, 2020, 49, pp. 259–266.
Kohli, D. , Gupta, S.S. , Recent Trends of IoT in Smart City Development. Lecture Notes on Data Engineering and Communications Technologies, 2020, 49, pp. 275–280.
Singh, K. , Sengupta, S. , “Diagnostic of the Malarial Parasite in RBC Images for Automated Diseases Prediction,” Towards Smart World. New York: Chapman and Hall/CRC, pp. 210–228, https://doi.org/10.1201/9781003056751.
Sharma, L. , Garg, P. (Eds.), (2020). From Visual Surveillance to Internet of Things. New York: Chapman and Hall/CRC, https://doi.org/10.1201/9780429297922.
Sharma, L. (Ed.), (2021). Towards Smart World. New York: Chapman and Hall/CRC, https://doi.org/10.1201/9781003056751.
Sharma, L. , “Human Detection and Tracking Using Background Subtraction in Visual Surveillance,” Towards Smart World. New York: Chapman and Hall/CRC, pp. 317–328, https://doi.org/10.1201/9781003056751.
Sharma, L. , Singh, A. , Yadav, D.K. , “Fisher’s Linear Discriminant Ratio based Threshold for Moving Human Detection in Thermal Video,” Infrared Physics and Technology, Philadelphia: Elsevier.
Sharma, L. , Yadav, D.K. , Bharti, S.K. , “An Improved Method for Visual Surveillance using Background Subtraction Technique”, IEEE, 2nd International Conference on Signal Processing and Integrated Networks (SPIN-2015), Amity University, Noida, India, February 19–20, 2015.
Yadav, D.K. , Sharma, L. , Bharti, S.K. , “Moving Object Detection in Real-Time Visual Surveillance using Background Subtraction Technique”, IEEE, 14th International Conference in Hybrid Intelligent Computing (HIS-2014), Gulf University for Science and Technology, Kuwait, December 14–16, 2014.
Abramson, N. , Braverman, D. , Sebestyen, G. , “Pattern recognition,” IEEE Transactions on Information Theory, vol. IT-9, pp. 257–261, 1963.
Newell, A. , Simon, H. , “The logic theory machine—A complex information processing system,” IRE Transactions on Information Theory, vol. IT-2, pp. 61–79, 1956.
Faulk, R. , “An inductive approach to mechanical translation,” Communications ACM, vol. 1, pp. 647–655, 1964.
Sharma, L. , Garg, P.K. , “IoT and its applications,” From Visual Surveillance to Internet of Things, Taylor & Francis Group, CRC Press, Vol. 1, pp. 29.
Sharma, L. , Garg, P.K. “Smart E-healthcare with Internet of Things: Current Trends Challenges, Solutions and Technologies,” From Visual Surveillance to Internet of Things, CRC Press, Taylor & Francis Group, pp. 215–234, October 2019.
Sharma, L. , Garg, P.K. “A foresight on e-healthcare trailblazers”, From Visual Surveillance to Internet of Things, CRC Press, Taylor & Francis Group, pp. 235–244, October 2019.

Image Processing Using Artificial Intelligence: Case Study on Classification of High-Dimensional Remotely Sensed Images

Gilmore, J. F. 1985. Artificial intelligence in image processing. Proceedings of the SPIE 0528, Digital Image Processing, https://doi.org/10.1117/12.946419.

Xin, Z. , Wang, D. , 2019. Application of artificial intelligence algorithms in image processing. Journal of Visual Communication and Image Representation, 61, 42–49, ISSN 1047-3203, https://doi.org/10.1016/j.jvcir.2019.03.004.

Pereira, C. S. , Morais, R. , Reis, M. J. C. S. 2017. Recent advances in image processing techniques for automated harvesting purposes: A review. Intelligent Systems Conference (IntelliSys), London, pp. 566–575, doi:10.1109/IntelliSys.2017.8324352.

Frejlichowski, D . 2020. Special Issue on “Advances in Image Processing, Analysis and Recognition Technology”. Applied Sciences, 10, 7582.

Gross, J. E. , Nemani, R. R. , Turner, W. , Melton, F. 2006. Remote sensing for the national parks. Park Science, 24, 30−36.

Philipson, P. , Lindell, T. 2003. Can coral reefs be monitored from space? Ambio, 32, 586−593.

Phinn, S. R. , Stow, D. A. , Franklin, J. , Mertes, L. A. K. , Michaelsen, J. 2003. Remotely sensed data for ecosystem analyses: Combining hierarchy theory and scene models. Environmental Management, 31, 429−441.

Anghel, A. , Vasile, G. , Boudon, R. , d’Urso, G. , Girard, A. , Boldo, D. , Bost, V. 2016. Combining spaceborne SAR images with 3D point clouds for infrastructure monitoring applications. ISPRS Journal of Photogrammetry and Remote Sensing, 111, 45–61. ISSN 0924-2716.

Li, Y. , Liao, Q. F. , Li, X. , Liao, S. D. , Chi, G. B. , Peng, S. L. 2003. Towards an operational system for regional-scale rice yield estimation using a time-series of Radarsat ScanSAR images. International Journal of Remote Sensing, 24, 4207−4220.

Schuck, A. , Paivinen, R. , Hame, T. , Van Brusselen, J. , Kennedy, P. , Folving, S. 2003. Compilation of a European forest map from Portugal to the Ural Mountains based on earth observation data and forest statistics. Forest Policy and Economics, 5, 187−202.

Ethem, A . 2010. Introduction to Machine Learning. MIT Press. p. 9. ISBN 978-0-262-01243-0.

Chutia, D. , Bhattacharyya, D.K. , Sarma, J. , Raju, P.N.L. 2017. An effective ensemble classification framework using random forests and a correlation based feature selection technique. Transactions in GIS, 21, 1165–1178. https://doi.org/10.1111/tgis.12268.

Kussul, N. , Lavreniuk, M. , Skakun, S. , Shelestov, A. 2017. Deep learning classification of land cover and crop types using remote sensing data. IEEE Geoscience and Remote Sensing Letters, 14(5), 778–782. doi:10.1109/LGRS.2017.2681128.

Chutia, D. , Borah, N. , Baruah, D. et al. 2020. An effective approach for improving the accuracy of a random forest classifier in the classification of Hyperion data. Applied Geomatics, 12, 95–105, https://doi.org/10.1007/s12518-019-00281-8.

Rokach, L . 2010. Ensemble-based classifiers. Artificial Intelligence Review, 33(1–2), 1–39.

Kannadhasan, S. , Bhapith, V. B. 2014. Research issues on digital image processing for various applications in this world. Global Journal of Advanced Research, 1(1), 46–55, ISSN: 2394-5788, http://gjar.org/publishpaper/vol1issue1/d5.pdf.

Cohen, E. A. K. , Abraham, A. V. , Ramakrishnan, S. et al. 2019. Resolution limit of image analysis algorithms. Nature Communications, 10, 79, https://doi.org/10.1038/s41467-019-08689-x.

Asokan, A. , Anitha, J. , Ciobanu, M. , Gabor, A. , Naaji, A. , Hemanth, D. J. 2020. Image processing techniques for analysis of satellite images for historical maps classification—An overview. Applied Sciences, 10, 4207.

Namikawa, L. , Castejon, E. , Fonseca, L. 2009. Digital Image Processing in Remote Sensing. Tutorials of the XXII Brazilian Symposium on Computer Graphics and Image Processing, Rio de Janeiro, Brazil, pp. 59–71. doi:10.1109/SIBGRAPI-Tutorials.2009.1.3

Landgrebe, D. A. 2003. Signal Theory Methods in Multispectral Remote Sensing. John Wiley & Sons, Hoboken.

Hubert-Moy, L. , Cotonnec, A. , Le Du, L. , Chardin, A. , Perez, P. A. 2001. Comparison of parametric classification procedures of remotely sensed data applied on different landscape units. Remote Sensing of Environment, 75, 174–187.

Chen, D. , Stow, D. A. 2002. The effect of training strategies on supervised classification at different spatial resolution. Photogrammetric Engineering and Remote Sensing, 68, 1155–1162.

Mather, P. M. 2004. Computer Processing of Remotely-Sensed Images: An Introduction. 3rd Ed., John Wiley & Sons, Chichester.

Gong, P. , Howarth, P. J. 1990. An assessment of some factors influencing multispectral land-cover classification. Photogrammetric Engineering and Remote Sensing, 56, 597–603.

Lu, D ., Weng, Q. 2007. A survey of image classification methods and techniques for improving classification performance. International Journal of Remote Sensing, 28(5), 823–870.

Song, C. , Woodcock, C. E. , Seto, K. C. , Lenney, M. P. , Macomber, S. A. 2001. Classification and change detection using Landsat TM data: when and how to correct atmospheric effect. Remote Sensing of Environment, 75, 230–244.

Gilabert, M. A. , Conese, C. , Maselli, F. 1994. An atmospheric correction method for the automatic retrieval of surface reflectance from TM images. International Journal of Remote Sensing, 15, 2065–2086.
Chavez, P. S. Jr. 1996. Image-based atmospheric corrections—Revisited and improved. Photogrammetric Engineering and Remote Sensing, 62, 1025–1036.
Stefan, S. , Itten, K. I. 1997. A physically-based model to correct atmospheric and illumination effects in optical satellite data of rugged terrain. IEEE Transactions on Geoscience and Remote Sensing, 35, 708–717.
Tokola, T. , Löfman, S. , Erkkilä, A . 1999. Relative calibration of multitemporal Landsat data for forest cover change detection. Remote Sensing of Environment, 68, 1–11.
Heo, J. , Fitzhugh, T. W. 2000. A standardized radiometric normalization method for change detection using remotely sensed imagery. Photogrammetric Engineering and Remote Sensing, 66, 173–182.
Du, Q. , Chang, C. 2001. A linear constrained distance-based discriminant analysis for hyperspectral image classification. Pattern Recognition, 34, 361–373.
Canty, M. J. , Nielsen, A. A. , Schmidt, M. 2004. Automatic radiometric normalization of multitemporal satellite imagery. Remote Sensing of Environment, 91, 441–451.
Hale, S. R. , Rock, B. N. 2003. Impacts of topographic normalization on land cover classification accuracy. Photogrammetric Engineering and Remote Sensing, 69, 785–792.
Jensen, J. R. 1996. Introduction to Digital Image Processing: A Remote Sensing Perspective. 2nd Ed., Piscataway, NJ: Prentice Hall.
Foody, G. M. , Mathur, A. 2004. A relative evaluation of multiclass image classification by support vector machines. IEEE Transactions on Geoscience and Remote Sensing, 42, 1335–1343.
Chutia, D. , Bhattacharyya, D. K. , Sudhakar, S. 2012. Effective feature extraction approach for fused images of Cartosat-I and Landsat ETM+ satellite sensors. Applied Geomatics, 4, 217–224. https://doi.org/10.1007/s12518-012-0088-y.
Hsu, P. H. 2007. Feature extraction of hyperspectral images using Wavelet and matching pursuit. ISPRS Journal of Photogrammetry and Remote Sensing, 62(2), 78–92.
Harris, J. R. , Ponomarev, P. , Shang, J. , Rogge, D. 2006. Noise reduction and best band selection techniques for improving classification results using hyperspectral data: application to lithological mapping in Canada’s Arctic. Canadian Journal of Remote Sensing, 32(5), 341–354.
Murat Dundar, M. , Landgrebe, D. 2002. A model-based mixture-supervised classification approach in hyperspectral data analysis. IEEE Transactions on Geoscience and Remote Sensing, 40(12), 2692–2699.
Mader, S. , Vohland, M. , Jarmer, T. , Casper, M . 2006. Crop classification with hyperspectral data of the HyMap sensor using different feature extraction techniques. In 2nd Workshop of the EARSel SIG on Remote Sensing of Land Use & Land Cover, edited by M Braun , Bonn, Germany, pp. 96–101.
Green, A. A. , Berman, M. , Switzer, P. , Craig, M. D. 1988. A transformation for ordering multispectral data in terms of image quality with implications for noise removal. IEEE Transactions on Geoscience and Remote Sensing, 26(1), 65–74.
Hyvärinen, A. , Oja, E . 2000. Independent component analysis: algorithms and applications. Neural Networks, 13(4), 411–430.
Yang, C. , Everitt, J. H. , Johnson, H. B. 2009. Applying image transformation and classification techniques to airborne hyperspectral imagery for mapping Ashe juniper infestations. International Journal of Remote Sensing, 30(11), 2741–2758.
Chutia, D. , Bhattacharyya, D. K. , Kalita, R. , Sudhakar, S. 2014. OBCsvmFS: Object-based classification supported by support vector machine feature selection approach for hyperspectral data. Journal of Geomatics, 8(1), 12–19.
Anilkumar, R. , Chutia, D. , Goswami, J. , Sharma, V. , Raju, P. L. N. 2018. Evaluation of the performance of the fused product of Hyperion and RapidEye red edge bands in the context of classification accuracy. Journal of Geomatics, 12(1), 35–46.
Borah, N. , Chutia, D. , Baruah, D. , Raju, P. L. N. 2017. Dimension reduction of hyperion data for improving classification performance – An assessment. IEEE International Conference On Recent Trends In Electronics Information Communication Technology, May 19–20, Bengaluru, India.
Kohavi, R. 1995. Wrappers for performance enhancement and oblivious decision graphs. PhD thesis, Stanford University.
Kohavi, R. , John, G. 1996. Wrappers for feature subset selection. Artificial Intelligence, 97(1–2), 273–324. Special issue on relevance.
Hall, M. A. 1999. Correlation-based Feature Subset Selection for Machine Learning. Hamilton, New Zealand. PhD thesis.
Pushpalatha, K. R. , Karegowda, A. G. 2017. CFS based feature subset selection for enhancing classification of similar looking food grains – A filter approach. 2nd International Conference On Emerging Computation and Information Technologies (ICECIT), Tumakuru, pp. 1–6, doi:10.1109/ICECIT.2017.8453403.
Ross, Q. 1993. C4.5: Programs for machine learning, vol. 16. Morgan Kaufmann Publishers, San Mateo, pp. 235–240.
Breiman, L . 2001. Random forests. Machine Learning, 45(1), 5–32.

Sonobe, R. , Hiroshi, T. , Xiufeng, W. , Nobuyuki, K. , Hideki, S. 2014. Random forest classification of crop type usingmulti-temporal TerraSAR-X dual-polarimetric data. Remote Sensing Letters, 5(2), 157–164.
Ham, Y. , Han, K. K. , Lin, J. J. et al. 2016. Visual monitoring of civil infrastructure systems via camera-equipped Unmanned Aerial Vehicles (UAVs): A review of related works. Visualization in Engineering, 4, 1. https://doi.org/10.1186/s40327-015-0029-z.
Yao, Y. , Zhang, J. , Hong, Y. , Liang, H. , He, J. 2018. Mapping fine-scale urban housing prices by fusing remotely sensed imagery and social media data. Transactions in GIS, 22, 561–581. https://doi.org/10.1111/tgis.12330.

Artificial Intelligence and Image Processing

Artificial Intelligent overview . Available at: https://becominghuman.ai/where-is-artificial-intelligence-used-today-3fd076d15b68 [accessed April 12, 2019].
L. Sharma , P. Garg (Eds.), From Visual Surveillance to Internet of Things. New York: Chapman and Hall/CRC, 2020, https://doi.org/10.1201/9780429297922
L. Sharma , “Human Detection and Tracking Using Background Subtraction in Visual Surveillance”, Towards Smart World. New York: Chapman and Hall/CRC, pp. 317–328, December 2020. https://doi.org/10.1201/9781003056751
Artificial Intelligence: How Does AI Work? Author B. J. Copeland, Independently Published, 2019.
L. Sharma (Ed.), Towards Smart World. New York: Chapman and Hall/CRC, 2021, https://doi.org/10.1201/9781003056751
L. Sharma , A. Singh , D. K. Yadav , “Fisher’s Linear Discriminant Ratio based Threshold for Moving Human Detection in Thermal Video”, Infrared Physics and Technology, Elsevier, March 2016.
L. Sharma , D. K. Yadav , S. K. Bharti , “An Improved Method for Visual Surveillance using Background Subtraction Technique”, IEEE, 2nd International Conference on Signal Processing and Integrated Networks (SPIN-2015), Amity University, Noida, India, February 19–20, 2015.
Dileep Kumar Yadav , Lavanya Sharma , Sunil Kumar Bharti , “Moving Object Detection in Real-Time Visual Surveillance using Background Subtraction Technique”, IEEE, 14th International Conference in Hybrid Intelligent Computing (HIS-2014), Gulf University for Science and Technology, Kuwait, December 14–16, 2014.
N. Abramson , D. Braverman , G. Sebestyen , Pattern recognition. IEEE Transactions on Information Theory, vol. IT-9, pp. 257–261, 1963.
A. Newell , H. Simon , The logic theory machine—a complex information processing system, IRE Transactions on Information Theory, vol. IT-2, pp. 61–79, 1956.
L. Sharma , P. K. Garg , “IoT and its applications”, From Visual Surveillance to Internet of Things, Taylor & Francis Group, CRC Press, Vol. 1, pp. 29.
L. Sharma , P. K. Garg , “Smart E-healthcare with Internet of Things: Current Trends Challenges, Solutions and Technologies”, From Visual Surveillance to Internet of Things, CRC Press, Taylor & Francis Group, pp. 215–234, 2019.
L. Sharma , P. K. Garg , “A foresight on e-healthcare Trailblazers”, From Visual Surveillance to Internet of Things, CRC Press, Taylor & Francis Group, pp. 235–244, 2019.
L. Sharma , S. Sengupta , B. Kumar , An improved technique for enhancement of satellite images. Journal of Physics: Conference Series, 1714, 012051, 2021.
Artificial Intelligent overview . Available at: https://sisu.ut.ee/imageprocessing/avaleht [accessed April 12, 2019].
Artificial Intelligent overview . Available at: https://www.apriorit.com/dev-blog/599-ai-for-image-processing [accessed April 12, 2019].
Gonazalez and woods, “Digital Image processing”, pearson Eductaion international, third edition
S. Singh , L. Sharma , B. Kumar , A machine learning based predictive model for coronavirus pandemic scenario. Journal of Physics: Conference Series, 1714, 012023, 2021.
X. P. B. Artizzu , A. Ribeiro , A. Tellaeche , G. Pajares , C. F. Quintanilla , Improving weed pressure assessment using digital images from an experience-based reasoning approach, Computers and Electronics in Agriculture, 65, pp. 176–185, 2009.
B. Sridhar , Cross-layered embedding of watermark on image for high authentication, Pattern Recognition and Image Analysis, vol. 29, no. 1, pp. 194–199, 2019.
U. Walz , Remote sensing and digital image processing, Bastian, Olaf and Steinhardt, Uta editors. Kluwer Academic Publishers, 2002.
Artificial Intelligent basic . Available at: https://www.tutorialandexample.com/artificial-intelligence-tutorial/ [accessed April 12, 2019].
Artificial Intelligent algorithm . Available at: https://www.upgrad.com/blog/types-of-artificial-intelligence-algorithms/ [accessed April 12, 2019].
R. Faulk , An inductive approach to mechanical translation. Communications of the ACM, vol. 1, pp. 647–655, 1964.

Xin Zhang , Wang Dahu , Application of artificial intelligence algorithms in image processing, Journal of Visual Communication and Image Representation, vol. 61, pp. 42–49. 2019. ISSN 1047-3203, https://doi.org/10.1016/j.jvcir.2019.03.004.

John Stoitsis , Ioannis Valavanis , Stavroula G. Mougiakakou , Spyretta Golemati , Alexandra Nikita , Konstantina S. Nikita , Computer aided diagnosis based on medical image processing and artificial intelligence methods, Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, vol. 569, no. 2, pp. 591–595, 2006. ISSN 0168-9002, https://doi.org/10.1016/j.nima.2006.08.134.

Bala Prabhakar , Rishi Kumar Singh , Khushwant S. Yadav , Artificial Intelligence (AI) impacting Diagnosis of Glaucoma and Understanding the Regulatory aspects of AI-based software as medical device, Computerized Medical Imaging and Graphics, 101818, 2020.

