



(REVIEW ARTICLE)



From computing science to intelligent computing: A review of artificial and computational intelligence in data and information analysis

Muhammad Awais Ali ^{1,*}, Maida Maqsood ², Madhavi Arun Mahajan ³, Hassan Nawaz ⁴, Ammad Maqsood ⁵, Obaid Muhammad Abdullah ⁶ and Anaiza Maqsood ⁷

¹ Department of Electrical Engineering, Bahria University, Pakistan.

² Department of English, Government College Women University, Sialkot, Pakistan.

³ MCA department, Dr. D.Y.Patil Institute of Management and Research Pimpri Pune, India.

⁴ Cloud deployment Technical Director, Huawei Technologies, UAE.

⁵ Department of Civil Engineering, The University of Lahore, Lahore, Pakistan.

⁶ Department of Veterinary Surgery, University of Veterinary and Animal Science, Lahore, Pakistan.

⁷ The Standard Girls College, Sialkot, Pakistan.

World Journal of Advanced Engineering Technology and Sciences, 2024, 11(02), 257–268

Publication history: Received on 13 February 2024; revised on 23 March 2024; accepted on 26 March 2024

Article DOI: <https://doi.org/10.30574/wjaets.2024.11.2.0101>

Abstract

Artificial intelligence put forward using human intelligence index by use of advanced algorithms and models that transform computational principles of AI. Deep learning is a category of Artificial intelligence that shows the best problem-solving techniques and ways across different domains. Also, Computational Intelligence (CI) enhances conventional computing strategies through processes such as fuzzy logic, evolutionary algorithms, and neural networks that enables smarter decision-making among vague variables. Intelligent computing's impact is expanded over technological domains, that shows transformative changes in healthcare systems, finance industry, and other industrial processes. Having access to these technologies through collective platforms and open-source initiatives look after innovation. This review shatter perspectives from research scholars, industrial persons, and research communities, highlighting the current landscape and future prospects of A.I. and computational intelligence. Interdisciplinary applications and cross-cutting research initiatives represent the transformative potential of integrating intelligent computing techniques into expanded strategies. This wide scattering of A.I. and computational intelligence gives rise to the ethical concerns that majorly includes algorithmic biases and privacy issues to the end user. Meaningful dialogues and ethical practices are imperative to harnessing A.I. for social good in our interconnected world. This article represents the interdependent relationship between A.I., computational intelligence, and data science, offering deep knowledges into their synergistic applications and societal implications. It highlights the need for responsible A.I. deployment and ethical considerations to ensure the beneficial use of intelligent computing technologies.

Keywords: Computational Intelligence; Artificial Intelligence; Computing Technologies; Intelligent Computing; Critical Thinking

1. Introduction

Artificial and Computational Intelligence has arisen in software engineering as it forsakes customary computational techniques and embraces A.I. and CI. This shift presents new information investigation issues and potential open doors. Understanding this interaction is significant as cutting-edge innovation and human insight consolidate. The mid-twentieth century saw programmable P.C.'s and calculation normalization, beginning to register science. Early PCs performed foreordained positions utilizing deterministic calculations. Framework issues become clear as

* Corresponding author: Muhammad Awais Ali <https://orcid.org/0009-0007-3223-7140>

circumstances become more perplexing. Analysts utilized A.I. to imitate picking up, thinking, and decision-production to give robots human insight.

A.I. brought state-of-the-art mind-motivated techniques, beginning another processing science age. I was charmed by A.I.'s ability to further develop P.C. execution by gaining the information. Ongoing A.I. strategies, from direct relapse to profound learning, have progressed independent frameworks, picture acknowledgment, and standard language handling.

Integral worldview computational insight began from natural and transformative techniques: transformative calculations, fluffy rationale, and brain networks enhanced and tackled P.C. knowledge issues. Computational knowledge calculations are more adaptable than rules-based ones (Sarker, 2021).

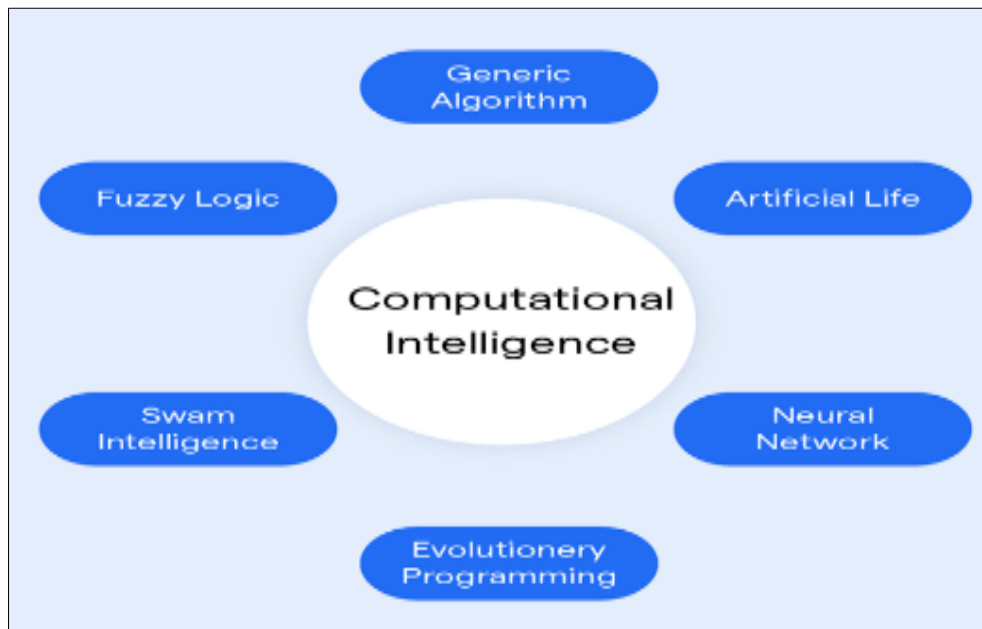


Figure 1 Computational Intelligence: Applications & Types

Objectives of the Review

Given these headways, this paper explains how software engineering has advanced into shrewd registering, zeroing in on A.I. and computational knowledge in information and data examination. This audit will analyze past exploration and writing to enlighten the ideas, procedures, and applications driving this new course.

This paper makes sense of the applied underpinnings of A.I. and CI, including its experts, cons, and connections. This article means to give perusers a total comprehension of shrewd figuring ideal models like A.I. and developmental calculation's hypothetical establishments so they might better grasp their upsides and downsides.

Also, this study will examine advanced mechanics, network protection, medical services, and money. This paper utilizes genuine contextual investigations and applications to show how A.I. influences information and data handling. A.I. helps with advancement, direction, and complex critical thinking.

This assessment additionally tries to recognize future A.I., computational knowledge, and innovative work patterns. This paper looks at propels in logical A.I., meta-learning, and a multitude of knowledge to propose future examination and social ramifications.