Manu Goyal , Thomas Knackstedt , Shaofeng Yan , Saeed Hassanpour , Artificial intelligence-based image classification methods for diagnosis of skin cancer: Challenges and opportunities, Computers in Biology and Medicine, vol. 127, 2020.

Y. Zhong , L. Zhang , W. Gong , Unsupervised remote sensing image classification using an artificial immune network. International Journal of Remote Sensing, vol. 32, no. 19, pp. 5461–5483, 2011. DOI:10.1080/01431161.2010.502155

J. Chen , M. Zhang , B. Xu , J. Sun , A. S. Mujumdar , Artificial intelligence assisted technologies for controlling the drying of fruits and vegetables using physical fields: A review. Trends in Food Science & Technology, vol. 105, pp. 251–260, 2020.

A. I. Mubarak , Mahmoud, H. Ren , Forest Fire Detection Using a Rule-Based Image Processing Algorithm and Temporal Variation. Mathematical Problems in Engineering, 2018 | Article ID 7612487 | https://doi.org/10.1155/2018/7612487

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Deep logic models . Integrating learning and reasoning with deep logic models. Available at: https://arxiv.org/abs/1901.04195 [accessed on 20 June 2021.

Kashif Sultan , Hazrat Ali , and Zhongshan Zhang . Big data perspective and challenges in next generation networks. Future Internet, 10:56, 2018.

G. Auda , M. Kamel , and H. Raafat . Modular neural network architectures for classification. In Proceedings of International Conference on Neural Networks (ICNN'96), 2:1279–1284, 1996.

Kunihiko Fukushima . Neocognitron: A hierarchical neural network capable of visual pattern recognition. Neural Networks, 1(2):119–130, 1988.

Y. Lecun , L. Bottou , Y. Bengio , and P. Haffner . Gradient-based learning applied to document recognition. Proceedings of the IEEE, 86(11):2278–2324, 1998.

Geoffrey E. Hinton, Simon Osindero, and Yee-Whye Teh. A fast learning algorithm for deep belief nets. Neural Computation, 18(7):1527–1554, 2006.

G. E. Hinton and R. R. Salakhutdinov . Reducing the dimensionality of data with neural networks. Science, 313(5786):504–507, 2006.

Xavier Glorot and Yoshua Bengio . Understanding the difficulty of training deep feed-forward neural networks. volume 9 of Proceedings of Machine Learning Research, pages 249–256, Chia Laguna Resort, Sardinia, Italy, 13–15 May 2010. JMLR Workshop and Conference Proceedings.

M. Ranzato , F. J. Huang , Y. Boureau , and Y. LeCun . Unsupervised learning of invariant feature hierarchies with applications to object recognition. In 2007 IEEE Conference on Computer Vision and Pattern Recognition, pages 1–8, 2007.

Alex Krizhevsky , Ilya Sutskever , and Geoffrey E. Hinton . Imagenet classification with deep convolutional neural networks. NIPS'12, pages 1097–1105, Red Hook, NY, 2012. Curran Associates Inc.

Karen Simonyan and Andrew Zisserman . Very deep convolutional networks for large-scale image recognition. In International Conference on Learning Representations, 2015. https://arxiv.org/abs/1409.1556.

C. Szegedy , Wei Liu , Yangqing Jia , P. Sermanet , S. Reed , D. Anguelov , D. Erhan , V. Van-Houcke , and A. Rabinovich . Going deeper with convolutions. In 2015 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), pages 1–9, 2015.

K. He , X. Zhang , S. Ren , and J. Sun . Deep residual learning for image recognition. In 2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), pages 770–778, 2016.

Andreas Veit , Michael Wilber , and Serge Belongie . Residual networks behave like ensem-bles of relatively shallow networks. NIPS'16, page 550–558, Red Hook, NY, 2016. Curran Associates Inc.

Sergey Zagoruyko and Nikos Komodakis . Wide residual networks. In Edwin R. Hancock , Richard C. Wilson , and William A. P. Smith , editors, Proceedings of the British Machine Vision Conference (BMVC), pages 87.1–87.12. BMVA Press, September 2016.

S. Sun , Z. Cao , H. Zhu , and J. Zhao . A survey of optimization methods from a machine learning perspective. IEEE Transactions on Cybernetics, 50(8):3668–3681, 2020.
Ning Qian . On the momentum term in gradient descent learning algorithms. Neural Networks, 12(1):145–151, 1999.
John Duchi , Elad Hazan , and Yoram Singer . Adaptive subgradient methods for online learning and stochastic optimization. Journal of Machine Learning Research, 12(null):2121–2159, 2011.
Matthew D. Zeiler . ADADELTA: an adaptive learning rate method. CoRR, abs/1212.5701, 2012.
Diederik P. Kingma and Jimmy Ba . Adam: A method for stochastic optimization. In Yoshua Bengio and Yann LeCun , editors, 3rd International Conference on Learning Rep-resentations, ICLR 2015, San Diego, CA, May 7–9, 2015, Conference Track Proceedings, 2015.
Jorge Nocedal . Updating quasi newton matrices with limited storage. Mathematics of Computation, 35(151):951–958, 1980.
G. Cheng , X. Xie , J. Han , L. Guo , and G. Xia . Remote sensing image scene classification meets deep learning: Challenges, methods, benchmarks, and opportunities. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 13:3735–3756, 2020.
N. Longbotham , C. Chaapel , L. Bleiler , C. Padwick , W. J. Emery , and F. Pacifici . Very high resolution multiangle urban classification analysis. IEEE Transactions on Geoscience and Remote Sensing, 50(4):1155–1170, 2012.
Amin Tayyebi , Bryan Christopher Pijanowski , and Amir Hossein Tayyebi . An urban growth boundary model using neural networks, gis and radial parameterization: An ap-plication to Tehran, Iran. Landscape and Urban Planning, 100(1):35–44, 2011.
T. Zhang and X. Huang . Monitoring of urban impervious surfaces using time series of high-resolution remote sensing images in rapidly urbanized areas: A case study of shenzhen. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 11(8):2692–2708, 2018.
Xin Huang , Dawei Wen , Jiayi Li , and Rongjun Qin . Multi-level monitoring of subtle urban changes for the megacities of china using high-resolution multi-view satellite imagery. Remote Sensing of Environment, 196:56–75, 2017.
Jun Li , Yanqiu Pei , Shaohua Zhao , Rulin Xiao , Xiao Sang , and Chengye Zhang . A review of remote sensing for environmental monitoring in China. Remote Sensing, 12(7):1–25, 2020.
Xiaoxiao Li and Guofan Shao . Object-based urban vegetation mapping with high-resolution aerial photography as a single data source. International Journal of Remote Sensing, 34(3):771–789, 2013.
Yichun Xie , Zongyao Sha , and Mei Yu . Remote sensing imagery in vegetation mapping: a review. Journal of Plant Ecology, 1(1):9–23, 2008.
S.M. Hamylton , R.H. Morris , R.C. Carvalho , N. Roder , P. Barlow , K. Mills , and L. Wang . Evaluating techniques for mapping island vegetation from unmanned aerial vehicle (uav) images: Pixel classification, visual interpretation and machine learning approaches. International Journal of Applied Earth Observation and Geoinformation, 89:102085, 2020.
T. Blaschke . Object based image analysis for remote sensing. ISPRS Journal of Pho-togrammetry and Remote Sensing, 65(1):2–16, 2010.
Desheng Liu and Fan Xia . Assessing object-based classification: advantages and limita-tions. Remote Sensing Letters, 1(4):187–194, 2010.
R. Minetto , M. Pamplona Segundo , and S. Sarkar . Hydra: An ensemble of convolutional neural networks for geospatial land classification. IEEE Transactions on Geoscience and Remote Sensing, 57(9):6530–6541, 2019.
G. Cheng , C. Yang , X. Yao , L. Guo , and J. Han . When deep learning meets metric learning: Remote sensing image scene classification via learning discriminative cnns. IEEE Transactions on Geoscience and Remote Sensing, 56(5):2811–2821, 2018.
Q. Wang , S. Liu , J. Chanussot , and X. Li . Scene classification with recurrent attention of vhr remote sensing images. IEEE Transactions on Geoscience and Remote Sensing, 57(2):1155–1167, 2019.
Ian J. Goodfellow , Jean Pouget-Abadie , Mehdi Mirza , Bing Xu , David Warde-Farley , Sherjil Ozair , Aaron Courville , and Yoshua Bengio . Generative adversarial nets. NIPS'14, page 2672–2680, Cambridge, MA, 2014. MIT Press.
Y. Duan , X. Tao , M. Xu , C. Han , and J. Lu . GAN-NL: Unsupervised representation learning for remote sensing image classification. In 2018 IEEE Global Conference on Signal and Information Processing (GlobalSIP), pages 375–379, 2018.
D. Lin , K. Fu , Y. Wang , G. Xu , and X. Sun . Marta gans: Unsupervised representation learning for remote sensing image classification. IEEE Geoscience and Remote Sensing Letters, 14(11):2092–2096, 2017.
Yi Yang and Shawn Newsam . Bag-of-visual-words and spatial extensions for land-use classification. GIS '10, pages 270–279, New York, NY, 2010. Association for Computing Machinery.
Gui-Song Xia , Wen Yang , Julie Delon , Yann Gousseau , Hong Sun , and Henri Matre . Structural high-resolution satellite image indexing. International Archives of the Pho-togrammetry, Remote Sensing and Spatial Information Sciences – ISPRS Archives, 38, 07 2010.
O. A. B. Penatti , K. Nogueira , and J. A. dos Santos . Do deep features generalize from everyday objects to remote sensing and aerial scenes domains? In 2015 IEEE Conference on Computer Vision and Pattern Recognition Workshops (CVPRW), pages 44–51, 2015.

Saikat Basu , Sangram Ganguly , Supratik Mukhopadhyay , Robert DiBiano , Manohar Karki , and Ramakrishna Nemani . Deepsat – a learning framework for satellite imagery. Proceedings of the 23rd SIGSPATIAL International Conference on Advances in Geographic Information Systems, November 2015, Article 37, pages 1–10.
Yan-Gang Zhao , Funing Zhong , and Min Zhang . Scene classification via latent dirichlet allocation using a hybrid generative/discriminative strategy for high spatial resolution remote sensing imagery. Remote Sensing Letters, 4:07 2013.
P. Helber , B. Bischke , A. Dengel , and D. Borth . Eurosat: A novel dataset and deep learning benchmark for land use and land cover classification. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 12(7):2217–2226, 2019.
Gencer Sumbul , Marcela Charfuelan , Begum Demir , and Volker Markl . Bigearthnet: A large-scale benchmark archive for remote sensing image understanding. pages 5901–5904, 2019.
L. Jiao , F. Zhang , F. Liu , S. Yang , L. Li , Z. Feng , and R. Qu . A survey of deep learning-based object detection. IEEE Access, 7:128837–128868, 2019.
C. Ar and S. Aksoy . Detection of compound structures using a gaussian mixture model with spectral and spatial constraints. IEEE Transactions on Geoscience and Remote Sensing, 52(10):6627–6638, 2014.
X. Bai , H. Zhang , and J. Zhou . VHR object detection based on structural feature extraction and query expansion. IEEE Transactions on Geoscience and Remote Sensing, 52(10):6508–6520, 2014.
J. Han , D. Zhang , G. Cheng , L. Guo , and J. Ren . Object detection in optical remote sensing images based on weakly supervised learning and high-level feature learning. IEEE Transactions on Geoscience and Remote Sensing, 53(6):3325–3337, 2015.
Y. Long , Y. Gong , Z. Xiao , and Q. Liu . Accurate object localization in remote sensing images based on convolutional neural networks. IEEE Transactions on Geoscience and Remote Sensing, 55(5):2486–2498, 2017.
A. Salberg . Detection of seals in remote sensing images using features extracted from deep convolutional neural networks. In 2015 IEEE International Geoscience and Remote Sensing Symposium (IGARSS), pages 1893–1896, 2015.
I. Sevo and A. Avramovic . Convolutional neural network based automatic object detection on aerial images. IEEE Geoscience and Remote Sensing Letters, 13(5):740–744, 2016.
G. Cheng , P. Zhou , and J. Han . Learning rotation-invariant convolutional neural net-works for object detection in vhr optical remote sensing images. IEEE Transactions on Geoscience and Remote Sensing, 54(12):7405–7415, 2016.
Z. Deng , H. Sun , S. Zhou , J. Zhao , and H. Zou . Toward fast and accurate vehicle detection in aerial images using coupled region-based convolutional neural networks. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 10(8):3652–3664, 2017.
Yanfei Zhong , Xiaobing Han , and Liangpei Zhang . Multi-class geospatial object detec-tion based on a position-sensitive balancing framework for high spatial resolution remote sensing imagery. ISPRS Journal of Photogrammetry and Remote Sensing, 138:281–294, 2018.
Gong Cheng and Junwei Han . A survey on object detection in optical remote sensing images. ISPRS Journal of Photogrammetry and Remote Sensing, 117:11–28, 2016.
Sebastien Razakarivony and Frederic Jurie . Vehicle detection in aerial imagery: A small target detection benchmark. Journal of Visual Communication and Image Representation, 34:187–203, 2016.
H. Zhu , X. Chen , W. Dai , K. Fu , Q. Ye , and J. Jiao . Orientation robust object detection in aerial images using deep convolutional neural network. In 2015 IEEE International Conference on Image Processing (ICIP), pages 3735–3739, 2015.
K. Liu and G. Mattyus . Fast multiclass vehicle detection on aerial images. IEEE Geo-science and Remote Sensing Letters, 12(9):1938–1942, 2015.
Z. Liu , H. Wang , L. Weng , and Y. Yang . Ship rotated bounding box space for ship extraction from high-resolution optical satellite images with complex backgrounds. IEEE Geoscience and Remote Sensing Letters, 13(8):1074–1078, 2016.
G. Xia , X. Bai , J. Ding , Z. Zhu , S. Belongie , J. Luo , M. Datcu , M. Pelillo , and L. Zhang . Dota: A large-scale dataset for object detection in aerial images. In 2018 IEEE/CVF Conference on Computer Vision and Pattern Recognition, pages 3974–3983, 2018.
Ke Li , Gang Wan , Gong Cheng , Liqiu Meng , and Junwei Han . Object detection in optical remote sensing images: A survey and a new benchmark. ISPRS Journal of Photogram-metry and Remote Sensing, 159:296–307, 2020.
J. Long , E. Shelhamer , and T. Darrell . Fully convolutional networks for semantic segmen-tation. In 2015 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), pages 3431–3440, 2015.
L. Chen , G. Papandreou , I. Kokkinos , K. Murphy , and A. L. Yuille . Deeplab: Semantic image segmentation with deep convolutional nets, atrous convolution, and fully connected crfs. IEEE Transactions on Pattern Analysis and Machine Intelligence, 40(4):834–848, 2018.
Wei Liu , Andrew Rabinovich , and Alexander C. Berg . ParseNet: Looking Wider to See Better. arXiv e-prints, page arXiv:1506.04579, June 2015.

H. Zhao , J. Shi , X. Qi , X. Wang , and J. Jia . Pyramid scene parsing network. In 2017 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), pages 6230–6239, 2017.
E. Maggiori , Y. Tarabalka , G. Charpiat , and P. Alliez . Can semantic labeling methods generalize to any city? The INRIA aerial image labeling benchmark. In 2017 IEEE International Geoscience and Remote Sensing Symposium (IGARSS), pages 3226–3229, 2017.
S. Ji , S. Wei , and M. Lu . Fully convolutional networks for multisource building extraction from an open aerial and satellite imagery data set. IEEE Transactions on Geoscience and Remote Sensing, 57(1):574–586, 2019.
I. Demir , K. Koperski , D. Lindenbaum , G. Pang , J. Huang , S. Basu , F. Hughes , D. Tuia , and R. Raskar . Deepglobe 2018: A challenge to parse the earth through satellite images. In 2018 IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshops (CVPRW), pages 172–179, 2018.
I. Szottka and M. Butenuth . Tracking multiple vehicles in airborne image sequences of complex urban environments. In 2011 Joint Urban Remote Sensing Event, pages 13–16, 2011.
K. Fang , Y. Xiang , X. Li , and S. Savarese . Recurrent autoregressive networks for online multi-object tracking. In 2018 IEEE Winter Conference on Applications of Computer Vision (WACV), pages 466–475, 2018.
Chanho Kim , F. Li , and J. Rehg . Multi-object tracking with neural gating using bilinear lstm. In ECCV, 2018.
R. Henschel , L. Leal-Taixe , D. Cremers , and B. Rosenhahn . Fusion of head and full-body detectors for multi-object tracking. In 2018 IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshops (CVPRW), pages 1509–150909, 2018.
Siyi Li and Dit-Yan Yeung . Visual object tracking for unmanned aerial vehicles: A benchmark and new motion models. In AAAI, 2017.
Matthias Mueller , Neil Smith , and Bernard Ghanem . A benchmark and simulator for UAV tracking. European Conference on Computer Vision, volume 9905, pp. 445–461, 2016.
Hongyang Yu , Guorong Li , Weigang Zhang , Dawei Du , Qi Tian , and Nicu Sebe . The unmanned aerial vehicle benchmark: Object detection, tracking and baseline. International Journal of Computer Vision, 12:201.
Q. Liu , Z. He , X. Li , and Y. Zheng . PTB-TIR: A thermal infrared pedestrian tracking benchmark. IEEE Transactions on Multimedia, 22(3):666–675, 2020.
Olaf Ronneberger , Philipp Fischer , and Thomas Brox . U-net: Convolutional networks for biomedicatl image segmentation. In: N. Navab , J. Hornegger , W. Wells , and A. Frangi (eds), Medical Image Computing and Computer-Assisted Intervention – MICCAI 2015. MICCAI 2015. Lecture Notes in Computer Science, volume 9351. Cham, Switzerland: Springer. https://doi.org/10.1007/978-3-319-24574-4_28.
Vijay Badrinarayanan , Alex Kendall , and Roberto Cipolla . Segnet: A deep convolutional encoder-decoder architecture for image segmentation. IEEE Transactions on Pattern Analysis and Machine Intelligence, 2017:2481–2495.
John E. Ball , Derek T. Anderson , and Chee Seng Chan Sr . Comprehensive survey of deep learning in remote sensing: theories, tools, and challenges for the community. Journal of Applied Remote Sensing, 11(4):1–54, 2017.
Thomas Elsken , Jan Hendrik Metzen , and Frank Hutter . Neural architecture search: A survey. Journal of Machine Learning Research, 20(55):1–21, 2019.
J. Yang , Y. Zhao , J. C. Chan , and C. Yi . Hyperspectral image classification using two-channel deep convolutional neural network. In 2016 IEEE International Geoscience and Remote Sensing Symposium (IGARSS), pages 5079–5082, 2016.
M. Iftene , Q. Liu , and Y. Wang . Very high resolution images classification by fine tuning deep convolutional neural networks. In Charles M. Falco and Xudong Jiang , editors, Eighth International Conference on Digital Image Processing (ICDIP 2016), volume 10033, pages 464–468. International Society for Optics and Photonics, SPIE, 2016.
Esam Othman , Yakoub Bazi , Naif Alajlan , Haikel Alhichri , and Farid Melgani . Using convolutional features and a sparse autoencoder for land-use scene classification. International Journal of Remote Sensing, 37(10):2149–2167, 2016.

Improved Combinatorial Algorithms Test for Pairwise Testing Used for Testing Data Generation in Big Data Applications

K. Burr and W. Young , "Combinatorial test techniques: Table-based automation, test generation, and test coverage," in Proceedings of the International Conference on Software Testing, Analysis, and Review (STAR), San Diego, CA, 1998.
S. R. Dalal , A. Jain , N. Karunanithi , J. M. Leaton , C. Lott , G. C. Patton , and B. M. Horowitz , "Model-Based Testing in Practice," in Proceedings of the International Conference on Software Engineering, Los Angeles, CA, pp. 285–294, 1999.
I. S. Dunietz , W. K. Ehrlich , B. D. Szablak , C. L. Mallows , and A. Iannino , "Applying design of experiments to software testing," in Proceedings of the International Conference on Software Engineering (ICSE 97), New York, pp. 205–215, 1997.