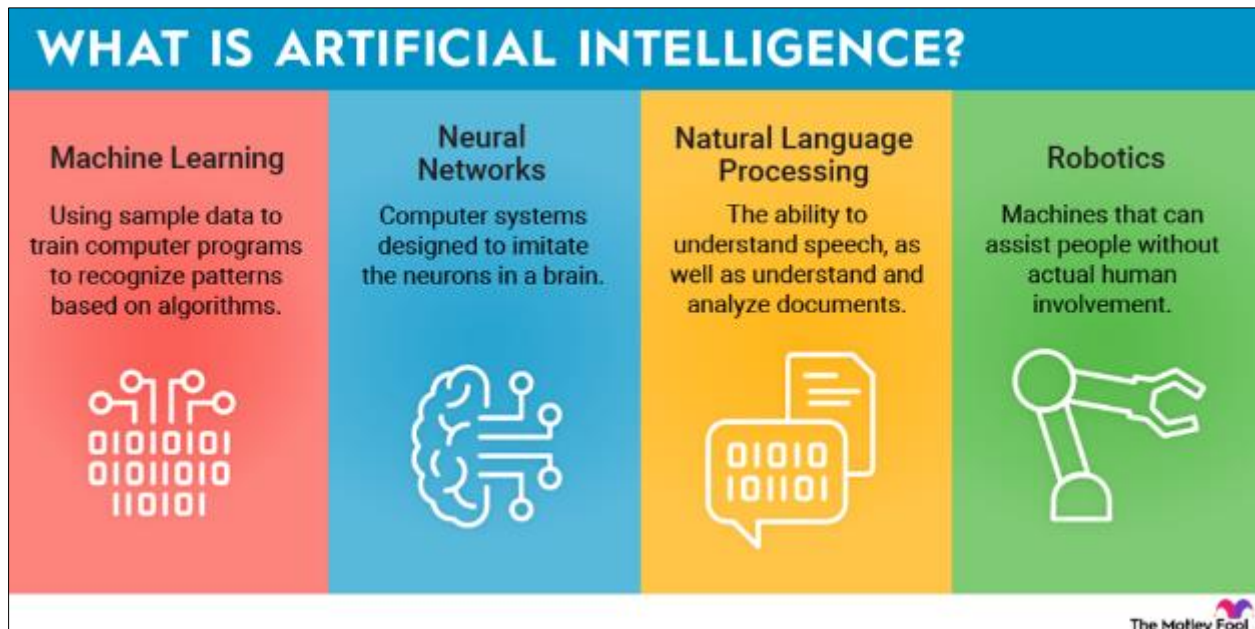


Figure 2 What Is Artificial Intelligence

1.1. Scope and Organization of the Article

This page covers information examination, A.I., and computational reasoning. Key A.I. issues are shrouded on the page. Future parts cover A.I. techniques, transformative calculation, and cross-breed draws near. The main area covers the experiences and ideas of A.I., as well as computational insight. To show its handiness, the concentrate then, at that point, investigates clever registering applications in mechanical technology, medical services, online protection, and money. The last area discusses flow and future patterns, recommending examination and advancement. This article helps researchers, specialists, and devotees. Its huge degree and coordinated association will assist perusers with understanding registering pivotal information and data handling capacities (Górriz *et al.*, 2020).

2. Evolution of Computing Science

Achievements, revelations, and outlook changes have denoted the move from registering science to fake and computational knowledge. This article talks about tourist spots in software engineering, the coming of A.I., and CI in information and data examination.

2.1. Historical Overview

Math devices and other crude counting gadgets were utilized to work out in early times. Programmable machines were created in the nineteenth hundred years. Charles Babbage's Scientific Motor laid out current processing by executing guidelines precisely.

The twentieth century's electronic P.C.'s expanded, registering immensely. The Electronic Mathematical Integrator and Registering (ENIAC) changed figuring during the 1940s. Individual and centralized server P.C.'s of the 1970s and 1980s expanded handling power.

Incorporating circuits and microchips scaled-down equipment and expanded figuring gadgets, speeding processing. FORTRAN, COBOL, C, and C++ work on programming improvement, empowering numerous area explicit applications (Iqbal *et al.*, 2020b).