P. E. Ammann and A. J. Offutt , “Using formal methods to derive test frames in category-partition testing,” in Ninth Annual Conference on Computer Assurance (COMPASS’94), Gaithersburg, MD, pp. 69–80, 1994.
D. M. Cohen , S. R. Dalal , J. Parelius , and G. C. Patton , “The combinatorial design approach to automatic test generation,” IEEE Software, vol. 13, no. 5, pp. 83–87, 1996.
C. Kaner , J. Bach , and B. Pettichord , Lessons Learned in Software Testing: A Context Driven Approach. New York: John Wiley & Sons, 2002.
S. R. Dalal , A. J. N. Karunanithi , J. M. L. Leaton , G. C. P. Patton , and B. M. Horowitz , “Model-based testing in practice,” in Proceedings of the International Conference on Software Engineering (ICSE 99), New York, pp. 285–294, 1999.
M. Grindal , J. Offutt , and S. F. Andler . Combination testing strategies – A survey. GMU Technical Report, 2004.
S. Splaine and S. P. Jaskiel , The Web Testing Handbook. Orange Park, FL: STQE Publishing, 2001.
D. M. Cohen , S. R. Dalal , A. Kajla , and G. C. Patton , “The Automatic Efficient Test Generator (AETG) System,” in Proceedings of the 5th Int'l Symposium on Software Reliability Engineering, IEEE Computer Society Press, 1994, pp. 303–309.
R. Brownlie , J. Prowse , and M. Phadke , “Robust testing of AT&T PMX/star mail using OATS,” AT&T Technical Journal, vol. 71, no. 3, pp. 41–47, 1992.
S. Dalal , A. Jain , N. Karunanithi , J. Leaton , and C. Lott , “Model-based testing of a highly programmable system,” in Proceedings of the Nineth International Symposium on Software Reliability Engineering (ISSRE 98), Paderborn, Germany, 1998, pp. 174–178.
Q. Jiang , M. Hušková , S.G. Meintanis , and L. Zhu , “Asymptotics, finite-sample comparisons and applications for two-sample tests with functional data,” Journal of Multivariate Analysis, vol. 170, pp. 202–220, 2019.
S. López , A.A. Márquez , F.A. Márquez , and A. Peregrín , “Evolutionary design of linguistic fuzzy regression systems with adaptive defuzzification in big data environments,” Cognitive Computation, pp. 1–12, 2019.
G. Aneiros , R. Cao , R. Fraiman , C. Genest , and P. Vieu , “Recent advances in functional data analysis and high-dimensional statistics,” Journal of Multivariate Analysis, vol. 170, pp. 3–9, 2019.
L. Sharma , S. Sengupta and B. Kumar , “An Improved Technique for Enhancement of Satellite Images,” Journal of Physics: Conference Series, vol. 1714, p. 012051, 2021.
D. M. Cohen , S. R. Dalal , M. L. Fredman , and G. C. Patton , “The AETG system: An approach to testing based on combinatorial design,” IEEE Transactions on Software Engineering, 23(7), 1997.
J. Bach and P. Shroeder . “Pair wise testing – A best practice that isn’t,” in Proceedings of the 22nd Pacific North West Software Quality Conference, pp. 180–196, 2004.
C. J. Colbourn , M. B. Cohen , and R. C. Turban , “A deterministic density algorithm for pair-wise interaction coverage,” in Proceedings of the IASTED International Conference on Software Engineering, 2004.
L. Copeland , A Practitioner’s Guide to Software Test Design. Boston, MA: Artech House Publishers, 2003.
S. Dalal and C. L. Mallows , “Factor-Covering Designs for Testing Software,” Technometrics, vol. 50, no. 3, pp. 234–243, 1998.
Y. Lei and K. C. Tai , “In-parameter-order: A test generation strategy for pair-wise testing,” in Proceedings of the 3rd IEEE High-Assurance Systems Engineering Symposium, 1998, pp. 254–261.
Z. Liu , “Research of performance test technology for big data applications,” in 2014 IEEE International Conference on Information and Automation (ICIA). IEEE, 2014.
N. Li et al. “A scalable big data test framework,” in 2015 IEEE 8th international conference on software testing, verification and validation (ICST). IEEE, 2015.
V. D. Kumar and P. Alencar . “Software engineering for big data projects: Domains, methodologies and gaps,” in 2016 IEEE International Conference on Big Data (Big Data). IEEE, 2016.
J. Chandrasekaran et al. “Applying combinatorial testing to data mining algorithms,” in 2017 IEEE International Conference on Software Testing, Verification and Validation Workshops (ICSTW). IEEE, 2017.
G. Qi et al. “Fault-diagnosis for reciprocating compressors using big data and machine learning,” Simulation Modelling Practice and Theory, vol. 80, pp. 104–127, 2018.
D. Gupta , A. Rana , and S. Tyagi . “A novel representative dataset generation approach for big data using hybrid cuckoo search,” International Journal of Advances in Soft Computing & Its Applications, vol. 10, no. 1, 2018.
S. Singh , L. Sharma and B. Kumar , “A machine learning based predictive model for coronavirus pandemic scenario,” Journal of Physics: Conference Series, vol. 1714, p. 012023, 2021.
L. Sharma , P. Garg , (Eds.). (2020). From Visual Surveillance to Internet of Things. New York: Chapman and Hall/CRC, https://doi.org/10.1201/9780429297922
L. Sharma , (Ed.). Towards Smart World. New York: Chapman and Hall/CRC, 2021. https://doi.org/10.1201/9781003056751
L. Sharma , “Human Detection and Tracking Using Background Subtraction in Visual Surveillance”, Towards Smart World. New York: Chapman and Hall/CRC, https://doi.org/10.1201/9781003056751, pp. 317–328, December 2020.
T. Bouwmans , S. Javed , M. Sultana , and S. K. Jung , Deep neural network concepts for background subtraction: A systematic review and comparative evaluation. Neural Networks, vol. 117, pp. 8–66, 2019.

K. Burroughs , A. Jain , and R. L. Erickson . “Improved quality of protocol testing through techniques of experimental design,” in Proceedings of the IEEE International Conference on Communications (Supercomm/ICC’94), May 1–5, New Orleans, Louisiana, pp. 745–752, 1994.
J. D. McGregor and D. A. Sykes , A Practical Guide to Testing Object-Oriented Software. Boston, MA: Addison-Wesley, 2001.

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R. Adams , “10 Powerful Examples of Artificial Intelligence In Use Today,” 2019, [online]. Available: https://www.forbes.com/sites/robertadams/2017/01/10/10-powerful-examples-of-artificial-intelligence-in-use-today/#29b0c64420de.
L. Sharma (Ed.). Towards Smart World. New York: Chapman and Hall/CRC, 2021. https://doi.org/10.1201/9781003056751
L. Sharma and P. Garg (Eds.). From Visual Surveillance to Internet of Things. New York: Chapman and Hall/CRC, 2020. https://doi.org/10.1201/9780429297922
S. Jha and E. J. Topol . “Adapting to Artificial Intelligence: Radiologists and pathologists as information specialists,” in JAMA 2016; 316: 2353–2354.
F. Jiang , Y. Jiang , H. Zhi , et al. “Artificial intelligence in healthcare: Past, present and future,” in Stroke and Vascular Neurology, 2017; e000101. doi:10.1136/svn-2017-000101
C. Langlotz , B. Allen , and B. Erickson , et al. “A roadmap for foundational research on artificial intelligence in medical imaging: From the 2018,” in NIH/RSNA/ACR/The Academy Workshop. Department of Radiology, 2019; 190613.
A. Webb and G. C. Kagadis , “Introduction to biomedical imaging”, in Medical Physics, 2003; 30(8): 2267–2267.
G. Freiherr , CAT and MRI Scans and their Significance, [online] Available: https://www.dicardiology.com/article/how-ai-can-unlock-data-ct-and-mri-scans
P. Seebock , “Deep learning in medical image analysis,” Master’s thesis, Vienna University of Technology, Faculty of Informatics, 2015.
A. Y. Letyagin et al. , “Artificial Intelligence for Imaging Diagnostics in Neurosurgery,” in 2019 International Multi-Conference on Engineering, Computer and Information Sciences (SIBIRCON), Novosibirsk, Russia, 2019, pp. 0336–0337, doi:10.1109/SIBIRCON48586.2019.8958201.
S. Dinakaran and P. Anitha , “A review and study on AI in health care issues,” in International Journal of Scientific Research in Computer Science, Engineering and Information Technology, 2018; 281–288. doi:10.32628/CSEIT183886.
M. P. McBee , O. A. Awan , A. T. Colucci , et al. , “Deep learning in radiology,” in Academic Radiology, 2018; 25(11): 1472–1480.
A. S. Panayides et al. , “AI in Medical Imaging Informatics: Current Challenges and Future Directions,” in IEEE Journal of Biomedical and Health Informatics, vol. 24, no. 7, pp. 1837–1857, July 2020, doi:10.1109/JBHI.2020.2991043.
E. Köse , N. N. Öztürk , S. R. Karahan , et al. , “Artificial intelligence in surgery,” in European Archives of Medical Research, 2018; 34 (Suppl. 1): S4–S6.
L. Sharma and P. K. Garg , “Smart E-healthcare with Internet of Things: Current Trends Challenges, Solutions and Technologies”, From Visual Surveillance to Internet of Things, CRC Press, Taylor & Francis Group, pp. 215–234, October 2019.
L. Sharma and P. K. Garg , “A foresight on e-healthcare Trailblazers”, From Visual Surveillance to Internet of Things, CRC Press, Taylor & Francis Group, pp. 235–244, October 2019.
W. Hsu , M. K. Markey M. D. Wang , et al. “Biomedical imaging informatics in the era of precision medicine: Progress challenges and opportunities,” in Journal of the American Medical Informatics Association, 2013; 20: 1010–1013.
A. A. Shvets , A. Rakhlin , A. A. Kalinin , and V. I. Iglovikov , “Automatic Instrument Segmentation in Robot-Assisted Surgery using Deep Learning,” in 2018 17th IEEE International Conference on Machine Learning and Applications (ICMLA), Orlando, FL, 2018, pp. 624–628, doi:10.1109/ICMLA.2018.00100.
S. Speidel , M. Delles , C. Gutt , and R. Dillmann , et al. “Tracking of instruments in minimally invasive surgery for surgical skill analysis,” in Medical Imaging and Augmented Reality, Springer, Berlin, Heidelberg, pp. 148–155, 2006.
Z. Pezzementi , S. Voros G. D. Hager , et al. “Articulated object tracking by rendering consistent appearance parts”, in Robotics and Automation 2009. ICRA’09. IEEE International Conference on, pp. 3940–3947, 2009.
D. Lee , H. W. Yu , H. Kwon , H. J. Kong , K. E. Lee , H. C. Kim , et al. , “Evaluation of surgical skills during robotic surgery by deep learning-based multiple surgical instrument tracking in training and actual operations,” Journal of Clinical Medicine, 2020; 9: 1964.

K. Brian , et al. “10 promising AI applications in healthcare,” 2018, [online] Available: https://hbr.org/2018/05/10-promising-ai-applications-in-health-care.
Ch. Krishnaveni , S. Arvapalli , and J. Sharma , et al. “Artificial intelligence in pharma industry–A review,” 2020. doi:10.21276/IJIPSR.2019.07.10.506.
E. D’Agaro , “Artificial intelligence used in genome analysis studies,” in The EuroBiotech Journal, 2018; 2. doi:10.2478/ebtj-2018-0012.

Virtual and Augmented Reality Mental Health Research and Applications

Armstrong, T. , & Olatunji, B. O. (2012). Eye tracking of attention in the affective disorders: A meta-analytic review and synthesis. Clinical Psychology Review, 32(8), 704–723.
American Psychiatric Association . (2013). Diagnostic and statistical manual of mental disorders (DSM-5®). American Psychiatric Pub.
Azuma, R. , Baillot, Y. , Behringer, R. , Feiner, S. , Julier, S. , & MacIntyre, B. (2001). Recent advances in augmented reality. IEEE Computer Graphics and Applications, 21(6), 34–47.
Bar-Haim, Y. (2010). Research review: Attention bias modification (ABM): A novel treatment for anxiety disorders. Journal of Child Psychology and Psychiatry, 51(8), 859–870.
Baus, O. , & Bouchard, S. (2014). Moving from virtual reality exposure-based therapy to augmented reality exposure-based therapy: A review. Frontiers in Human Neuroscience, 8, 112.
Beck, A. T. (2008). The evolution of the cognitive model of depression and its neurobiological correlates. American Journal of Psychiatry, 165(8), 969–977.
Ben-Eliyahu, A. , Moore, D. , Dorph, R. , & Schunn, C. D. (2018). Investigating the multidimensionality of engagement: Affective, behavioral, and cognitive engagement across science activities and contexts. Contemporary Educational Psychology, 53, 87–105.
Berman, M. G. , Peltier, S. , Nee, D. E. , Kross, E. , Deldin, P. J. , & Jonides, J. (2011). Depression, rumination and the default network. Social Cognitive and Affective Neuroscience, 6(5), 548–555.
Blanke, O. , & Metzinger, T. (2009). Full-body illusions and minimal phenomenal selfhood. Trends in Cognitive Sciences, 13(1), 7–13.
Borghi, A. M. , Barca, L. , Binkofski, F. , & Tummolini, L. (2018). Varieties of abstract concepts: Development, use and representation in the brain. *Philosophical Transactions of the Royal Society B: Biological Sciences, 373*(1752), 20170121.
Botella, C. , Bretón-López, J. , Quero, S. , Baños, R. , & García-Palacios, A. (2010). Treating cockroach phobia with augmented reality. Behavior Therapy, 41(3), 401–413.
Botella, C. , Pérez-Ara, M. Á. , Bretón-López, J. , Quero, S. , García-Palacios, A. , & Baños, R. M. (2016). In vivo versus augmented reality exposure in the treatment of small animal phobia: A randomized controlled trial. PloS one, 11(2), e0148237.
Bowman, D. A. and McMahan, R. P. (2007). Virtual Reality: How Much Immersion Is Enough? Computer, 40(7), 36–43. doi:10.1109/MC.2007.257
Braun, N. , Debener, S. , Spychala, N. , Bongartz, E. , Sörös, P. , Müller, H. H. , & Philipsen, A. (2018). The senses of agency and ownership: A review. Frontiers in Psychology, 9, 535.
Bretón-López, J. , Quero, S. , Botella, C. , García-Palacios, A. , Baños, R. M. , & Alcaniz, M. (2010). An augmented reality system validation for the treatment of cockroach phobia. Cyberpsychology, Behavior, and Social Networking, 13(6), 705–710.
Britton, J. C. , Grillon, C. , Lissek, S. , Norcross, M. A. , Szuhany, K. L. , Chen, G. , … Pine, D. S. (2013). Response to learned threat: An fMRI study in adolescent and adult anxiety. American Journal of Psychiatry, 170(10), 1195–1204.
Chandrasiri, A. , Collett, J. , Fassbender, E. , & De Foe, A. (2020). A virtual reality approach to mindfulness skills training. Virtual Reality, 24(1), 143–149.
Chrastil, E. R. , & Warren, W. H. (2012). Active and passive contributions to spatial learning. Psychonomic Bulletin & Review, 19(1), 1–23.
Chrastil, E. R. , & Warren, W. H. (2013). Active and passive spatial learning in human navigation: Acquisition of survey knowledge. Journal of Experimental Psychology: Learning, Memory, and Cognition, 39(5), 1520.
Cipresso, P. , Giglioli, I. A. C. , Raya, M. A. , & Riva, G. (2018). The past, present, and future of virtual and augmented reality research: A network and cluster analysis of the literature. Frontiers in Psychology, 9, 2086.
Cisler, J. M. , & Koster, E. H. (2010). Mechanisms of attentional biases towards threat in anxiety disorders: An integrative review. Clinical Psychology Review, 30(2), 203–216.
Collins, P. Y. , Patel, V. , Joestl, S. S. , March, D. , Insel, T. R. , Daar, A. S. , … Glass, R. I. (2011). Grand challenges in global mental health. Nature, 475(7354), 27–30.
Cotrena, C. , Branco, L. D. , Shansis, F. M. , & Fonseca, R. P. (2016). Executive function impairments in depression and bipolar disorder: Association with functional impairment and quality of life. Journal of Affective Disorders, 190, 744–753.

Csikszentmihalyi, M. , & Csikzentmihaly, M. (1990). Flow: The psychology of optimal experience (Vol. 1990). New York: Harper & Row.
Cummins, F. (2014). Agency is distinct from autonomy. *AVANT* . Pismo Awangardy Filozoficzno-Naukowej, (2), 98–112.
DeJong, H. , Fox, E. , & Stein, A. (2019). Does rumination mediate the relationship between attentional control and symptoms of depression? Journal of Behavior Therapy and Experimental Psychiatry, 63, 28–35.
Difede, J. , & Hoffman, H. G. (2002). Virtual reality exposure therapy for World Trade Center post-traumatic stress disorder: A case report. Cyberpsychology & Behavior, 5(6), 529–535.
Duque, A. , & Vázquez, C. (2015). Double attention bias for positive and negative emotional faces in clinical depression: Evidence from an eye-tracking study. Journal of Behavior Therapy and Experimental Psychiatry, 46, 107–114.
Epp, A. M. , Dobson, K. S. , Dozois, D. J. , & Frewen, P. A. (2012). A systematic meta-analysis of the Stroop task in depression. Clinical Psychology Review, 32(4), 316–328.
Falconer, C. J. , Rovira, A. , King, J. A. , Gilbert, P. , Antley, A. , Fearon, P. , … Brewin, C. R. (2016). Embodying self-compassion within virtual reality and its effects on patients with depression. BJPsych Open, 2(1), 74–80.
Fenske, M. J. , & Eastwood, J. D. (2003). Modulation of focused attention by faces expressing emotion: Evidence from flanker tasks. Emotion, 3(4), 327–343. https://doi.org/10.1037/1528-3542.3.4.327
Fredrickson, B. L. (2001). The role of positive emotions in positive psychology: The broaden-and-build theory of positive emotions. American Psychologist, 56(3), 218.
Fredrickson, B. L. (2013). Positive emotions broaden and build. In Advances in experimental social psychology (Vol. 47, pp. 1–53). New York: Academic Press.
Freeman, D. , Slater, M. , Bebbington, P. E. , Garety, P. A. , Kuipers, E. , Fowler, D. , … Vinayagamoorthy, V. (2003). Can virtual reality be used to investigate persecutory ideation? The Journal of Nervous and Mental Disease, 191(8), 509–514.
Freeman, D. , Haselton, P. , Freeman, J. , Spanlang, B. , Kishore, S. , Albery, E. , … Nickless, A. (2018). Automated psychological therapy using immersive virtual reality for treatment of fear of heights: A single-blind, parallel-group, randomised controlled trial. The Lancet Psychiatry, 5(8), 625–632.
Freeman, D. , Reeve, S. , Robinson, A. , Ehlers, A. , Clark, D. , Spanlang, B. , & Slater, M. (2017). Virtual reality in the assessment, understanding, and treatment of mental health disorders. Psychological Medicine, 47(14), 2393–2400.
Freeman, D. (2008). Studying and treating schizophrenia using virtual reality: A new paradigm. Schizophrenia Bulletin, 34(4), 605–610.
Giglioli, I. A. C. , Pallavicini, F. , Pedroli, E. , Serino, S. , & Riva, G. (2015). Augmented reality: A brand new challenge for the assessment and treatment of psychological disorders. Computational and Mathematical Methods in Medicine, 2015, Article ID 862942. doi:10.1155/2015/862942
Harvey, P. O. , Fossati, P. , Pochon, J. B. , Levy, R. , LeBastard, G. , Lehéricy, S. , & Dubois, B. (2005). Cognitive control and brain resources in major depression: An fMRI study using the n-back task. Neuroimage, 26(3), 860–869.
Heeren, A. , Mogoaşe, C. , Philippot, P. , & McNally, R. J. (2015). Attention bias modification for social anxiety: A systematic review and meta-analysis. Clinical Psychology Review, 40, 76–90.
Hoffman, H. G. , Sharar, S. R. , Coda, B. , Everett, J. J. , Ciol, M. , Richards, T. , & Patterson, D. R. (2004). Manipulating presence influences the magnitude of virtual reality analgesia. Pain, 111(1–2), 162–168.
Jerald, J. (2015). The VR book: Human-centered design for virtual reality. Morgan & Claypool.
Juan, M. C. , Botella, C. , Alcaniz, M. , Banos, R. , Carrion, C. , Melero, M. , & Lozano, J. A. (2004, November). An augmented reality system for treating psychological disorders: Application to phobia to cockroaches. In Third IEEE and ACM international symposium on mixed and augmented reality (pp. 256–257). IEEE.
Kertzman, S. , Reznik, I. , Hornik-Lurie, T. , Weizman, A. , Kotler, M. , & Amital, D. (2010). Stroop performance in major depression: Selective attention impairment or psychomotor slowness? Journal of Affective Disorders, 122(1–2), 167–173.
Keyes, C. L. (2006). Subjective well-being in mental health and human development research worldwide: An introduction. Social Indicators Research, 77(1), 1–10.
Li, B. J. , Bailenson, J. N. , Pines, A. , Greenleaf, W. J. , & Williams, L. M. (2017). A public database of immersive VR videos with corresponding ratings of arousal, valence, and correlations between head movements and self-report measures. Frontiers in Psychology, 8, 2116.
Lin, J. H. T. (2017). Fear in virtual reality (VR): Fear elements, coping reactions, immediate and next-day fright responses toward a survival horror zombie virtual reality game. Computers in Human Behavior, 72, 350–361.
Lisk, S. , Vaswani, A. , Linetzky, M. , Bar-Haim, Y. , & Lau, J. Y. (2020). Systematic review and meta-analysis: Eye-tracking of attention to threat in child and adolescent anxiety. Journal of the American Academy of Child & Adolescent Psychiatry, 59(1), 88–99.
Lobo, L. , Heras-Escribano, M. , & Travieso, D. (2018). The history and philosophy of ecological psychology. Frontiers in Psychology, 9, 2228.
Luck, M. , & d'Inverno, M. (1995, June). A formal framework for agency and autonomy. In ICMAS (Vol. 95, pp. 254–260).

McMahan, R. P. , Bowman, D. A. , Zielinski, D. J. , & Brady, R. B. (2012). Evaluating display fidelity and interaction fidelity in a virtual reality game. IEEE Transactions on Visualization and Computer Graphics, 18(4), 626–633.
Metzinger, T. K. (2018). Why is virtual reality interesting for philosophers? Frontiers in Robotics and AI, 5, 101.
Michaliszyn, D. , Marchand, A. , Bouchard, S. , Martel, M. O. , & Poirier-Bisson, J. (2010). A randomized, controlled clinical trial of in virtuo and in vivo exposure for spider phobia. Cyberpsychology, Behavior, and Social Networking, 13(6), 689–695.
Moore, J. W. (2016). What is the sense of agency and why does it matter? Frontiers in Psychology, 7, 1272.
Moreno, A. , Wall, K. J. , Thangavelu, K. , Craven, L. , Ward, E. , & Dissanayaka, N. N. (2019). A systematic review of the use of virtual reality and its effects on cognition in individuals with neurocognitive disorders. Alzheimer's & Dementia: Translational Research & Clinical Interventions, 5, 834–850.
Nakamura, J. , & Csikszentmihalyi, M. (2014). The concept of flow. In Flow and the foundations of positive psychology (pp. 239–263). Dordrecht: Springer.
Niharika, P. , Reddy, N. V. , Srujana, P. , Srikanth, K. , Daneswari, V. , & Geetha, K. S. (2018). Effects of distraction using virtual reality technology on pain perception and anxiety levels in children during pulp therapy of primary molars. Journal of Indian Society of Pedodontics and Preventive Dentistry, 36(4), 364.
Öst, L. G. , Salkovskis, P. M. , & Hellström, K. (1991). One-session therapist-directed exposure vs. self-exposure in the treatment of spider phobia. Behavior Therapy, 22(3), 407–422.
Pacherie, E. (2007). The sense of control and the sense of agency. Psyche, 13(1), 1–30.
Pienkos, E. , Giersch, A. , Hansen, M. , Humpston, C. , McCarthy-Jones, S. , Mishara, A. , and Thomas, N. (2019). Hallucinations beyond voices: A conceptual review of the phenomenology of altered perception in psychosis. Schizophrenia Bulletin, 45(Supplement_1), S67–S77.
Reddy, V. (2019). Mental health issues and challenges in India: A review. International Journal of Social Sciences Management and Entrepreneurship (IJSSME), 3(2).
Richardson, J. C. , & Newby, T. (2006). The role of students' cognitive engagement in online learning. American Journal of Distance Education, 20(1), 23–37.
Riva, E. , Freire, T. , & Bassi, M. (2016). The flow experience in clinical settings: Applications in psychotherapy and mental health rehabilitation. In Flow experience (pp. 309–326). Cham: Springer.
Riva, G. (2011). The key to unlocking the virtual body: Virtual reality in the treatment of obesity and eating disorders. *Journal of Diabetes Science and Technology, 5*(2), 283–292.
Rizzo, A. S. , & Shilling, R. (2017). Clinical virtual reality tools to advance the prevention, assessment, and treatment of PTSD. European Journal of Psychotraumatology, 8(sup5), 1414560.
Rotgans, J. I. , & Schmidt, H. G. (2011). Cognitive engagement in the problem-based learning classroom. Advances in Health Sciences Education, 16(4), 465–479.
Rothbaum, B. O. , Hodges, L. , Smith, S. , Lee, J. H. , & Price, L. (2000). A controlled study of virtual reality exposure therapy for the fear of flying. Journal of Consulting and Clinical Psychology, 68(6), 1020.
Rothbaum, B. O. , Hodges, L. , Smith, S. , Lee, J. H. , & Price, L. (2002). A controlled study of virtual reality exposure therapy for the fear of flying. Year Book of Psychiatry and Applied Mental Health, 2002(1), 109–111.
Sanchez, A. , Vazquez, C. , Marker, C. , LeMoult, J. , & Joormann, J. (2013). Attentional disengagement predicts stress recovery in depression: An eye-tracking study. Journal of Abnormal Psychology, 122(2), 303.
Sanchez-Vives, M. V. , Spanlang, B. , Frisoli, A. , Bergamasco, M. , & Slater, M. (2010). Virtual hand illusion induced by visuomotor correlations. PloS one, 5(4), e10381.
Schacter, D. L. , Gilbert, D. T. , & Wegner, D. M. (2009). Introducing psychology. New York: Macmillan.
Schroer, S. A. (2019). Jakob von Uexküll: The concept of umwelt and its potentials for an anthropology beyond the human. Ethnos, 1–21.
Sheline, Y. I. , Barch, D. M. , Price, J. L. , Rundle, M. M. , Vaishnavi, S. N. , Snyder, A. Z. , … Raichle, M. E. (2009). The default mode network and self-referential processes in depression. Proceedings of the National Academy of Sciences, 106(6), 1942–1947.
Sheline, Y. I. , Barch, D. M. , Donnelly, J. M. , Ollinger, J. M. , Snyder, A. Z. , & Mintun, M. A. (2001). Increased amygdala response to masked emotional faces in depressed subjects resolve with antidepressant treatment: An fMRI study. Biological Psychiatry, 50(9), 651–658.
Slater, M. , & Wilbur, S. (1997). A framework for immersive virtual environments (FIVE): Speculations on the role of presence in virtual environments. Presence: Teleoperators & Virtual Environments, 6(6), 603–616.
Slater, M. (2009). Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments. Philosophical Transactions of the Royal Society B: Biological Sciences, 364(1535), 3549–3557.
Smith, R. (2010). The long history of gaming in military training. Simulation & Gaming, 41(1), 6–19.
Soujanya Kodavalla, S. , Jai Bhagwan Goel, M. , & Srivastava, P. (2019, November). Indian virtual reality affective database with self-report measures and EDA. In 25th ACM Symposium on Virtual Reality Software and Technology (pp. 1–2).
Srivastava, P. , & Srinivasan, N. (2010). Time course of visual attention with emotional faces. Attention, Perception, & Psychophysics, 72(2), 369–377.
Srivastava, P. , Rimzhim, A. , Vijay, P. , Singh, S. , & Chandra, S. (2019). Desktop VR is better than nonambulatory HMD VR for spatial learning. Frontiers in Robotics and AI, 6, 50.

Sutherland, I. E. (1965). The ultimate display. *Multimedia: From Wagner to* Virtual Reality, 1.
Valmaggia, L. R. , Latif, L. , Kempton, M. J. , & Rus-Calafell, M. (2016). Virtual reality in the psychological treatment for mental health problems: A systematic review of recent evidence. Psychiatry Research, 236, 189–195.
Vuorre, M. , & Metcalfe, J. (2016). The relation between the sense of agency and the experience of flow. Consciousness and Cognition, 43, 133–142.
Warren, W. H. (2006). The dynamics of perception and action. Psychological Review, 113(2), 358.
Wiebking, C. , Bauer, A. , De Greck, M. , Duncan, N. W. , Tempelmann, C. , & Northoff, G. (2010). Abnormal body perception and neural activity in the insula in depression: An fMRI study of the depressed “material me”. The World Journal of Biological Psychiatry, 11(3), 538–549.
Wilson, C. J. , & Soranzo, A. (2015). The use of virtual reality in psychology: A case study in visual perception. Computational and Mathematical Methods in Medicine, 2015.
Wrzesien, M. , Burkhardt, J. M. , Alcañiz, M. , & Botella, C. (2011, September). How technology influences the therapeutic process: A comparative field evaluation of augmented reality and in vivo exposure therapy for phobia of small animals. In IFIP Conference on Human-Computer Interaction (pp. 523–540). Berlin, Heidelberg: Springer.
Wrzesien, M. , Alcañiz, M. , Botella, C. , Burkhardt, J. M. , Bretón-López, J. , Ortega, M. , & Brotons, D. B. (2013). The therapeutic lamp: Treating small-animal phobias. IEEE Computer Graphics and Applications, 33(1), 80–86.
Yoshie, M. , & Haggard, P. (2017). Effects of emotional valence on sense of agency require a predictive model. Scientific Reports, 7(1), 1–8.
Zhao, X. H. , Wang, P. J. , Li, C. B. , Hu, Z. H. , Xi, Q. , Wu, W. Y. , & Tang, X. W. (2007). Altered default mode network activity in patient with anxiety disorders: An fMRI study. European Journal of Radiology, 63(3), 373–378.

Solar Potential Estimation and Management Using IoT, Big Data, and Remote Sensing in a Cloud Computing Environment

Badenko, V. , Fedotov, A. , & Vinogradov, K. (2013a). Computational Science and Its Applications–ICCSA 2013 (Vol. 7974). Springer International Publishing. https://doi.org/10.1007/978-3-642-39649-6
Badenko, V. , Kurtener, D. , Yakushev, V. , Torbert, A. , & Badenko, G. (2013b). Computational Science and Its Applications – ICCSA 2013, 7974, 57–69. https://doi.org/10.1007/978-3-642-39649-6
Elshayal . (2018). Elshayal Smart GIS 18.022. Retrieved from https://freesmartgis.blogspot.com/
Engineering, C. , & Board, D. (2018). Role of IoT in Make in India. (D. K. Tripathy , Ed.) (Vol. 2). Kolkata.
Escolar, S. , Chessa, S. , & Carretero, J. (2014). Energy management in solar cells powered wireless sensor networks for quality of service optimization. Personal and Ubiquitous Computing, 18(2), 449–464. https://doi.org/10.1007/s00779-013-0663-1
Esri . (2018). ArcGIS 10.3.1 for Desktop quick start guide—Help | ArcGIS Desktop. Retrieved September 1, 2018 , from http://desktop.arcgis.com/en/arcmap/10.3/get-started/quick-start-guides/arcgis-desktop-quick-start-guide.htm
Fang, S. , Xu, L. D. , Member, S. , Zhu, Y. , Ahati, J. , Pei, H. , … Liu, Z. (2014). An integrated system for regional environmental monitoring and management based on Internet of Things. IEEE Transactions on Industrial Informatics, 10(2), 1596–1605. https://doi.org/10.1109/TII.2014.2302638
Google Earth . (2018). Google Earth. Retrieved January 30, 2018 , from https://earth.google.com/web/
Hermann, S. , Miketa, A. , & Fichaux, N. (2014). Estimating the Renewable Energy Potential in Africa. International Renewable Energy Agency. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2014/IRENA_Africa_Resource_Potential_Aug2014.pdf
Hu, T. , Zheng, M. , Tan, J. , Zhu, L. , & Miao, W. (2015). Intelligent photovoltaic monitoring based on solar irradiance big data and wireless sensor networks. Ad Hoc Networks, 35, 127–136. https://doi.org/10.1016/j.adhoc.2015.07.004
Kumar, K. R. , & Kalavathi, M. S. (2018). Artificial intelligence based forecast models for predicting solar power generation. Materials Today: Proceedings, 5(1), 796–802. https://doi.org/10.1016/j.matpr.2017.11.149
Lefevre, M. , Albuisson, M. , & Wald, L. (2004). Description of the software Heliosat-II for the conversion of images acquired by Meteosat satellites in the visible band into maps of solar radiation available at ground level. HAL Archives-Ouvertes, 1–44.
Litjens, G. B. M. A. , Kausika, B. B. , Worrell, E. , & van Sark, W. G. J. H. M. (2018). A spatio-temporal city-scale assessment of residential photovoltaic power integration scenarios. Solar Energy, 174(October), 1185–1197. https://doi.org/10.1016/j.solener.2018.09.055
Markovic, D. S. , Zivkovic, D. , Branovic, I. , Popovic, R. , & Cvetkovic, D. (2013). Smart power grid and cloud computing. Renewable and Sustainable Energy Reviews, 24, 566–577. https://doi.org/10.1016/j.rser.2013.03.068

Mohseninia, M. (2017). Solar monitoring and the Internet of Things | PV Tech. Retrieved March 1, 2019 , from https://www.pv-tech.org/news/solar-monitoring-and-the-internet-of-things
Mulder, F. M. (2014). Implications of diurnal and seasonal variations in renewable energy generation for large scale energy storage. Journal of Renewable and Sustainable Energy, 6, 1–13. https://doi.org/10.1063/1.4874845
Ranganadham, M. V. S. (2018). Energy Statistics. Retrieved from http://mospi.nic.in/sites/default/files/publication_reports/Energy_Statistics_2018.pdf
Saran, S. , Wate, P. , Srivastav, S. K. , & Krishna Murthy, Y. V. N. (2015). CityGML at semantic level for urban energy conservation strategies. Annals of GIS, 21(1), 27–41. https://doi.org/10.1080/19475683.2014.992370
Sharma, S. (2016). Expanded cloud plumes hiding Big Data ecosystem. Future Generation Computer Systems, 59, 63–92. https://doi.org/10.1016/j.future.2016.01.003
Smith, M. J. de, Goodchild, M. F. , & Longley, P. A. (2018). Geospatial Analysis. Retrieved from www.spatialanalysisonline.com
Spanias, A. S. (2017). Solar Energy Management as an Internet of Things (IoT) Application. In 8th International Conference on Information, Intelligence, Systems & Applications (IISA). Larnaca, Cyprus: IEEE. https://doi.org/10.1109/IISA.2017.8316460
Teluguntla, P. , Thenkabail, P. , Oliphant, A. , Xiong, J. , Gumma, M. K. , Congalton, R. G. , … Huete, A. (2018). A 30-m landsat-derived cropland extent product of Australia and China using random forest machine learning algorithm on Google Earth Engine cloud computing platform. ISPRS Journal of Photogrammetry and Remote Sensing, 144, 325–340. https://doi.org/10.1016/j.isprsjprs.2018.07.017
Wikipedia . (2018). Kevin Ashton. Retrieved March 20, 2019 , from https://en.wikipedia.org/wiki/Kevin_Ashton
Xiong, J. , Thenkabail, P. S. , Gumma, M. K. , Teluguntla, P. , Poehnelt, J. , Congalton, R. G. , … Thau, D. (2017). Automated cropland mapping of continental Africa using Google Earth Engine cloud computing. ISPRS Journal of Photogrammetry and Remote Sensing, 126, 225–244. https://doi.org/10.1016/j.isprsjprs.2017.01.019
Yingzi, L. , & Yexia, H. (2019). Comparison and selection of solar radiation data for photovoltaic power generation project. Journal of Electrical Engineering & Technology, 14, 685–692. https://doi.org/10.1007/s42835-019-00110-3
Zaeem Hosain, S. (2018). The Internet of Things for Business. (S. Z. Hosain , Ed.) (3rd ed.). Aeris.
Zhang, X. , & Grijalva, S. (2016). A data driven approach for detection and estimation of residential PV installations. IEEE Transactions on Smart Grid, 3053, 1–1. https://doi.org/10.1109/TSG.2016.2555906

Object Detection under Hazy Environment for Real-Time Application

Shugang Zhang , Zhiqiang Wei , Jie Nie , Lei Huang , Shuang Wang , Zhen Li , “A Review on Human Activity Recognition Using Vision-Based Method”, Journal of Healthcare Engineering, 2017:31, 2017. Article ID 3090343. https://doi.org/10.1155/2017/3090343.
N. McFarlane and C. Schofield . “Segmentation and tracking of piglets in images,” British Machine Vision and Applications, 41(12):187–193, 1995.
J. Zheng and Y. Wang . “Extracting roadway background image: A mode based approach,” 2006. Transportation Research Board, TRB 2006.
J. Zeng , L. Xie , and Z. Liu . “Type-2 fuzzy Gaussian mixture models,” Pattern Recognition, 41(12):3636–3643, 2008.
C. Wren and A. Azarbayejani . “Pfinder: Real-time tracking of the human body,” IEEE Transactions on Pattern Analysis and Machine Intelligence, 19(7):780–785, 1997.
A. Elgammal and L. Davis . “Non-parametric model for background subtraction,” 6th European Conference on Computer Vision, ECCV 2000, pp. 751–767, 2000.
H. Lin , T. Liu , and J. Chuang . “A probabilistic SVM approach for background scene initialization.” ICIP 2002, September 2002.
N. Oliver , B. Rosario , and A. Pentland . “A Bayesian computer vision system for modeling human interactions,” International Conference on Vision Systems, 22(8):841–843, 1999.
D. Tsai and C. Lai . “Independent component analysis based background subtraction for indoor surveillance,” IEEE Transactions on Image Processing, 18(1):158–167, 2009.
L. Sharma and P. Garg (Eds.). From Visual Surveillance to Internet of Things. New York: Chapman and Hall/CRC, 2020. https://doi.org/10.1201/9780429297922.
L. Sharma (Ed.). Towards Smart World. New York: Chapman and Hall/CRC, 2021. https://doi.org/10.1201/9781003056751.
S. Messelodi and C. Modena . “A Kalman filter based background updating algorithm robust to sharp illumination changes,” International Conference on Image Analysis and Processing, ICIAP 2005, 3617:163–170, 2005.
R. Chang , T. Ghandi , and M. Trivedi . “Vision modules for a multi sensory bridge monitoring approach,” IEEE Conference on Intelligent Transportation Systems, ITS 2004, pp. 971–976, 2004.