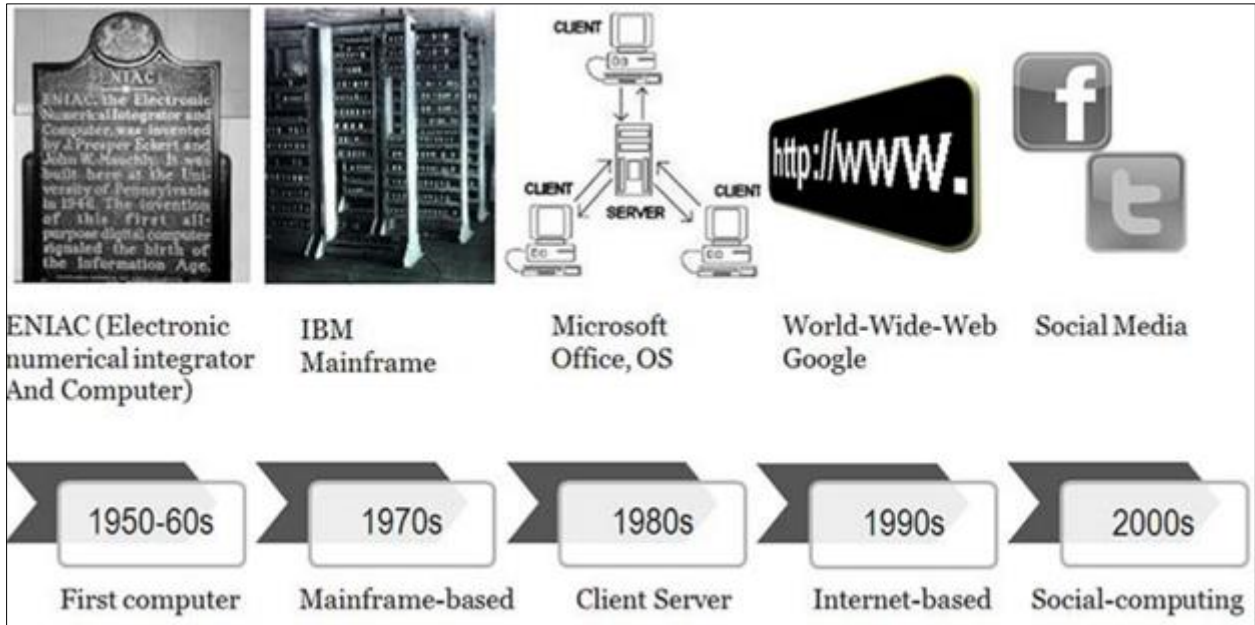


Figure 3 The Evolution of Computing | The Social Design of Technical Systems

2.2. Milestones in Computing Science

A few software engineering projects have laid the way for A.I. systems. The 1947 semiconductor changed gadgets by supplanting enormous vacuum tubes with more modest, quicker, and dependable gadgets. In the late twentieth 100 years, web-associated web P.C.'s worldwide have sent off the data age. This organization's massive information exchange supported exchange, correspondence, and joint effort. GUIs worked on registering. This development, like the 1984 Mac and Windows, brought down the hindrances of the P.C. section.

The vast information period started when the new century rolled over, and sensors, the IoT, and web-based entertainment created tremendous volumes of information. Information science and A.I. were created from the requirement for further developed registering instruments to inspect and gain from monstrous datasets.

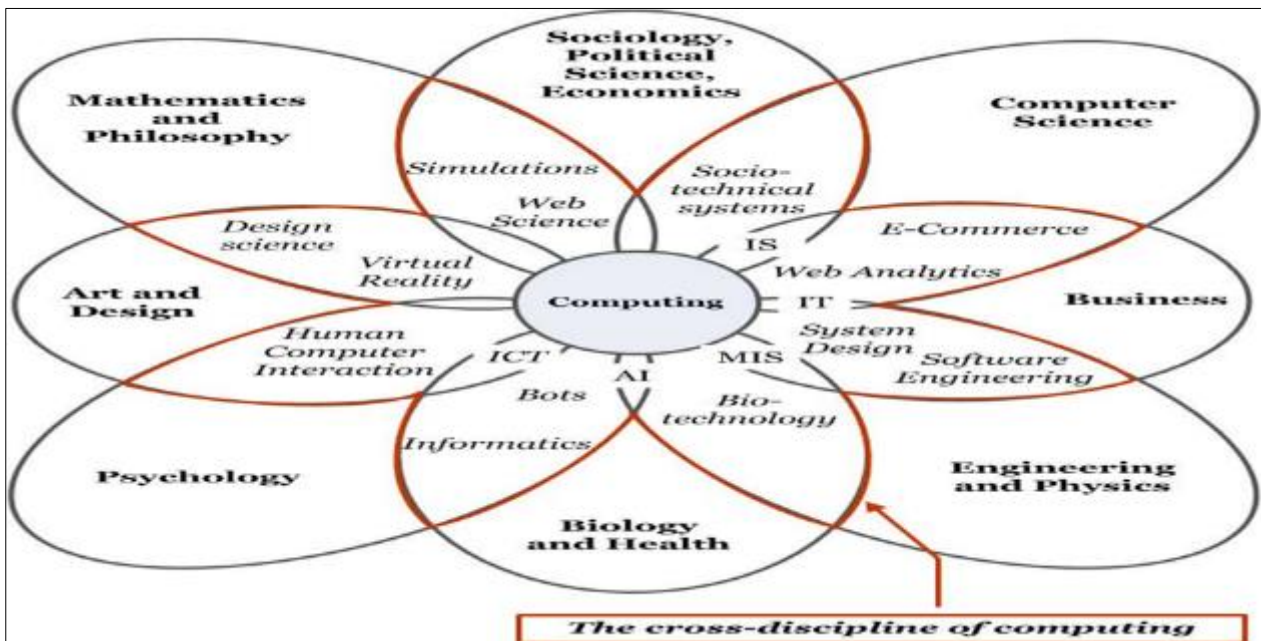


Figure 4 The Evolution of Computing

2.3. Initial AI/CI

Artificial Intelligence has potential due to strong P.C.'s and complex calculations. "man-made reasoning" signifies different ways of making P.C.'s think and carry on like people.

Master frameworks altered A.I. These frameworks utilized rule-based thinking to recreate human ability in particular fields. A.I. calculations produced information-driven estimates after rule-based strategies fizzled.

Since profound learning, particularly brain organizations, became well known, A.I. has moved along. Profound learning models outperform people in mind-motivated undertakings, including picture, everyday language, and discourse acknowledgment.

A.I. consciousness branch computational knowledge incorporates swarm insight, developmental calculations, and fluffy rationale. These techniques use organic cycles and customary frameworks to handle convoluted improvement and dynamic issues.

Canny processing utilizes A.I.; furthermore, C.S. permits machines to peruse, reason, and gain information. Because of this change in worldview, medical services, money, transportation, and assembly are entering another period of advancement and opportunity.

Imaginative reasoning and inventive revelations have progressed in registering science. Extensive information, robust calculations, and bountiful P.C. assets are introducing wise registering, opening up vast potential outcomes. A.I. also, CI opens new information and data investigation wildernesses. This will improve our lives, working environments, and advancements (Iqbal *et al.*, 2020a).

3. Fundamentals of Artificial Intelligence

A.I. has changed figuring science, changing how we investigate and grasp information. This survey article examines A.I.'s major ideas, from traditional to present-day standards, and its numerous information and data handling applications.

3.1. Definition and Concepts

A.I. is the capacity for innovation. Generally, P.C.'s mirror the canny human way of behaving and thinking. A.I. guides frameworks in learning, critical thinking, insight, and language. A.I. calculations further develop through A.I.

A.I. has various vital thoughts. Model: Information portrayal encodes P.C. intelligible information. This allows PCCs to reason, process data, and choose. A.I. frameworks' critical thinking calculations scan numerous choices for complex arrangements. NLP helps PCCs decipher and create human language, empowering human-PC cooperation (Sharma & Ghose, 2020).

3.2. Classical A.I. Approaches

Customary representative thinking and critical thinking arranged artificial intelligence. Master frameworks encode theme experts' information into rules to create human-like choices. Designing, money, and medication utilized these frameworks for finding and arranging.

Likewise, antiquated representative rationale utilizes formal rationale to communicate data and reason new bits of insight from old ones. This technique is used in hypothesis demonstration. Information-based A.I. Expansiveness and profundity first pursuit calculations were additionally made to explore issue areas and effectively find the best arrangements. Customary A.I. techniques worked; however, they required help overseeing monstrous informational collections or uncertainty. These cutoff points made new A.I. ideal models (Shamshirband *et al.*, 2020).