M. Yazdi and T. Bouwmans . “New trends on moving object detection in video images captured by a moving camera: A survey,” Computer Science Review, 28:157–177, 2018.
L. Sharma , “Human Detection and Tracking Using Background Subtraction in Visual Surveillance”, Towards Smart World. New York: Chapman and Hall/CRC, https://doi.org/10.1201/9781003056751, pp. 317–328, December 2020.
M. Zhao , N. Li , and C. Chen . “Robust automatic video object segmentation technique,” International Conference on Image Processing, September 2002.
P. Pahalawatta , D. Depalov , T. Pappas , and A. Katsaggelos . “Detection, classification, and collaborative tracking of multiple targets using video sensors,” International Workshop on Information Processing for Sensor Networks, pp. 529–544, April 2003.
B. Orten , M. Soysal , and A. Alatan . “Person identification of surveillance video by combining Mpeg-7 experts.” WIAMIS 2005, April 2005.
K. Simonyan and A. Zisserman . “Very deep convolutional networks for large-scale image recognition,” arXiv:1409.1556, 2014.
T. Yu , J. Yang , and W. Lu . “Combining background subtraction and convolutional neural network for anomaly detection in pumping-unit surveillance,” *Algorithms*, 12, May 2019. https://doi.org/10.3390/A12060115
L. Sharma , D. K. Yadav , S. K. Bharti , “An improved method for visual surveillance using background subtraction technique,” IEEE, 2nd International Conference on Signal Processing and Integrated Networks (SPIN-2015), Amity University, Noida, India, February 19–20, 2015.
H. Kim , R. Sakamoto , I. Kitahara , T. Toriyama , and K. Kogure . “Background subtraction using generalized Gaussian family model,” IET Electronics Letters, 44(3):189–190, 2008.
A. Francois , G. Medioni . “Adaptive Color Background Modeling for Real –time Segmentation of Video Streams,” International Conference in Imaging Science, Systems and Technology, pp. 227–232, June 1999.
L. Sharma , P. K. Garg , “Block based adaptive learning rate for moving person detection in video surveillance,” From Visual Surveillance to Internet of Things, CRC Press, Taylor & Francis Group, pp. 201–214, October 2019.
T. Tanaka , A. Shimada , D. Arita , and R. Taniguchi . “Object segmentation under varying illumination based on combinational background modeling,” Proceeding of the 4th Joint Workshop on Machine Perception and Robotics, 2008.
A. Krizhevsky , I. Sutskever , and G. E. Hinton . “ImageNet classification with deep convolutional neural networks,” Advances in Neural Information Processing Systems, 1, 1097–1105, 2012.
D. K. Yadav , L. Sharma , and S. K. Bharti , “Moving object detection in real-time visual surveillance using background subtraction technique,” IEEE, 14th International Conference in Hybrid Intelligent Computing (HIS-2014), Gulf University for Science and Technology, Kuwait, December 14–16, 2014.
K. Toyama and J. Krumm . “Wallflower: Principles and practice of background maintenance,” International Conference on Computer Vision ICCV 1999, pp. 255–261, 1999.
S. Diamantas and K. Alexis . “Optical flow based background subtraction with a moving camera: application to autonomous driving.” In: G. Bebis et al. (eds.), Advances in Visual Computing, ISVC 2020. Lecture notes in Computer Science, 12510. Cham, Switzerland: Springer, 2018.
B.D. Lucas and T. Kanade . “An iterative image registration technique with an application to stereo vision,” in Proceedings of the 7th International Joint Conference on Artifitial Intelligence (IJCAI), pp. 674–679, August 24–28, 1981.
S. Bucak and B. Gunsel . “Incremental subspace learning and generating sparse representations via non-negative matrix factorization,” Pattern Recognition, 42(5):788–797, 2009.
L. Sharma , A. Singh , and D. K. Yadav , “Fisher’s Linear Discriminant Ratio based Threshold for Moving Human Detection in Thermal Video,” Infrared Physics and Technology, Elsevier, March 2016.
F. Schrof , D. Kalenichenko , and J. Philbin , “FaceNet: a unifed embedding for face recognition and clustering,” in Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR ’15), pp. 815–823, IEEE, Boston, MA, June 2015.

Real-Time Road Monitoring Using Deep Learning Algorithm Deployed on IoT Devices

Bhatt Umang , Mani Shouvik , Xi Edgar , and J. Kolter , “Intelligent Pothole Detection and Road Condition Assessment,” Data for Good Exchange 2017, New York, September 2017.
Kamaljit Kaur Sandhu . (2018, July 24), “Over 9300 deaths, 25000 injured in 3 years due to potholes,” India Today, Available online: https://www.indiatoday.in/india/story/over-9300-deaths-25000-injured-in-3-years-due-to-potholes-1294147-2018-07-24.
“ Diving into the UK’s pothole problem ,” In Day Insure, Available online: https://www.dayinsure.com/news/diving-into-the-uks-pothole-problem, September 30, 2019.

Kim Taehyeong and S. Ryu , “Review and analysis of pothole detection methods,” Journal of Emerging Trends in Computing and Information Sciences, 2014, vol. 5, pp. 603–608.
Akagic Amila , Buza Emir , and Omanovic Samir , “Pothole Detection: An Efficient Vision Based Method Using RGB Color Space Image Segmentation,” 2017 40th International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO), IEEE, 2017, pp. 1104–1109 [doi:10.23919/MIPRO.2017.7973589].
Dingan Liao, Hu Lu , Xingpei Xu , and Quansheng Gao , “Image Segmentation Based on Deep Learning Features,” 2019 Eleventh International Conference on Advanced Computational Intelligence (ICACI), IEEE, 2019, pp. 296–301 [doi:10.1109/ICACI.2019.8778464].
Voulodimos Athanasios , Doulamis Nikolaos , Doulamis Anastasios , and Protopapadakis Eftychios , “Deep Learning for Computer Vision: A Brief Review,” Computational Intelligence and Neuroscience, vol. 2018, 2018, pp. 1–13 [doi:10.1155/2018/7068349].
Zhao Zhong-Qiu , Zheng Peng , Xu Shou-Tao , and Wu Xindong , “Object Detection with Deep Learning: A Review,” IEEE Transactions on Neural Networks and Learning Systems, vol. 30, no. 11, 2019, pp. 3212–3232 [doi:10.1109/TNNLS.2018.2876865].
Nassif Ali , Shahin Ismail , Attili Imtinan , Azzeh Mohammad , and Shaalan Khaled , “Speech Recognition Using Deep Neural Networks: A Systematic Review,” IEEE Access, vol. 7, 2019, pp. 19143–19165 [doi:10.1109/ACCESS.2019.2896880].
Vargas Manuel , Lima Beatriz , and Evsukoff Alexandre , “Deep Learning for Stock Market Prediction from Financial News Articles,” 2017 IEEE International Conference on Computational Intelligence and Virtual Environments for Measurement Systems and Applications (CIVEMSA), IEEE, 2017, pp. 60–65 [doi:10.1109/CIVEMSA.2017.7995302].
Chen Qi , Wang Wei , Wu Fangyu , De Suparna , Wang Ruili , Zhang Bailing , and Huang Xin , “A Survey on an Emerging Area: Deep Learning for Smart City Data,” IEEE Transactions on Emerging Topics in Computational Intelligence, vol. 3, no. 5, 2019, pp. 392–410 [doi:10.1109/TETCI.2019.2907718].
Dargan Shaveta , Kumar Munish , Maruthi Rohit Ayyagari , and Kumar Gulshan , “A Survey of Deep Learning and Its Applications: A New Paradigm to Machine Learning,” Archives of Computational Methods in Engineering, June 2019 [doi:10.1007/s11831-019-09344-w].
Shen Li , Margolies Laurie , Rothstein Joseph , Fluder Eugene , McBride Russell , and Sieh Weiva , “Deep Learning to Improve Breast Cancer Detection on Screening Mammography,” Scientific Reports, vol. 9, no. 1, 2019, p. 12495 [doi:10.1038/s41598-019-48995-4].
Kłosowski Piotr , “Deep Learning for Natural Language Processing and Language Modelling,” 2018 Signal Processing: Algorithms, Architectures, Arrangements, and Applications (SPA), IEEE, 2018, pp. 223–228 [doi:10.23919/SPA.2018.8563389].
Aiman Umme and Vishwakarma Virendra , “Face Recognition Using Modified Deep Learning Neural Network,” 2017 8th International Conference on Computing, Communication and Networking Technologies (ICCCNT), IEEE, 2017, pp. 1–5 [doi:10.1109/ICCCNT.2017.8203981].
Vaidya Rohan , Trivedi Darshan , Satra Sagar , and Pimpale Mrunalini , “Handwritten Character Recognition Using Deep-Learning,” 2018 Second International Conference on Inventive Communication and Computational Technologies (ICICCT), IEEE, 2018, pp. 772–775 [doi:10.1109/ICICCT.2018.8473291].
Dhiman Amita and Klette Reinhard , “Pothole Detection Using Computer Vision and Learning,” IEEE Transactions on Intelligent Transportation Systems, 2019, pp. 1–15 [doi:10.1109/TITS.2019.2931297].
Wang Kelvin , “Challenges and Feasibility for Comprehensive Automated Survey of Pavement Conditions,” Applications of Advanced Technologies in Transportation Engineering (2004), American Society of Civil Engineers, 2004, pp. 531–536 [doi:10.1061/40730(144)99].
Hou Zhiqiong , Wang Kelvin , and Gong Weiguo , “Experimentation of 3D Pavement Imaging through Stereovision,” International Conference on Transportation Engineering 2007, American Society of Civil Engineers, 2007, pp. 376–381 [doi:10.1061/40932(246)62].
Chang Kuan-Tsung , J. Chang , and Liu Jin-King , “Detection of Pavement Distress using 3D Laser Scanning Technology,” In Proceedings of International Conference on Computing in Civil Engineering 2005, pp. 1–11 [doi:10.1061/40794(179)103].
Li Qingguang , Yao Ming , Yao Xun , and Xu Bugao , “A Real-Time 3D Scanning System for Pavement Distortion Inspection,” Measurement Science and Technology, vol. 21, no. 1, 2010, p. 015702 [doi:10.1088/0957-0233/21/1/015702].
Joubert Damien , Tyatyantsi Ayanda , J. Mphahlehle , and V. Manchidi , “Pothole Tagging System,” In Proceedings of the 4th Robotics and Mechatronics Conference of South Africa, CSIR International Conference Centre, Pretoria, November 2011, pp. 23–25.
Moazzam Imran , Kamal Khurram , Mathavan Senthan , Ahmed Syed , and Rahman Mujib , “Metrology and visualization of potholes using the Microsoft Kinect sensor,” In Proceedings of the 16th International IEEE Annual Conference on Intelligent Transportation Systems, 2013 [doi:10.1109/ITSC.2013.6728408].
Mednis Artis , Strazdins Girts , Zviedris Reinholds , Kanonirs Georgijs , and Selavo Leo , “Real time pothole detection using Android smartphones with accelerometers,” 2011 International Conference on Distributed Computing in Sensor Systems and Workshops (DCOSS), Barcelona, 2011, pp. 1–6 [doi:10.1109/DCOSS.2011.5982206].

Ghadge Manjusha , Pandey Dheeraj , and Kalbande Dhananjay , “Machine Learning Approach for Predicting Bumps on Road,” 2015 International Conference on Applied and Theoretical Computing and Communication Technology (ICATccT), IEEE, 2015, pp. 481–485 doi:10.1109/ICATCCT.2015.7456932.
Seraj Fatjon , van der Zwaag , Berend Jan , Dilo Arta , Luarasi Tamara , and Havinga Paul , “RoADS: A Road Pavement Monitoring System for Anomaly Detection Using Smart Phones,” International Workshop on Modeling Social Media International Workshop on Mining Ubiquitous and Social Environments International Workshop on Machine Learning for Urban Sensor Data, SenseML 2014, Berlin: Springer, 2014. pp. 1–16.
Jo Youngtae and Ryu Seungki , “Pothole Detection System Using a Black-Box Camera,” Sensors, vol. 15, no. 11, 2015, pp. 29316–29331 [doi:10.3390/s151129316].
Oliveira Henrique and Correia Paulo , “CrackIT; An Image Processing Toolbox for Crack Detection and Characterization.” 2014 IEEE International Conference on Image Processing (ICIP), IEEE, 2014, pp. 798–802 [doi:10.1109/ICIP.2014.7025160].
Zhang Lei , Yang Fan , Zhang Yimin , and Zhu Ying , “Road Crack Detection Using Deep Convolutional Neural Network,” 2016 IEEE International Conference on Image Processing (ICIP), IEEE, 2016, pp. 3708–3712 [doi:10.1109/ICIP.2016.7533052].
Hu Yong and Zhao Chun-Xia , “A Novel LBP Based Methods for Pavement Crack Detection,” Journal of Pattern Recognition Research, vol. 5, no. 1, 2010, pp. 140–147 [doi:10.13176/11.167].
Zou Qin , Cao Yu , Li Qingquan , Mao Qingzhou , and Wang Shoupeng , “CrackTree: Automatic Crack Detection from Pavement Images,” Pattern Recognition Letters, vol. 33, no. 3, 2012, pp. 227–238 [doi:10.1016/j.patrec.2011.11.004].
Maeda Hiroya , Sekimoto Yoshihide , Seto Toshikazu , Kashiyama Takehiro , and Omata Hiroshi , “Road Damage Detection and Classification Using Deep Neural Networks with Smartphone Images,” Computer-Aided Civil and Infrastructure Engineering, vol. 33, no. 12, 2018, pp. 1127–1141 [doi:10.1111/mice.12387].
Ren Shaoqing , He Kaiming , Girshick Ross , and Sun Jian , “Faster R-CNN: Towards Real-Time Object Detection with Region Proposal Networks,” IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 39, no. 6, 2017, pp. 1137–1149 [doi:10.1109/TPAMI.2016.2577031].
Liu Wei , Anguelov Dragomir , Erhan Dumitru , Szegedy Christian , Reed Scott , Fu Cheng-Yang , and Berg Alexander , “SSD: Single Shot MultiBox Detector,” European Conference on Computer Vision, vol. 9905, 2016, pp. 21–37 [doi:10.1007/978-3-319-46448-0_2].
Sandler Mark , Howard Andrew , Zhu Menglong , Zhmoginov Andrey , and Chen Liang-Chieh , “MobileNetV2: Inverted Residuals and Linear Bottlenecks,” 2018 IEEE/CVF Conference on Computer Vision and Pattern Recognition, IEEE, 2018, pp. 4510–4520 [doi:10.1109/CVPR.2018.00474].
Wojke Nicolai , Bewley Alex , and Paulus Dietrich , “Simple Online and Realtime Tracking with a Deep Association Metric,” 2017 IEEE International Conference on Image Processing (ICIP), IEEE, 2017, pp. 3645–3649 [doi:10.1109/ICIP.2017.8296962].
K. Host , M. Ivasic-Kos , and M. Pobar , “Tracking Handball Players with the DeepSORT Algorithm,” In Proceedings of the 9th International Conference on Pattern Recognition Applications and Methods - Volume 1, ICPRAM, 2020, ISBN 978-989-758-397-1, pp. 593–599. [doi:10.5220/0009177605930599]
“ Deploy machine learning models on mobile and IoT devices ,” Available online: https://www.tensorflow.org/lite.
Murad A. Qurishee , “Low-cost deep learning UAV and Raspberry Pi solution to real-time pavement condition assessment,” Degree of Master of Science, The University of Tennessee at Chattanooga Chattanooga, Tennessee, May 2019.
Rezatofighi Hamid , Tsoi Nathan , Gwak JunYoung , Sadeghian Amir , Reid Ian , and Savarese Silvio , “Generalized intersection over union: A metric and a loss for bounding box regression.” 2019 IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), 2019, pp. 658–666.

AI-Based Real-Time Application: Pattern Recognition Automatic License Plate and Vehicle Number Detection Using Image Processing and Deep Learning (with OpenCV)

Agarwal, T. (2014), “The evolution and future scope of augmented reality”, International Journal of Computer Science Issues, 11(6).
Andrew, N. G. , Ngiam, J. , Yu Foo, C. , Mai, Y. , Suen, C. , Coates, A. , et al. , (2020), Deep Learning Tutorial published by Stanford, February 2017.
ANPR systems and its solutions , ANPR Systems | Automatic License Plate Recognition Systems (titanhz.com).
Bousquet, O. , & Pez-Cruz, F. (2003), “Kernel methods and their applications to signal processing,” 2003 IEEE International Conference on Acoustics, Speech, and Signal Processing, 2003. Proceedings. (ICASSP’03), pp. 4–860. doi:10.1109/ICASSP.2003.1202779.
Bouwmans, T. , Javed, S. , Sultana, M. , & Jung, S. K. (2019), “Deep neural network concepts for background subtraction: A systematic review and comparative evaluation”, Neural Networks, 117, 8–66.

Bushkovskyi, O. (2020), “What is pattern recognition and why it matters?”
Chand, D. , Gupta, S. , & Kavati, I. (2020), Computer Vision based Accident Detection for Autonomous Vehicles. India: Department of Computer Science and Engineering National Institute of Technology Warangal.
Dhote, S. (2020), “What is ANPR and How can we use it?” What is ANPR and How Can we Use it? – Proche (theproche.com).
Fogel, L. J. , Owens, M. J. , & Walsh, M. J. (1965), “Artificial intelligence through a simulation of evolution”, in Biophysics and Cybernetic Systems Maxfield, Washington, DC: Spartan Books.
Gao, X. , Zhang, J. , & Wei, Z. (2018), “Deep learning for sequence pattern recognition”, IEEE 15th International Conference on Networking, Sensing and Control (ICNSC), Zhuhai, doi:10.1109/ICNSC.2018.8361281.
Ghadage, S. S. , & Khedkar, S. K. (2019), “A review paper on automatic number plate recognition system using machine learning algorithms”, International Journal of Engineering Research & Technology (IJERT), 8(12).
Giraldo, J. H. , & Bouwmans, T. (2020), “GraphBGS: Background Subtraction via Recovery of Graph Signals”. arXiv preprint arXiv:2001.06404.
Golden, R. M. (2002), Statistical Pattern Recognition. University of Texas at Dallas Richardson.
Gowshalya Shri, A. M. , & Arulprakash, M. (2014), “A Scheme for Detection of License Number Plate by the Application of Genetic Algorithms”, International Journal of Innovative Research in Computer and Communication Engineering, 2(1).
He, K. , Zhang, X. , Ren, S. , & Sun, L. (2016), “Deep Residual Learning for Image Recognition”, IEEE Conference on Computer Vision and Pattern Recognition (CVPR), Las Vegas, NV, doi:10.1109/CVPR.2016.90.
Jiang, S. , Qin, H. , Zhang, B. , & Zheng, J. (2011), Optimized Loss Functions for Object detection: A Case Study on Nighttime Vehicle Detection. Hefei, China: School of Automotive and Transportation Engineering, Hefei University of Technology.
Makkar, S. , & Sharma, L. (2019), “A Face Detection using Support Vector Machine: Challenging Issues, Recent trend, solutions and proposed framework”, in Third International Conference on Advances in Computing and Data Sciences, Inderprastha Engineering College, Ghaziabad.
Patel, C. , Shah, D. , & Patel, A. (2013), Automatic Number Plate Recognition System (ANPR): A survey. International Journal of Computer Applications (IJCA), 69, 21–33.
Prasad TVSNVC (2020), “Pattern Recognition: The basis of Human and Machine Learning”, Pattern Recognition | Importance of Pattern Recognition (analyticsvidhya.com).
Rao, M. S. , & Reddy, B. E. (2011), “Comparative analysis of pattern recognition methods: An overview”, Indian Journal of Computer Science and Engineering (IJCSE).
Roy, S. (2007), Vehicle License Plate Extraction and Recognition. Kharagpur: Department of Computer Science and Engineering, Indian Institute of Technology.
Safari, P. , & Kleinsteuber, M. (2013), “Deep Learning for Sequential Pattern Recognition”, Master Thesis submitted at Technische Universitat Munchen.
Samra, G. A. (2016), “Genetic algorithms based orientation and scale invariant localization of vehicle plate number”, International Journal of Scientific & Engineering Research, 7(4).
Sawon (2020), An Overview of Neural Approach on Pattern Recognition.
Sharma, L. (2020), “Human detection and tracking using background subtraction in visual surveillance”, Towards Smart World. New York: Chapman and Hall/CRC, https://doi.org/10.1201/9781003056751. pp. 317–328.
Sharma, L. (Ed.) (2021), Towards Smart World. New York: Chapman and Hall/CRC, https://doi.org/10.1201/9781003056751.
Sharma, L. , & Garg, P. (Eds.) (2020a), From Visual Surveillance to Internet of Things. New York: Chapman and Hall/CRC, https://doi.org/10.1201/9780429297922.
Sharma, L. , & Garg, P. K. (2020b), “Block based adaptive learning rate for moving person detection in video surveillance”, From Visual Surveillance to Internet of Things, Taylor & Francis Group, CRC Press, Vol. 1, pp. 201.
Sharma, L. Singh, A. , & Yadav, D. K. (2016), “Fisher’s linear discriminant ratio based threshold for moving human detection in thermal video”, Infrared Physics and Technology.