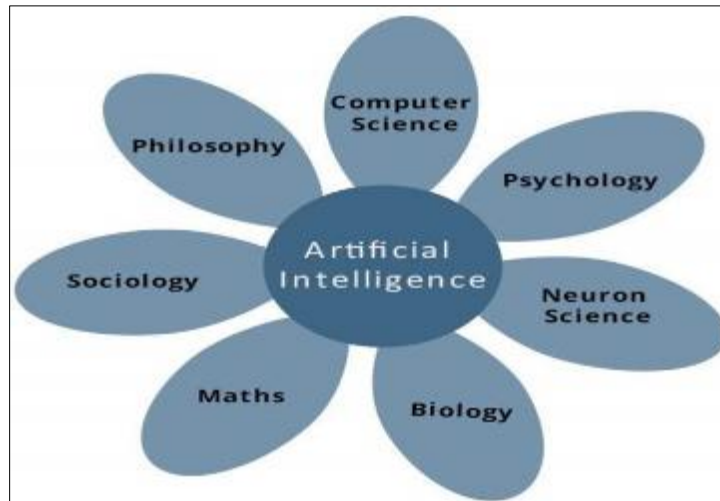


Figure 5 Artificial Intelligence

3.3. Modern AI Paradigms

Processor power and information accessibility have changed A.I. ideal models, high-level A.I., and profound learning. A.I. calculations consequently identify information examples and connections. This further develops ordinary language grasping, photograph recognizable proof, and discourse acknowledgment.

Multifaceted brain networks permit "profound learning" to learn information progressive systems, making it famous. The mind, like organizations, can group photographs, decipher dialects, and mess around. Another ongoing A.I. worldview supports learning and works on independent robots and interactivity by helping specialists settle on successive choices regarding ecological info.

Transformative calculations and probabilistic graphical models utilize graphical systems to communicate moving interdependencies and vulnerability in current A.I. These alternate points of view on A.I. make it more versatile and better at certifiable issues (Sarker, 2022).

3.4. Applications in Data and Information Analysis

Numerous ventures have changed action plans thanks to artificial intelligence-based information and data investigation. Medical services utilization of A.I. incorporates customized treatment, drug detailing, clinical picture investigation, and sickness I.D. Artificial intelligence-controlled chatbots and menial helpers support retail, money, and telecom client care.

A.I. calculations dissect monetary information, anticipate stock qualities, and distinguish extortion. A.I. further develops operations and transportation through astute transportation, prescient upkeep, and driverless automobiles. A.I. assists network protection specialists with uncovering dangers, distinguishing shortcomings, and lessening gambles in advanced frameworks.

A.I.'s. Moving from the old style to the current ideal models has changed information and data examination in different disciplines. A.I., profound learning, and other state-of-the-art A.I. strategies are moving to figure research toward astute processing and to change how we address issues and settle on choices with innovation (Swapnarekha *et al.*, 2020).

4. Computational Intelligence Techniques

Because of the combination of A.I. furthermore, CI, software engineering has entered another period of wise registering. This survey paper shows that these worldview improvements have changed information and data examination. It looks at developmental calculations, swarm insight, fluffy frameworks, brain organizations, profound learning, and half-breed ways to make sense of their capabilities, advances, and scholarly and modern applications.

4.1. Overview of Computational Intelligence

Present-day artificial intelligence depends on normal insight-affected computational knowledge. Dissimilar to unequivocal programming-based registering ideal models, computational knowledge approaches copy human

direction, learning, versatility, and development. Consolidating software engineering, science, mental brain research, and neuroscience, computational knowledge settles information and data handling difficulties.

4.2. Evolutionary Algorithms

Evolutionary algorithms (E.A.'s) enhance and search utilizing everyday choice and hereditary legacy. These calculations transform, hybridize, and pick applicant arrangements to advance wellness. Transformative calculations succeed in streamlining, A.I., and framework configuration by investigating huge arrangement spaces and tracking down ideal or close ideal arrangements (Ji *et al.*, 2021).

4.3. Neural Networks and Deep Learning

Enlivened by cerebrum life structures and physiology, profound learning and brain networks increment information examination and example location. Preparing brain networks with layers of hubs can assist them with learning complex information yield mappings. This worldview is extended by multifaceted profound brain networks for progressive component reflection and portrayal of learning. Profound learning's picture and sound acknowledgment, normal language handling, support learning, and other benchmark assignments have changed medical care, banking, and independent frameworks.

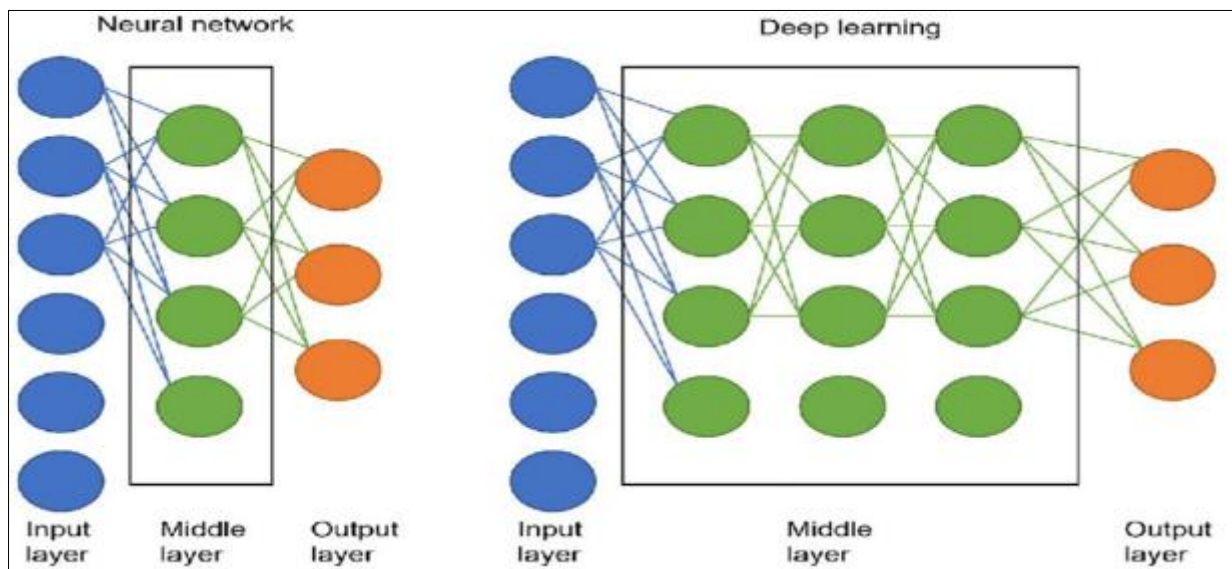


Figure 6 Deep learning and a neural network

4.4. Fuzzy Systems

Fuzzy frameworks address and reason with imprecision and vulnerability utilizing human-like language. Fluffy rationale utilizes levels of truth rather than parallel truth values, improving it for uncertain conditions. Fluffy sets, rules, and deduction processes improve control frameworks, design acknowledgment, and choice to help model understanding and variation. Fluffy frameworks address muddled and unusual issues utilizing accurate information and information fuzziness (Alam and Mohanty, 2022).

4.5. Swarm Intelligence

Social bug settlements and organized systems animate a multitude of information computations for progression, decisive reasoning, and autonomous bearing. These computations reflect focal experts' self-affiliation, adaptable approach to acting, and trouble adaptability on adjacent guidelines. Swarm information computations prevail at combinatorial, booking, packing, and particle swarm improvement in counterfeit honey bee states, bacterial rummaging, and underground bug territory smoothing out. Swarm understanding utilizes total information for speedy and versatile data and information dealing. The philosophies handle astounding, one-of-a-kind circumstances (Sun *et al.*, 2021).

4.6. Hybrid Approaches

Crossover A.I. strategies consolidate numerous A.I. strategies to upgrade qualities and avoid blemishes. Blended models utilizing transformative calculations, brain organizations, fluffy frameworks, and crowd insight can handle complex issues better than single techniques. Cross-breed structures further develop generalizability and investigate double-dealing compromises and absent or uproarious information power. For better information and data investigation, state-of-the-art A.I. research joins neuro-transformative calculations with fluffy hereditary frameworks and many roused brain organizations.