Design of a Chess Agent Using Reinforcement Learning with SARSA Network

Sutton, R. S. , & Barto, A. G. (2015). Reinforcement Learning: An Introduction, MIT Press, Cambridge, MA.
Budd, C. (2018). Robots to play games, https://plus.maths.org/content/robots-play-games
Turing, A. , & Champernowne, D. G. Turochamp, https://www.chessprogramming.org/Turochamp
Tesauro, G. (1995). Temporal difference learning and TD-Gammon. Journal of the International Computer Games, 18, 88.
Zhao, D. , Wang, H. , Shao, K. , & Zhu, Y. (2016). Deep reinforcement learning with experience replay based on SARSA. 1–6. doi:10.1109/SSCI.2016.7849837.

Mnih, V. , Kavukcuoglu, K. , Silver, D. , Graves, A. , Antonoglou, I. , Wierstra, D. , & Riedmiller, M. (2013). Playing Atari with deep reinforcement learning. arXiv preprint arXiv:1312.5602.

Silver, D. , Schrittwieser, J. , Simonyan, K. , Antonoglou, I. , Huang, A. , Guez, A. , Hubert, T. , Baker, L. , Lai, M. , Bolton, A. , Chen, Y. , Lillicrap, T. , Hui, F. , Sifre, L. , Driessche, G. , Graepel, T. , & Hassabis, D. (2017). Mastering the game of Go without human knowledge. Nature, 550, 354–359. doi:10.1038/nature24270.

Silver, D. , Hubert, T. , Schrittwieser, J. , Antonoglou, I. , Lai, M. , Guez, A. , & Hassabis, D. (2017). Mastering chess and shogi by self-play with a general reinforcement learning algorithm. arXiv preprint arXiv:1712.01815.

Groen, A. Reinforcement Learning Chess, https://github.com/arjangroen/RLC

Li, Y. (2019). Reinforcement learning applications. arXiv preprint arXiv:1908.06973.

Zheng, G. , Zhang, F. , Zheng, Z. , Xiang, Y. , Yuan, N. J. , Xie, X. , & Li, Z. (2018). DRN: A deep reinforcement learning framework for news recommendation. In Proceedings of the 2018 World Wide Web Conference (WWW '18). International World Wide Web Conferences Steering Committee, Republic and Canton of Geneva, CHE, 167–176. https://doi.org/10.1145/3178876.3185994

Moving Objects Detection in Video Processing:

B. Garcia-Garcia , T. Bouwmans , A. J. R. Silva (2020). Background subtraction in real applications: Challenges, current models and future directions. Computer Science Review, 35, 100204.

T. Bouwmans , A. Sobral , S. Javed , S. K. Jung , E. H. Zahzah (2017). Decomposition into low-rank plus additive matrices for background/foreground separation: A review for a comparative evaluation with a large-scale dataset. Computer Science Review, 23, 1–71.

T. Bouwmans (2014). Traditional and recent approaches in background modeling for foreground detection: An overview. Computer Science Review, 11, 31–66.

T. Bouwmans , S. Javed , M. Sultana , S. K. Jung (2019). Deep neural network concepts for background subtraction: A systematic review and comparative evaluation. Neural Networks, 117, 8–66.

J. H. Giraldo , T. Bouwmans (2020). GraphBGS: Background Subtraction via Recovery of Graph Signals. arXiv preprint arXiv:2001.06404.

O. Tezcan , P. Ishwar , J. Konrad (2020). BSUV-Net: A fully-convolutional neural network for background subtraction of unseen videos. In The IEEE Winter Conference on Applications of Computer Vision (pp. 2774–2783).

J. Gracewell , M. John (2020). Dynamic background modeling using deep learning autoencoder network, Multimedia Tools and Applications, 79, 4639–4659.

S. Choo , W. Seo , D. Jeong , N. Cho (2018). Multi-scale recurrent encoder-decoder network for dense temporal classification, IAPR International Conference on Pattern Recognition, ICPR 2018, Beijing, China.

A. Farnoosh , B. Rezaei , S. Ostadabbas (2021). DEEPBM: Deep probabilistic background model estimation from video sequences, International Conference on Pattern Recognition (ICPR 2020), Milan, Italy.

S. Ammar , T. Bouwmans , N. Zaghden , M. Neji (2019). Moving objects segmentation based on DeepSphere in video surveillance, International Symposium on Visual Computing, ISVC 2019, Tahoe City, USA.

M. Braham , M. Van Droogenbroeck (2016), Deep background subtraction with scene-specific convolutional neural networks, IWSSIP 2016, Bratislava, Slovakia.

T. Minematsu , A. Shimada , H. Uchiyama , R. Taniguchi (2018). Analytics of Deep Neural Network-based Background Subtraction, MDPI Journal of Imaging.

T. Minematsu , A. Shimada , R. Taniguchi (2020). Rethinking Background and Foreground in Deep Neural Network-Based Background Subtraction, IEEE International Conference on Image Processing, ICIP 2020, Abu Dhabi, UAE.

P. Patil , S. Murala (2018). MSFgNet: A novel compact end-to-end deep network for moving object detection, IEEE Transactions on Intelligent Transportation Systems.

I. Osman , M. Shehata (2020). MODSiam: Moving object detection using siamese networks, IEEE Canadian Conference on Electrical and Computer Engineering, CCECE 2020 (pp. 1–6).

M. Mandal , V. Dhar , A. Mishra , S. Vipparthi , M. Abdel-Mottaleb (2021). 3DCD: Scene independent end-to-end spatiotemporal feature learning framework for change detection in unseen videos, IEEE Transactions on Image Processing, 30, 546–558.

M. Sultana , A. Mahmood , S. Javed , S. Jung (2019). Unsupervised deep context prediction for background estimation and foreground segmentation, Machine Vision and Applications, 30, 375–395.

M. Sultana , A. Mahmood , T. Bouwmans , S. Jun (2019). Complete moving object detection in the context of robust subspace learning, Workshop on Robust Subspace Learning and Computer Vision, ICCV 2019, Seoul, South Korea.

M. Sultana , A. Mahmood , T. Bouwmans , S. Jung (2020). Unsupervised adversarial learning for dynamic background modeling, International Workshop on Frontiers of Computer Vision, IW-FCV 2020, Ibusuki, Japan.

M. Sultana , A. Mahmood , T. Bouwmans , S. Jung (2020). Dynamic background subtraction using least square adversarial learning, ICIP 2020, Abu Dhabi, UAE.

H. Didwania , S. Ghatak , S. Rup (2019). Multi-frame and Multi-scale Conditional Generative Adversarial Networks for Efficient Foreground Extraction, International Conference on Computer Vision and Image Process, CVIP 2019 (pp. 211–222).
W. Yu , J. Bai , L. Jiao (2020). Background Subtraction Based on GAN and Domain Adaptation for VHR Optical Remote Sensing Videos, IEEE Access.
S. S. Du , Y. Wang , X. Zhai , S. Balakrishnan , R. R. Salakhutdinov , A. Singh (2018). How many samples are needed to estimate a convolutional neural network? In Advances in Neural Information Processing Systems (pp. 373–383).
A. Parada-Mayorga , D. L. Lau , J. H. Giraldo , G. R. Arce (2019). Blue-noise sampling on graphs. IEEE Transactions on Signal and Information Processing over Networks, 5(3), 554–569.
N. Goyette , P. M. Jodoin , F. Porikli , J. Konrad , P. Ishwar (2012, June). Changedetection. net: A new change detection benchmark dataset. In 2012 IEEE Computer Society Conference on Computer Vision and Pattern Recognition Workshops (pp. 1–8).
K. He , G. Gkioxari , P. Dollár , R. Girshick (2017). Mask R-CNN. In Proceedings of the IEEE International Conference on Computer Vision (pp. 2961–2969).
S. Chen , R. Varma , A. Sandryhaila , J. Kovačević (2015). Discrete Signal Processing on Graphs: Sampling Theory. IEEE Transactions on Signal Processing, 63(24), 6510–6523.
A. Anis , A. Gadde , A. Ortega (2016). Efficient sampling set selection for bandlimited graph signals using graph spectral proxies. IEEE Transactions on Signal Processing, 64(14), 3775–3789.
G. Puy , N. Tremblay , R. Gribonval , P. Vandergheynst (2018). Random sampling of bandlimited signals on graphs. Applied and Computational Harmonic Analysis, 44(2), 446–475.
I. Z. Pesenson (2015, May). Sampling solutions of Schrödinger equations on combinatorial graphs. In 2015 International Conference on Sampling Theory and Applications (SampTA) (pp. 82–85). IEEE.
F. R. Chung , F. C. Graham (1997). Spectral graph theory (No. 92). American Mathematical Soc.
T. Y. Lin , M. Maire , S. Belongie , J. Hays , P. Perona , D. Ramanan , C. L. Zitnick (2014, September). Microsoft coco: Common objects in context. In European Conference on Computer Vision (pp. 740–755). Springer, Cham.
Lucas, B. D. , Kanade, T. (1981). An iterative image registration technique with an application to stereo vision.
T. Ojala , M. Pietikainen , T. Maenpaa (2002). Multiresolution gray-scale and rotation invariant texture classification with local binary patterns. IEEE Transactions on Pattern Analysis and Machine Intelligence, 24(7), 971–987.
R. A. Ulichney (1993, September). Void-and-cluster method for dither array generation. In Human Vision, Visual Processing, and Digital Display IV (Vol. 1913, pp. 332–343). International Society for Optics and Photonics.
I. Pesenson (2009). Variational splines and Paley–Wiener spaces on combinatorial graphs. Constructive Approximation, 29(1), 1–21.
R. A. Horn , C. R. Johnson (2012). Matrix analysis. Cambridge University Press.
N. Perraudin , J. Paratte , D. Shuman , L. Martin , V. Kalofolias , P. Vandergheynst , D. K. Hammond (2014). GSPBOX: A toolbox for signal processing on graphs. arXiv preprint arXiv:1408.5781.
J. H. Giraldo , T. Bouwmans (2020). Semi-supervised Background Subtraction of Unseen Videos: Minimization of the Total Variation of Graph Signals, IEEE International Conference on Image Processing.
J. H. Giraldo , S. Javed , T. Bouwmans (2020). Graph moving object segmentation, IEEE Transactions on Pattern Analysis and Machine Intelligence, October 25–28.

Application of Artificial Intelligence in Disaster Response

Al Banna, M. H. , Taher, K. A. , Kaiser, M. S. , Mahmud, M. , Rahman, M. S. , Hosen, A. S. M. S. , & Cho, G. H. (2020). Application of artificial intelligence in predicting earthquakes: State-of-the-art and future challenges. IEEE Access, 8, 192880–192923. https://doi.org/10.1109/ACCESS.2020.3029859
Alemohammad, H. , Maskey, M. , Estes, L. , Gentine, P. , Lunga, D. , & Yi, Z.-F. (Nana). (2020). Advancing Application of Machine Learning Tools for NASA ' s Earth Observation Data. https://cdn.earthdata.nasa.gov/conduit/upload/14287/NASA_ML_Workshop_Report.pdf
Anantrasirichai, N. , Biggs, J. , Albino, F. , Hill, P. , & Bull, D. (2018). Application of machine learning to classification of volcanic deformation in routinely generated InSAR data. Journal of Geophysical Research: Solid Earth, 123(8), 6592–6606. https://doi.org/10.1029/2018JB015911
Bernardinetti, S. , & Bruno, P. P. G. (2019). The hydrothermal system of Solfatara Crater (Campi Flegrei, Italy) inferred from machine learning algorithms. Frontiers in Earth Science, 7(November), 1–18. https://doi.org/10.3389/feart.2019.00286
Bruni Zani, N. , Lonati, G. , Mead, M. I. , Latif, M. T. , & Crippa, P. (2020). Long-term satellite-based estimates of air quality and premature mortality in Equatorial Asia through deep neural networks. Environmental Research Letters, 15(10). https://doi.org/10.1088/1748-9326/abb733

Bueno, A. , Benitez, C. , De Angelis, S. , Diaz Moreno, A. , & Ibanez, J. M. (2020). Volcano-Seismic transfer learning and uncertainty quantification with Bayesian neural networks. IEEE Transactions on Geoscience and Remote Sensing, 58(2), 892–902. https://doi.org/10.1109/TGRS.2019.2941494
Bui, D. T. , Tsangaratos, P. , Nguyen, V. T. , Liem, N. Van , & Trinh, P. T. (2020a). Comparing the prediction performance of a Deep Learning Neural Network model with conventional machine learning models in landslide susceptibility assessment. Catena, 188(July), 104426. https://doi.org/10.1016/j.catena.2019.104426
Bui, T. A. , Lee, P. J. , Lum, K. Y. , Loh, C. , & Tan, K. (2020b). Deep Learning for Landslide Recognition in Satellite Architecture. IEEE Access, 8, 143665–143678. https://doi.org/10.1109/ACCESS.2020.3014305
Dao, D. Van , Jaafari, A. , Bayat, M. , Mafi-Gholami, D. , Qi, C. , Moayedi, H. , Phong, T. Van , Ly, H. B. , Le, T. T. , Trinh, P. T. , Luu, C. , Quoc, N. K. , Thanh, B. N. , & Pham, B. T. (2020). A spatially explicit deep learning neural network model for the prediction of landslide susceptibility. Catena, 188(November), 104451. https://doi.org/10.1016/j.catena.2019.104451
DeVries, P. M. R. , Viégas, F. , Wattenberg, M. , & Meade, B. J. (2018). Deep learning of aftershock patterns following large earthquakes. Nature, 560(7720), 632–634. https://doi.org/10.1038/s41586-018-0438-y
Dou, J. , Yunus, A. P. , Merghadi, A. , Shirzadi, A. , Nguyen, H. , Hussain, Y. , Avtar, R. , Chen, Y. , Pham, B. T. , & Yamagishi, H. (2020). Different sampling strategies for predicting landslide susceptibilities are deemed less consequential with deep learning. Science of the Total Environment, 720(February), 137320. https://doi.org/10.1016/j.scitotenv.2020.137320
Fang, Z. , Wang, Y. , Peng, L. , & Hong, H. (2021). A comparative study of heterogeneous ensemble-learning techniques for landslide susceptibility mapping. International Journal of Geographical Information Science, 35(2), 321–347. https://doi.org/10.1080/13658816.2020.1808897
Farasin, A. , Colomba, L. , & Garza, P. (2020). Double-step U-Net: A deep learning-based approach for the estimation ofwildfire damage severity through sentinel-2 satellite data. Applied Sciences (Switzerland), 10(12). https://doi.org/10.3390/app10124332
Furtney, M. A. , Pritchard, M. E. , Biggs, J. , Carn, S. A. , Ebmeier, S. K. , Jay, J. A. , McCormick Kilbride, B. T. , & Reath, K. A. (2018). Synthesizing multi-sensor, multi-satellite, multi-decadal datasets for global volcano monitoring. Journal of Volcanology and Geothermal Research, 365, 38–56. https://doi.org/10.1016/j.jvolgeores.2018.10.002
Géron, A. 2017. Hands-on machine learning with Scikit-Learn and TensorFlow. Concepts, tools, and techniques to built intelligent systems. O'Reilly Media, Inc.
Govil, K. , Welch, M. L. , Ball, J. T. , & Pennypacker, C. R. (2020). Preliminary results from a wildfire detection system using deep learning on remote camera images. Remote Sensing, 12(1). https://doi.org/10.3390/RS12010166
Hosseini, F. S. , Choubin, B. , Mosavi, A. , Nabipour, N. , Shamshirband, S. , Darabi, H. , & Haghighi, A. T. (2020). Flash-flood hazard assessment using ensembles and Bayesian-based machine learning models: Application of the simulated annealing feature selection method. Science of the Total Environment, 711, 135161. https://doi.org/10.1016/j.scitotenv.2019.135161
Hu, R. , Fang, F. , Pain, C. C. , & Navon, I. M. (2019). Rapid spatio-temporal flood prediction and uncertainty quantification using a deep learning method. Journal of Hydrology, 575(March), 911–920. https://doi.org/10.1016/j.jhydrol.2019.05.087
Huang, F. , Zhang, J. , Zhou, C. , Wang, Y. , Huang, J. , & Zhu, L. (2020). A deep learning algorithm using a fully connected sparse autoencoder neural network for landslide susceptibility prediction. Landslides, 17(1), 217–229. https://doi.org/10.1007/s10346-019-01274-9
Hungr, O. , Leroueil, S. , & Picarelli, L. (2014). The Varnes classification of landslide types, an update. Landslides, 11(2), 167–194. https://doi.org/10.1007/s10346-013-0436-y
Izumi, T. , Shaw, R. , Djalante, R. , Ishiwatari, M. , & Komino, T. (2019). Disaster risk reduction and innovations. Progress in Disaster Science, 2, 100033. https://doi.org/10.1016/j.pdisas.2019.100033
Jha, A. K. , Bloch, R. , & Lamond, J. (2012). Cities and flooding: A guide to integrated urban flood risk management for the 21st century by Abhas Jha, Robin Bloch, Jessica Lamond, and other contributors. Journal of Regional Science, 52(5). https://doi.org/10.1111/jors.12006_6
Lara, F. , Lara-Cueva, R. , Larco, J. C. , Carrera, E. V. , & León, R. (2021). A deep learning approach for automatic recognition of seismo-volcanic events at the Cotopaxi volcano. Journal of Volcanology and Geothermal Research, 409. https://doi.org/10.1016/j.jvolgeores.2020.107142
Li, L. , Girguis, M. , Lurmann, F. , Pavlovic, N. , McClure, C. , Franklin, M. , Wu, J. , Oman, L. D. , Breton, C. , Gilliland, F. , & Habre, R. (2020). Ensemble-based deep learning for estimating PM2.5 over California with multisource big data including wildfire smoke. Environment International, 145, 106143. https://doi.org/10.1016/j.envint.2020.106143
Ma, J. , Cheng, J. C. P. , Jiang, F. , Gan, V. J. L. , Wang, M. , & Zhai, C. (2020a). Real-time detection of wildfire risk caused by powerline vegetation faults using advanced machine learning techniques. Advanced Engineering Informatics, 44(March), 101070. https://doi.org/10.1016/j.aei.2020.101070
Ma, Z. , Mei, G. , & Piccialli, F. (2020b). Machine learning for landslides prevention: A survey. Neural Computing and Applications, 8. https://doi.org/10.1007/s00521-020-05529-8
Meng, Q. , Wang, H. , He, M. , Gu, J. , Qi, J. , & Yang, L. (2020). Displacement prediction of water-induced landslides using a recurrent deep learning model. European Journal of Environmental and Civil Engineering,

0(0), 1–15. https://doi.org/10.1080/19648189.2020.1763847
Mignan, A. , & Broccardo, M. (2019a). Neural network applications in earthquake prediction (1994–2019): Meta-analytic insight on their limitations. ArXiv, 91(4). https://doi.org/10.1785/0220200021. Introduction
Mignan, A. , & Broccardo, M. (2019b). One neuron versus deep learning in aftershock prediction. Nature, 574(7776), E1–E3. https://doi.org/10.1038/s41586-019-1582-8
Mosavi, A. , Ozturk, P. , & Chau, K. W. (2018). Flood prediction using machine learning models: Literature review. Water (Switzerland), 10(11), 1–40. https://doi.org/10.3390/w10111536
Nhu, V. H. , Hoang, N. D. , Nguyen, H. , Ngo, P. T. T. , Thanh Bui, T. , Hoa, P. V. , Samui, P. , & Tien Bui, D. (2020). Effectiveness assessment of Keras based deep learning with different robust optimization algorithms for shallow landslide susceptibility mapping at tropical area. Catena, 188(November), 104458. https://doi.org/10.1016/j.catena.2020.104458
Ofli, F. , Meier, P. , Imran, M. , Castillo, C. , Tuia, D. , Rey, N. , Briant, J. , Millet, P. , Reinhard, F. , Parkan, M. , & Joost, S. (2016). Combining human computing and machine learning to make sense of big (Aerial) data for disaster response. Big Data, 4(1), 47–59. https://doi.org/10.1089/big.2014.0064
Orland, E. , Roering, J. J. , Thomas, M. A. , & Mirus, B. B. (2020). Deep learning as a tool to forecast hydrologic response for landslide-prone hillslopes. Geophysical Research Letters, 47(16). https://doi.org/10.1029/2020GL088731
Perol, T. , Gharbi, M. , & Denolle, M. A. (2017). Convolutional neural network for earthquake detection and location. ArXiv, 2016(March), 2–10.
Prakash, N. , Manconi, A. , & Loew, S. (2020). Mapping landslides on EO data: Performance of deep learning models vs. traditional machine learning models. Remote Sensing, 12(3). https://doi.org/10.3390/rs12030346
Pundir, A. S. , & Raman, B. (2019). Dual deep learning model for image based smoke detection. Fire Technology, 55(6), 2419–2442. https://doi.org/10.1007/s10694-019-00872-2
Reid, C. E. , Jerrett, M. , Petersen, M. L. , Pfister, G. G. , Morefield, P. E. , Tager, I. B. , Raffuse, S. M. , & Balmes, J. R. (2015). Spatiotemporal prediction of fine particulate matter during the 2008 Northern California wildfires using machine learning. Environmental Science and Technology, 49(6), 3887–3896. https://doi.org/10.1021/es505846r
Saravi, S. , Kalawsky, R. , Joannou, D. , Casado, M. R. , Fu, G. , & Meng, F. (2019). Use of artificial intelligence to improve resilience and preparedness against adverse flood events. Water (Switzerland), 11(5). https://doi.org/10.3390/w11050973
Seydoux, L. , Balestriero, R. , Poli, P. , Hoop, M. de , Campillo, M. , & Baraniuk, R. (2020). Clustering earthquake signals and background noises in continuous seismic data with unsupervised deep learning. Nature Communications, 11(1). https://doi.org/10.1038/s41467-020-17841-x
Stephens, W. , Wilt, G. E. , Lehnert, E. A. , Molinari, N. M. , & LeBlanc, T. T. (2020). A spatial and temporal investigation of medical surge in Dallas-Fort Wort during Hurricane Harvey. Disaster Medicine and Public Health Preparedness, 14(1), 111–118. https://doi.org/10.1017/dmp.2019.143.A
Sun, J. , Wauthier, C. , Stephens, K. , Gervais, M. , Cervone, G. , La Femina, P. , & Higgins, M. (2020a). Automatic detection of volcanic surface deformation using deep learning. Journal of Geophysical Research: Solid Earth, 125(9), 1–17. https://doi.org/10.1029/2020JB019840
Sun, W. , Bocchini, P. , & Davison, B. D. (2020b). Applications of artificial intelligence for disaster management. In Natural Hazards (Vol. 103, No. 3). Netherlands: Springer. https://doi.org/10.1007/s11069-020-04124-3
Tay, C. W. J. , Yun, S. H. , Chin, S. T. , Bhardwaj, A. , Jung, J. , & Hill, E. M. (2020). Rapid flood and damage mapping using synthetic aperture radar in response to Typhoon Hagibis, Japan. Scientific Data, 7(1), 1–9. https://doi.org/10.1038/s41597-020-0443-5
Titos, M. , Bueno, A. , García, L. , Benítez, C. , & Segura, J. C. (2020). Classification of isolated volcano-seismic events based on inductive transfer learning. IEEE Geoscience and Remote Sensing Letters, 17(5), 869–873. https://doi.org/10.1109/LGRS.2019.2931063
Wang, H. , Zhang, L. , Yin, K. , Luo, H. , & Li, J. (2021). Landslide identification using machine learning. Geoscience Frontiers, 12(1), 351–364. https://doi.org/10.1016/j.gsf.2020.02.012
Wang, R. Q. , Mao, H. , Wang, Y. , Rae, C. , & Shaw, W. (2018). Hyper-resolution monitoring of urban flooding with social media and crowdsourcing data. Computers and Geosciences, 111(September), 139–147. https://doi.org/10.1016/j.cageo.2017.11.008
Wang, W. , He, Z. , Han, Z. , Li, Y. , Dou, J. , & Huang, J. (2020). Mapping the susceptibility to landslides based on the deep belief network: A case study in Sichuan Province, China. Natural Hazards, 103(3), 3239–3261. https://doi.org/10.1007/s11069-020-04128-z
Wilkinson, M. D. , Dumontier, M. , Aalbersberg, I. J. , Appleton, G. , Axton, M. , Baak, A. , Blomberg, N. , Boiten, J. W. , da Silva Santos, L. B. , Bourne, P. E. , Bouwman, J. , Brookes, A. J. , Clark, T. , Crosas, M. , Dillo, I. , Dumon, O. , Edmunds, S. , Evelo, C. T. , Finkers, R. , … Mons, B. (2016). Comment: The FAIR guiding principles for scientific data management and stewardship. Scientific Data, 3, 1–9. https://doi.org/10.1038/sdata.2016.18
Ye, C. , Li, Y. , Cui, P. , Liang, L. , Pirasteh, S. , Marcato, J. , Goncalves, W. N. , & Li, J. (2019). Landslide detection of hyperspectral remote sensing data based on deep learning with constrains. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 12(12), 5047–5060. https://doi.org/10.1109/JSTARS.2019.2951725

Yu, M. , Yang, C. , & Li, Y. (2018). Big data in natural disaster management: A review. Geosciences (Switzerland), 8(5). https://doi.org/10.3390/geosciences8050165

Use of Robotics in Surgery: Current Trends, Challenges, and the Future

Overview of Robotic Surgery . Available at: https://www.narayanahealth.org/robotic-surgery/#:~:text=Robotic%20surgeries%20provide%20faster%20recovery,fewer%20complications%20due%20to%20surgery. [accessed on May 30 2020].
Overview of Robotic Surgery . Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1681689/ [accessed on April 20 2020].
Overview of Robotic Surgery . Available at: https://bmcbiomedeng.biomedcentral.com/articles/10.1186/s42490-019-0012-1 [accessed on April 20 2020].
Overview of Robotic Surgery . Available at: https://pubmed.ncbi.nlm.nih.gov/12731212/ [accessed on April 20 2020].
Kim HB , Lee JH , Park Do J , Lee HJ , Kim HH , Yang HK . Robot-assisted distal gastrectomy for gastric cancer in a situs inversus totalis patient. J Korean Surg Soc. 2012;82:321–324.
Matsuhira N , et al. Development of a functional model for amaster-slave combined manipulator for laparoscopic surgery. Adv Robot. 2003;17(6):523–539.
Focacci F , et al. Lightweight hand-held robot for laparoscopic surgery. In: Proceedings – IEEE International Conference on Robotics and Automation; 2007. pp. 599–604.
Bensignor T , et al. Evaluation of the effect of a laparoscopic robotized needle holder on ergonomics and skills. Surg Endosc. 2015;30(2):446–454.
Zahraee AH , et al. Toward the development of a hand-held surgical robot for laparoscopy. IEEE/ASME Trans Mechatron. 2010;15(6):853–861.
Gomez G . Sabiston Textbook of Surgery. 17th ed. Philadelphia, PA: Elsevier Saunders; 2004. Emerging Technology in surgery: informatics, electronics, robotics.
Hazey JW , Melvin WS . Robot-assisted general surgery. Semin Laparosc Surg. 2004;11:107–112.
Himpens J , Leman G , Cadiere GB . Telesurgical laparoscopic cholecystectomy [letter]. Surg Endosc. 1998;12:1091.
Hanly EJ , Talamini MA . Robotic abdominal surgery. Am J Surg. 2004;188:19S–26S.
Hubens G , Ruppert M , Balliu L , Vaneerdeweg W . What have we learnt after two years working with the da Vinci robot system in digestive surgery? Acta Chir Belg. 2004;104:609–614.
Brunaud L , Bresler L , Ayav A , et al. Advantages of using robotic Da Vinci system unilateral adrenalectomy: early results. Ann Chir. 2003;128:530–535.
El-Hakim A , Tweari A . Robotic prostatectomy – a review. MedGenMed. 2004;6:20.
Spaliviero M , Gill IS . Robot-assisted urologic procedures. Semin Laparosc Surg. 2004;11:81–88.
Phillips CK , Taneja SS , Stifelman MD . Robot-assisted laparoscopic partial nephrectomy: the NYU technique. J Endourol. 2005;19:441–445.
Guillonneau B , Cappele O , Martinez JB , Navarra S , Vallancien G . Robotic assisted, laparoscopic pelvic lymph node dissection in humans. J Urol. 2001;165:1078–1081.
Advincula AP , Falcone T . Laparoscopic robotic gynecologic surgery. Obstet Gynecol Clin North Am. 2004;31:599–609.
Falcone T , Goldberg J , Garcia-Ruiz A , Margossian H , Stevens L . Full robotic assistance for laparoscopic tubal anastomosis: a case report. J Laparoendosc Adv Surg Tech A. 1999;9:107–113.
Margossian H , Falcone T . Robotically assisted laparoscopic hysterectomy and adnexal surgery. J Laparoendosc Adv Surg Tech A. 2001;11:161–165.
Marchal F , Rauch P , Vandromme J , et al. Telerobotic-assisted laparoscopic hysterectomy for benign and oncologic pathologies: initial clinical experience with 30 patients. Surg Endosc. 2005;19:826–831.
Nifong LW , Chitwood WR , Pappas PS , et al. Robotic mitral valve surgery: a United States multicenter trial. J Thorac Cardiovasc Surg. 2005;129:1395–1404.
Chitwood WR, Jr Current status of endoscopic and robotic mitral valve surgery. Ann Thorac Surg. 2005;79:S2248–S2253.
Argenziano M , Oz MC , Kohmoto T , et al. Totally endoscopic atrial septal defect repair with robotic assistance. Circulation. 2003;108(suppl1):II191–II194.
Wimmer-Greinecker G , Deschka H , Aybek T , Mierdl S , Moritz A , Dogan S . Current status of robotically assisted coronary revascularization. Am J Surg. 2004;188:76S–82S.
Morgan JA , Ginsburg ME , Sonett JR , Argenziano M . Thoracoscopic lobectomy using robotic technology. Heart Surg Forum. 2003;6:E167–E169.
Melfi FM , Menconi GF , Mariani AM , Angeletti CA . Early experience with robotic technology for thoracoscopic surgery. Eur J Cardiothorac Surg. 2002;21:864–868.

Ballantyne GH . Robotic surgery, telerobotic surgery, telepresence, and telementoring. Review of early clinical results. Surg Endosc. 2002;16:1389–1402
Bentas W , Wolfram M , Brautigam R , et al. Da Vinci robot assisted Anderson-Hynes dismembered pyeloplasty: technique and 1 year follow-up. World J Urol. 2003;21:133–138.
Lorincz A , Langenburg S , Klein MD . Robotics and the pediatric surgeon. Curr Opin Pediatr. 2003;15:262–266.
Suematsu Y , Del Nido PJ . Robotic pediatric cardiac surgery: present and future perspectives. Am J Surg. 2004;188(suppl):98S–103S.
Cannon JW , Howe RD , Dupont PE , Triedman JK , Marx GR , del Nido PJ . Application of robotics in congenital cardiac surgery. Semin Thorac Cardiovasc Surg Pediatr Card Surg Annu. 2003;6:72–83.
Sharma L (Ed.). (2021). Towards Smart World. New York: Chapman and Hall/CRC, https://doi.org/10.1201/9781003056751
Sharma L , Garg P (Eds.). (2020). From Visual Surveillance to Internet of Things. New York: Chapman and Hall/CRC, https://doi.org/10.1201/9780429297922
Sharma L , Garg PK . "Smart E-healthcare with Internet of Things: Current Trends Challenges, Solutions and Technologies", From Visual Surveillance to Internet of Things, Taylor & Francis Group, CRC Press, Vol. 1, pp. 215.
Sharma L , Garg PK , Agarwal N . "A foresight on e-healthcar Trailblazers", From Visual Surveillance to Internet of Things, Taylor & Francis Group, CRC Press, Vol. 1, pp. 235.
Sharma L , Garg PK . "IoT and its applications", From Visual Surveillance to Internet of Things, Taylor & Francis Group, CRC Press, Vol. 1, pp. 29.
Sharma L , Singh S, Yadav DK . "Fisher's linear discriminant ratio based threshold for moving human detection in thermal video", Infrared Physics and Technology, Elsevier, March 2016.

Brain-Computer Interface: State-of-Art, Challenges, and the Future

Jokanović V , (2020), A man of the fifth dimension, Prometej, Novi Sad, (accepted).
Krucoff MO , Rahimpour S , Slutzky MW , Edgerton VR , Turner DA , (2016), Enhancing nervous system recovery through neurobiologics, neural interface training, and neurorehabilitation. Front Neurosci. 10: 584. doi:10.3389/fnins.2016.00584
Peterka DS , Takahashi H , Yuste R . (2011), Imaging voltage in neurons. Neuron. 69 (1): 9–21.
Mazzatenta A , Giugliano M , Campidelli S , et al. (2007), Interfacing neurons with carbon nanotubes: electrical signal transfer and synaptic stimulation in cultured brain circuits. J Neurosci. 27, (26): 6931–6936.
Shih JJ , Krusienski DJ , Wolpaw JR , (2012), Brain-computer interfaces in medicine. Mayo Clin Proc. 87, (3): 268–279.
Pisarchik AN , Maksimenko VA , Hramov AE , (2019), From novel technology to novel applications: Comment on "An Integrated Brain-Machine Interface Platform With Thousands of Channels" by Elon Musk and Neuralink. J Med Internet Res. 21, (10): e16356, doi:10.2196/16356
Nicolas-Alonso LF , Gomez-Gil J , (2012), Brain computer interfaces, a review, Sensors (Basel). 12, (2): 1211–1279.
Mak JN , Wolpaw JR . (2009) Clinical applications of brain-computer interfaces: Current state and future prospects. IEEE Rev Biomed Eng. 2: 187–199.
Tariq M , Trivailo PM , Simić M , (2018), EEG-Based BCI control schemes for lower-limb assistive-robots. Front Hum Neurosci. 12: 312, doi:10.3389/fnhum.2018.00312
Lazarou I , Nikolopoulos S , Petrantonakis PC , Kompatsiaris I , Tsolaki M , (2018), EEG-based brain-computer interfaces for communication and rehabilitation of people with motor impairment: A novel approach of the 21st century. Front Hum Neurosci. 12: 14. doi:10.3389/fnhum.2018.00014
Yuan H , Liu T , Szarkowski R , Rios C , Ashe J , He B , (2009), Negative covariation between task-related responses in alpha/beta-band activity and BOLD in human sensorimotor cortex: an EEG and fMRI study of motor imagery and movements. Neuroimage, 49 (3): 2596–2606.
Baxter BS , Edelman BJ , Sohrabpour A , He B , (2017), Anodal transcranial direct current stimulation increases bilateral directed brain connectivity during motor-imagery based brain-computer interface control. Front Neurosci. https://doi.org/10.3389/fnins.2017.00691
Wolpaw JR , McFarland DJ , Vaughan TM , Schalk G , (2003), The Wadsworth Center Brain–Computer Interface (BCI) research and development program, IEEE Trans Neural Syst Rehab Eng, 11, (2): 204–207.
Wolpaw JR , McFarland DJ , (2004), Control of a two-dimensional movement signal by a noninvasive brain–computer interface in humans. PNAS. 101, (51): 17849–17854.
Yuan H , He B . (2014), Brain-computer interfaces using sensorimotor rhythms: current state and future perspectives. IEEE Trans Biomed Eng. 61, (5): 1425–1435.
Woodman GF , (2010), A brief introduction to the use of event-related potentials in studies of perception and attention. Atten Percept Psychophys. 72, (8): 2031–2046.

Sur S , Sinha VK , (2009), Event-related potential: An overview. Ind Psychiatry J. 18 (1): 70–73.
Rezeika A , Benda M , Stawicki P , Gembler F , Saboor A , Volosyak I , (2018), Brain-computer interface spellers: A review. Brain Sci. 8, (4): 57. doi:10.3390/brainsci8040057
Nicolas-Alonso LF , Gomez-Gil J , (2012), Brain computer interfaces, a review. Sensors 12, (2), 1211–1279.
Luu TP , He Y , Brown S , Sho N , Contreras-Vidal JL , (2015), A closed-loop brain computer interface to a virtual reality avatar: Gait adaptation to visual kinematic perturbations. Int Conf Virtual Rehabil. 2015: 30–37.
McFarland DJ , Daly J , Boulay C , Parvaz M , (2017), Therapeutic applications of BCI technologies. Brain Comput Interfaces (Abingdon). 47, (1–2): 37–52.
Al-Taleb MKH , Purcell M , Fraser M , Petric-Gray N , Vuckovic A , (2019), Home used, patient self-managed, brain-computer interface for the management of central neuropathic pain post spinal cord injury: usability study. J Neuroeng Rehabil. 16, (1): 128. doi:10.1186/s12984-019-0588-7
Rashid M , Sulaiman N , Abdul Majeed A , et al. (2020), Current status, challenges, and possible solutions of EEG-based brain-computer interface: A comprehensive review. Front Neurorobot. 14: 25. doi:10.3389/fnbot.2020.00025.
Hoffmann U , Vesin J-M , Touradj E , Diserens K , (2008), An efficient P300-based brain–computer interface for disabled subjects. J Neurosci Methods 167: 115–125.
Schalk G , McFarland D , Hinterberger T , Birbaumer NR , Wolpaw J , (2004), BCI2000: a general-purpose Brain-Computer Interface (BCI) system, IEEE Trans Biomed Eng. 51, (6): 1034–1043.
Milsap G , Collard M , Coogan C , Crone NE , (2019), BCI2000Web and WebFM: Browser-Based Tools for Brain Computer Interfaces and Functional Brain Mapping. Front Neurosci. https://doi.org/10.3389/fnins.2018.01030
Jonathan R , Wolpaw J , Birbaumerc N , McFarland DJ , Pfurtschellere G , Vaughan TM , (2002), Brain–computer interfaces for communication and control. Clin Neurophysiol. 113: 767–791.
Padfield N , Zabalza J , Zhao H , Masero V , Ren J , (2019), EEG-based brain-computer interfaces using motor-imagery: Techniques and challenges. Sensors (Basel). 19, (6): 1423. doi:10.3390/s19061423
Schalk G , Leuthardt EC , (2011), Brain-computer interfaces using electrocorticographic signals. IEEE Rev Biomed Eng. 4: 140–154.
Al-Ezzi A , Kamel N , Ibrahima F , Gunaseli E , (2020), Review of EEG, ERP, and Brain Connectivity Estimators as Predictive Biomarkers of Social Anxiety Disorder. Front Psychol. 11: 730. doi:10.3389/fpsyg.2020.00730
Ramos-Murguialday A , Birbaumer N , (2015), Brain oscillatory signatures of motor tasks. J Neurophysiol. 113, (10): 3663–3682.
Nanopouls DV , (1995), Theory of Brain Function, Quantum Mechanics and Superstrings, Act-08/95 Cern-Th/95-128 Ctp-Tamu-22/95 hep-ph/9505374.
Bakas I , Kiritsis E , (1992), Beyond the Large N Limit: Non-linear W(infinity) as symmetry of the SL(2,R)/U(1) coset model. Int J Mod Phys. A7, (Suppl. 1A): 55.
Zamolodchikov AB , (1986), Ireversibility of flux of the renormalization group in 2D field theory. JETP Lett. 43, (1986), 730; *Sov. J Nucl Phys.* 46 (1987), 1090.
Clements EM , Das R , Li L , et al. (2017), Critical behavior and macroscopic phase diagram of the monoaxial chiral helimagnet Cr1/3NbS2 . Sci Rep. 7, (1): 6545. doi:10.1038/s41598-017-06728-5
Ellis J , Mohanty S , Nanopoulos DV , (1989), Quantum gravity and collapse of the wave function. Phys Lett B. 221, (2): 113–119.
Feynman RP , Vernon FL Jr. (2000), The theory of a general quantum system interacting with linear dissipative. Ann Phys (NY). 281, (2): 547–607.
Goodstein D , Goodstein J , (2000), Richard Feynman and the history of superconductivity. Phys Perspect. 2: 30–47.
Hawking S , (1976), Breakdown of predictability in gravitational collapse. Phys Rev. D14: 2460–2473.
Louis J , Mohaupt T , Theisen S , (2007), String theory: An overview. Lect Notes Phys. 721: 289–323.
Kelso JA , (2012), Multistability and metastability: Understanding dynamic coordination in the brain. Philos Trans R Soc Lond B Biol Sci. 367, (1591): 906–918.
Ito D , Tamate H , Nagayama M , Uchida T , Kudoh SN , Gohara K , (2010), Minimum neuron density for synchronized bursts in a rat cortical culture on multi-electrode arrays. Neuroscience. 171, (1): 50–61.
Korn H , Faure P , (2003), Is there chaos in the brain? II. Experimental evidence and related models. Comptes Rendus Biologies. 326, (9): 787–840.
Jokanović V , (2013), How our cells lives and died, Institute of Nuclear Sciences “Vincˇa”, Belgrade.
Lotte F , Bougrain L , Clerc M , (2015), Electroencephalography (EEG)-based Brain Computer Interfaces. Wiley Encyclopedia of Electrical and Electronics Engineering, Wiley, pp. 44, ff10.1002/047134608X.W8278ff. ffhal-01167515f
Borikar SS , Kochre SR , Zade YD , (2014), Brain Computer Interface, National Conference on Engineering Trends in Medical Science – NCETMS – 2014.
Byrne R , (1996), Relating brain size to intelligence in primates, in P. Mellars and K. Gibson Eds., Modelling the Early Human Mind, McDonald Institute Monographs, Cambridge, pp. 49–56.
Al-Quraishi MS , Elamvazuthi I , Daud SA , Parasuraman S , Borboni A , (2018), EEG-based control for upper and lower limb exoskeletons and prostheses: A systematic review. Sensors (Basel). 18, (10): 3342.

doi:10.3390/s18103342
Ackerman S , (1992), Discovering the Brain, The Institute of Medicine, National Academy of Sciences, Washington, DC.
Buzsáki G , (2006), Rhythms of the Brain, Oxford University Press.
Tierney AL , Nelson CA , (2009), Brain development and the role of experience in the early years. Zero Three. 30, (2): 9–13.
Skarda CA , Freeman WJ , (1987), How brains make chaos in order to make sense of the world. Behav Brain Sci. 10: 161–195.
Kriegeskorte N , Douglas PK , (2018), Cognitive computational neuroscience. Nat Neurosci. 21, (9): 1148–1160.
Gros C , (2012), Complex Adaptive Dynamical Systems, a Primer, Institute for Theoretical Physics Goethe University Frankfurt.
Schweizer S , Satpute AB , Atzil S , et al. (2019), The impact of affective information on working memory: A pair of meta-analytic reviews of behavioral and neuroimaging evidence. Psychol Bull. 145, (6): 566–609.
Signorelli CM , (2018), Can computers become conscious and overcome humans? Front Robot AI 5: 121. doi:10.3389/frobt.2018.00121
Zaytseva Y , Fajnerová I , Dvorˇácˇek B , et al. (2018), Theoretical modeling of cognitive dysfunction in schizophrenia by means of errors and corresponding brain networks. Front Psychol. 9: 1027. doi:10.3389/fpsyg.2018.01027
Markram H , Gerstner W , Sjöström PJ , (2011), A history of spike-timing-dependent plasticity. Front Synaptic Neurosci. 3: 4. doi:10.3389/fnsyn.2011.00004
David JC , (2003), Building Better Health: A Handbook for Behavioral Change, PAHO, Washington, DC.
Wolfe JM , (1998), Visual memory: What do you know about what you saw? Curr Biol. 8, (9): 303–304.
Lovinger DM , (2008), Communication networks in the brain: Neurons, receptors, neurotransmitters, and alcohol. Alcohol Res Health. 31, (3): 196–214.
Sejnowski TJ , (2018), The Deep Learning Revolution: Artificial Intelligence Meets Human Intelligence, MIT Press, Cambridge, MA.
Kuhl PK , (2010), Brain mechanisms in early language acquisition. Neuron. 67, (5): 713–727.
Mayford M , Siegelbaum SA , Kandel ER , (2012), Synapses and memory storage. Cold Spring Harb Perspect Biol. 4, (6): a005751. doi:10.1101/cshperspect.a005751
Kennedy P , (2014), Brain-machine interfaces as a challenge to the “moment of singularity”. Front Syst Neurosci. 8: 213. doi:10.3389/fnsys.2014.00213
Haushalter JL , (2018), Neuronal testimonial: Brain-computer interfaces and the law. V and L Rev. 71, (4): 1365–1400.
Crick FHC , (1979), Thinking about the brain. Sci Am. 241, (3): 219–233.
Koziol LF , Budding D , Andreasen N , et al. (2014), Consensus paper: The cerebellum’s role in movement and cognition. Cerebellum. 13, (1): 151–177.
De Sousa A , (2013), Towards an integrative theory of consciousness: part 2 (an anthology of various other models). Mens Sana Monogr. 11, (1): 151–209.
Duncan R , (2006), *Types for Quantum Computing*, Merton College, Oxford, PhD Thesis.
Schmidt J , Marques MRG , Botti S , Marques MAL , (2019), Recent advances and applications of machine learning in solidstate materials science. NPJ Comput Mater. 5, 83–118
Schirrmeister RT , Springenberg JT , Fiederer LDJ , et al. (2017), Deep learning with convolutional neural networks for EEG decoding and visualization. Hum Brain Mapp. 38, (11): 5391–5420.
Roy Y , Banville H , Albuquerque I , Gramfort A , Falk TH , Faubert J , (2019), Deep learning-based electroencephalography analysis: A systematic review, J Neural Eng. 16, (5), 051001–051037.
Montavon G , Samek W , Müller K-R , (2018), Methods for interpreting and understanding deep neural networks. Digit Signal Process. 73: 1–15.
Lewis MD , (2005), Bridging emotion theory and neurobiology through dynamic systems modeling. Behav Brain Sci. 28: 169–245.
Eichbaum QG , (2014), Thinking about thinking and emotion: The metacognitive approach to the medical humanities that integrates the humanities with the basic and clinical sciences. Perm J. 18, (4): 64–75.
Plotnitsky A , (2007), Prediction, repetition, and erasure in quantum physics: Experiment, theory, epistemology. J Mod Opt. 54, (16–17): 37th Winter Colloquium on the Physics of Quantum Electronics.
Erbas-Cakmak S , Leigh DA , McTernan CT , Nussbaumer AL , (2015), Artificial Molecular Machines. Chem Rev. 115, (18): 10081–10206.
Hänggi P , Marcheson F , (2009), Artificial Brownian motors: Controlling transport on the nanoscale. Rev Mod Phys. 81: 387–442.
Baroncini M , Casimiro L , de Vet C , Groppi J , Silvi S , Credi A , (2018), Making and operating molecular machines: A multidisciplinary challenge. Chem Open. 7: 169–179.
Ramezani H , Dietz H , (2020), Building machines with DNA molecules. Nat Rev Genet. 21, (1): 5–26.
Roberts AJ , Kon T , Knight PJ , Sutoh K , Burgess SA , (2013), Functions and mechanics of dynein motor proteins. Nat Rev Mol Cell Biol. 14, (11): 713–726.

Ross JL , Shuman H , Holzbaur ELF , Goldman YE , (2008), Kinesin and dynein-dynactin at intersecting microtubules: Motor density affects dynein function. Biophys J. 94, (8): 3115–3125.

Klarner FG , Kahlert B , (2003), Molecular tweezers and clips as synthetic receptors. Molecular recognition and dynamics in receptor-substrate complexes. Acc Chem Res. 36: 919–932.

Sumerin V , Schulz F , Atsumi M , Wang C , Nieger M , Leskelä M , Repo T , Pyykkö P , Rieger B , (2008), Molecular tweezers for hydrogen: Synthesis, characterization, and reactivity. Am Chem Soc. 130, (43): 14117–14119.86.

Jokanović V , (2012), Nanomedicine, the Greatest Challenge of 21st Century, Monograph, Data Status, Belgrade, Serbia.

Saadeh Y , Vyas D , (2014), Nanorobotic applications in medicine: Current proposals and designs. Am J Robot Surg. 1, (1): 4–11.

Zia K , Siddiqui T , Ali S , Farooq I , Zafar MS , Khurshid Z , (2019), Nuclear magnetic resonance spectroscopy for medical and dental applications: A comprehensive review. Eur J Dent. 13, (1): 124–128.

Saxena S , Pramod BJ , Dayananda BC , Nagaraju K , (2015), Design, architecture and application of nanorobotics in oncology. Indian J Cancer. 52: 236–241.

Patra JK , Das G , Fraceto LF , et al. (2018), Nano based drug delivery systems: recent developments and future prospects. J Nanobiotechnol. 16, (1): 71–104.

Li J , Esteban-Fernández de Ávila B , Gao W , Zhang L , Wang J , (2017), Micro/nanorobots for biomedicine: Delivery, surgery, sensing, and detoxification. Sci Robot. 2(4): eaam6431. doi:10.1126/scirobotics.aam6431

Martel S , Mohammadi M , Felfoul O , Lu Z , Pouponneau P , (2009), Flagellated magnetotactic bacteria as controlled MRI-trackable propulsion and steering systems for medical nanorobots operating in the human microvasculature. Int J Rob Res. 28, (4): 571–582.

Martins NRB , Angelica A , Chakravarthy K , Svidinenko Y , Boehm FJ , Opris I , Lebedev MA , Swan M , Garan SA , Rosenfeld JV , Tad H , Freitas RA Jr. , (2019), Human brain/cloud interface. Front Neurosci, 112–124.

Freitas RA Jr. , (2010), Comprehensive nanorobotic control of human morbidity and aging, in G.M. Fahy et al. Eds., The Future of Aging, 685 C, Springer Science Business Media B.V. doi: 10.1007/978-90-481-3999-6_23

Alberts B , Johnson A , Lewis J , et al. (2002), Molecular Biology of the Cell, 4th edition, Garland Science; Protein Function, New York. https://www.ncbi.nlm.nih.gov/books/NBK26911/

Tang SKY , Marshall WF , (2017), Self-repairing cells: How single cells heal membrane ruptures and restore lost structures. Science. 356, (6342): 1022–1025.

Silva GA , (2018), A New Frontier: The Convergence of Nanotechnology, Brain Machine Interfaces, and Artificial Intelligence. Front Neurosci. 12: 843. doi:10.3389/fnins.2018.00843

Pancrazio JJ , (2008), Neural interfaces at the nanoscale. Nanomedicine (Lond). 3, (6): 823–830.

Liu G , Zhao P , Qin Y , Zhao M , Yang Z , Chen H , (2020), Electromagnetic Immunity Performance of Intelligent Electronic Equipment in Smart Substation's Electromagnetic Environment. Energies. 13, (5): 1130–1149.

Lenarz T , (2018), Cochlear implant – state of the art. GMS Curr Top Otorhinolaryngol Head Neck Surg. 16: Doc 04. doi:10.3205/cto000143

Prochazka A , (2017), Neurophysiology and neural engineering: a review. J Neurophysiol. 118, (2): 1292–1309.

Benioff P , (1999), Quantum robots and quantum computers, in A.J.G. Hey , Ed. Feynman and Computation, Perseus Books, 155–176.

Bechtel W , (2008), Mental Mechanisms: Philosophical Perspectives on Cognitive Neuroscience, Erlbaum, New York.

Chiara DML , Giuntini R , Leporini R , Toraldo di Francia G , (2008), Quantum Computational Logics and Possible Applications. Int J Theoret Phys. 47: 44–60.

Lieberoth A , Pedersen MK , Marin AC , Planke T , Sherson JF , (2014), Getting Humans to do Quantum Optimization – User Acquisition, Engagement and Early Results from the Citizen Cyberscience Game Quantum Moves. Human Comput. 1, (2): 221–246.

Cavalcanti A , (2003), Assembly Automation with Evolutionary Nanorobots and Sensor-Based Control Applied to Nanomedicine. IEEE Trans Nanotech. 2, (2): 82–87.

Betthauser JL , Thakor NV , (2019), Neural Prostheses, in J. Webster Ed. Wiley Encyclopedia of Electrical and Electronics Engineering, John Wiley & Sons. doi:10.1002/047134608X.W1424.pub2

Yarovyy A , (2010), Applied Realization of Neural Network and Neurolike Parallel-Hierarchical System Based on GPGPU, 10th International Conference on Development and Application Systems, Suceava, Romania.

Wolpaw JR , (Guest Editor), Birbaumer N , Heetderks WJ , McFarland DJ , Peckham PH , Schalk G , Donchin E , Quatrano LA , Robinson CJ , Vaughan TM , (2000), Brain–Computer Interface Technology: A Review of the First International Meeting, IEEE Trans Rehabil Eng. 8, (2): 164–173.

Jokanović V , (2020), Smart healthcare in smart cities, in L. Sharma Ed. Towards Smart World: Homes to Cities using Internet of Things, 1st edition, Chapter 4, Taylor & Francis Group.

Artificial Intelligence: Challenges and Future Applications

Adixon, Robert (2019), Artificial Intelligence Opportunities & Challenges in Businesses, July 24 , https://towardsdatascience.com/artificial-intelligence-opportunities-challenges-in-businesses-ede2e96ae935

Anderson, Janna , Rainie, Lee and Luchsinger, Alex (2018), Artificial Intelligence and the Future of Humans, December 10, https://www.pewresearch.org/internet/2018/12/10/artificial-intelligence-and-the-future-of-humans/

Armstrong, Martin (2016), The Future of AI, https://www.statista.com/chart/6810/the-future-of-ai/)

ATOS (2020), Artificial intelligence, For your business, right now, https://atos.net/en/artificial-intelligence

Brighterion Inc . (2019), Artificial intelligence and machine learning: The next generation, Brighterion Mastercard, https://brighterion.com/wp-content/uploads/2019/05/Artificial-Intelligence-And-Machine-Learning-The-Next-Generation.pdf

Brown, Tony (2019), The AI Skills Shortage, IT Chronicles, https://itchronicles.com/artificial-intelligence/the-ai-skills-shortage/

Budman, Matthew , Hurley, Blythe , Bhat, Rupesh and Gangopadhyay, Nairita (2019), Future in the balance? How countries are pursuing an AI advantage, Deloitte Insights, https://www2.deloitte.com/us/en/insights/focus/cognitive-technologies/ai-investment-by-country.html

Chan, Tim (2017), How AI boosts industry profits and innovation, https://www.accenture.com/sg-en/company-news-release-businesses-singapore-benefit-ai

Davenport, Tom (2020), Return On Artificial Intelligence: The Challenge and the Opportunity, March 27 , https://www.forbes.com/sites/tomdavenport/2020/03/27/return-on-artificial-intelligence-the-challenge-and-the-opportunity/#bb9ec036f7c2

Gartner (2019), https://www.gartner.com/en/newsroom/press-releases/2019-01-21-gartner-survey-shows-37-percent-of-organizations-have

Grand View Research, Inc . (2020a), Artificial Intelligence Market Size Worth $390.9 Billion by 2025: February 5, https://www.prnewswire.com/news-releases/artificial-intelligence-market-size-worth-390-9-billion-by-2025-grand-view-research-inc-300999236.html

Grand View Research, Inc . (2020b), Market Analysis Report: July 20, https://www.grandviewresearch.com/industry-analysis/artificial-intelligence-ai-market?utm_source=prnewswire&utm_medium=referral&utm_campaign=ict_5-feb-20&utm_term=artificial-intelligence-ai-market&utm_content=rd1

Harkut, Dinesh G. , Kasat, Kashmira and Harkut, Vaishnavi D . (2019), Introductory Chapter: Artificial Intelligence - Challenges and Applications, https://www.intechopen.com/predownload/66147

https://www.indeed.com/lead/best-jobs-2019

Indeed (2019), Here Are the Top 10 AI Jobs, Salaries and Cities, Indeed Editorial Team June 28, https://www.indeed.com/lead/top-10-ai-jobs-salaries-cities

Iyar, Ananth (2018), Artificial Intelligence, April 22, https://witanworld.com/article/2018/04/22/witan-sapience-artificial-intelligence/

Johnson, Reece (2020), Jobs of the Future: Starting a Career in Artificial Intelligence, May 14 , 2020, https://www.bestcolleges.com/blog/future-proof-industries-artificial-intelligence/

Kiser, Grace and Mantha, Yoan (2019), Global AI Talent Report 2019, https://jfgagne.ai/talent-2019/

Koenig, Stephen (2020), What does the future of artificial intelligence mean for humans? July 28 , https://techxplore.com/news/2020-07-future-artificial-intelligence-humans.html

Krishna, Vishal (2017), 7 Indian industries that will be impacted by AI: The dawn of an era of tectonic change, https://yourstory.com/2017/10/7-indian-industries-that-will-be-impacted-by-ai?utm_pageloadtype=scroll

Lath, Anuja (2018), 6 challenges of artificial intelligence, BBN Times, May 22 , https://www.bbntimes.com/companies/6-challenges-of-artificial-intelligence

Loucks, Jeff , Davenport, Tom and Schatsky, David (2018), State of AI in the Enterprise, 2nd Edition, Deloitte Insights, Deloitte Development LLC.

Mani, Chithrai (2019), The Next-Generation Applications of Artificial Intelligence and Machine Learning, Forbes, November 6, https://www.forbes.com/sites/forbestechcouncil/2019/11/06/the-next-generation-applications-of-artificial-intelligence-and-machine-learning/#34814ff547bc

Markets & Markets (2018) Artificial intelligence market, https://www.marketsandmarkets.com/Market-Reports/artificial-intelligence-market-74851580.html

McKinsey Global Institute Report (2017) https://www.mckinsey.com/featured-insights/future-of-work/jobs-lost-jobs-gained-what-the-future-of-work-will-mean-for-jobs-skills-and-wages#

Mike Thomas, Mike (2020), The Future of Artificial Intelligence – 7 ways AI can change the world for better or worse, April 20 , https://builtin.com/artificial-intelligence/artificial-intelligence-future

Mind Commerce (2018), Next Generation Networking AI market 2018–2023, https://mindcommerce.com/reports/next-generation-networking-ai/

Mordor Intelligence (2019), AI image recognition market – growth, trends, and forecast (2020–2025).
Oblé, Frédéric , Monchalin, Eric and Lefebvre, Guillaume (2018), Reinvent your future with the promise of Artificial Intelligence, ATOS, https://atos.net/en/blog/reinvent-future-promise-artificial-intelligence
Polachowska, Kaja (2019), 12 challenges of AI adoption, June 6 , https://neoteric.eu/blog/12-challenges-of-ai-adoption/
Ransbotham, Sam , Kiron, David , Gerbert, Philipp and Martin, Reeves (2017), Reshaping Business With Artificial Intelligence Closing the Gap Between Ambition and Action, MIT Sloan Management Review and The Boston Consulting Group, September 2017.
Sahún, Enrique and Riocerezo, Gorka (2018), nae, March 17 , https://nae.global/en/market-expectations-for-artificial-intelligence/
Shankar, Ramya (2020), Future of Artificial Intelligence, April 9 , https://hackr.io/blog/future-of-artificial-intelligence
Talty, Stephan and Julien, Jules (2019), What Will Our Society Look Like When Artificial Intelligence Is Everywhere? https://www.smithsonianmag.com/innovation/artificial-intelligence-future-scenarios-180968403/
Thomas, Mike (2020), The Future of Artificial Intelligence – 7 ways AI can change the world for better … or worse, April 20 , https://builtin.com/artificial-intelligence/artificial-intelligence-future
Tiempo Development (2019), Artificial intelligence’s biggest challenges, July 22 , https://www.tiempodev.com/blog/artificial-intelligence-challenges/