4.7. Applications in Data and Information Analysis

A.I. has changed information investigation. Medical services, banking, assembling, and network safety utilize prescient demonstrating, abnormality identification, design acknowledgment, and choice help.

Simulated intelligence C.S. intermingling signals a shift from conventional software engineering to more savvy, versatile, and independent information and data handling frameworks. This survey's A.I. strategies can help scientists and experts find new areas and handle information-driven issues (Cai, 2022).

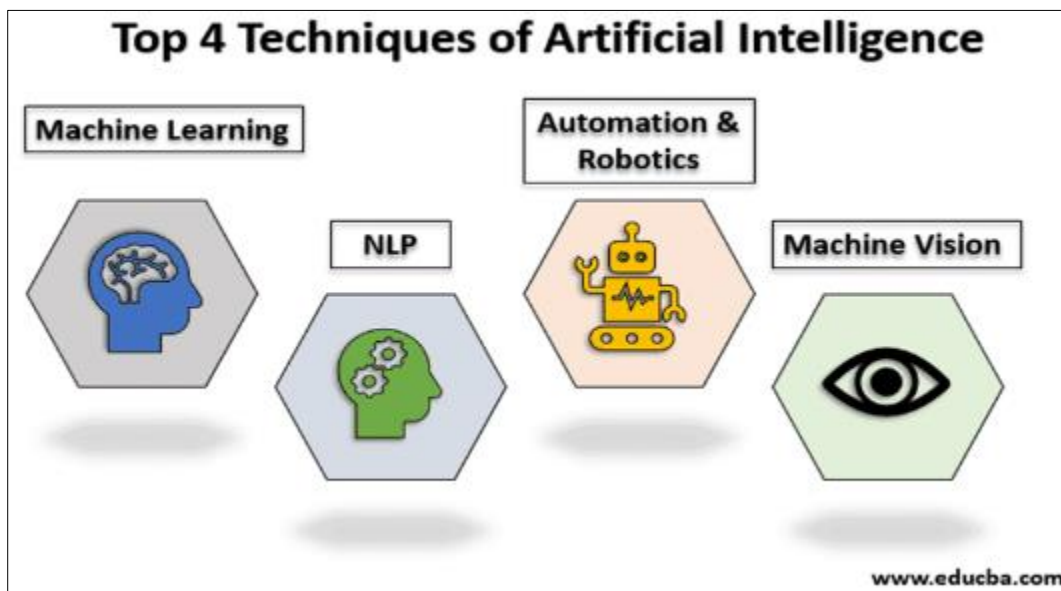


Figure 7 Artificial Intelligence Techniques

4.8. Emerging Trends in Intelligent Computing

The assertive discipline of software engineering has progressed in information and data examination due to A.I. and computational insight. This audit article discusses A.I. morals, growing applications, explainable A.I. (XAI), edge processing, quantum registering, and robotized A.I. Related issues and arrangements are likewise covered.

4.8.1. Quantum Computing and A.I.

Quantum computing will change processing with outstanding speedups. Quantum registering could work on handling gigantic datasets and testing improvement undertakings, reforming A.I. Quantum A.I. techniques, quantum tempering, and quantum brain networks have changed A.I. design disclosure, enhancement, and reproduction. Quantum A.I. faces equipment limitations, algorithmic intricacy, and particular information.

4.8.2. Edge Computing and A.I.

By decentralizing computing and stockpiling, edge figuring draws handling nearer to the information source. Edge registering lets A.I. applications settle on continuous choices and ends at the organization's edge, diminishing inactivity and data transmission. This change in outlook lets A.I. models be utilized in independent frameworks and IoT gadgets (Adly *et al.*, 2020).

4.8.3. Explainable A.I. (XAI)

XAI makes simulated intelligence frameworks more straightforward and interpretable so clients can fathom calculation rationale. Unlike black-box models, XAI procedures show how computer-based intelligence calculations work, cultivating responsibility. Artificial intelligence decisions can have expansive impacts, making XAI fundamental in medical care, banking, and law enforcement. Artificial intelligence advancement should embrace XAI thoughts to create dependable and capable frameworks (Tong *et al.*, 2021).

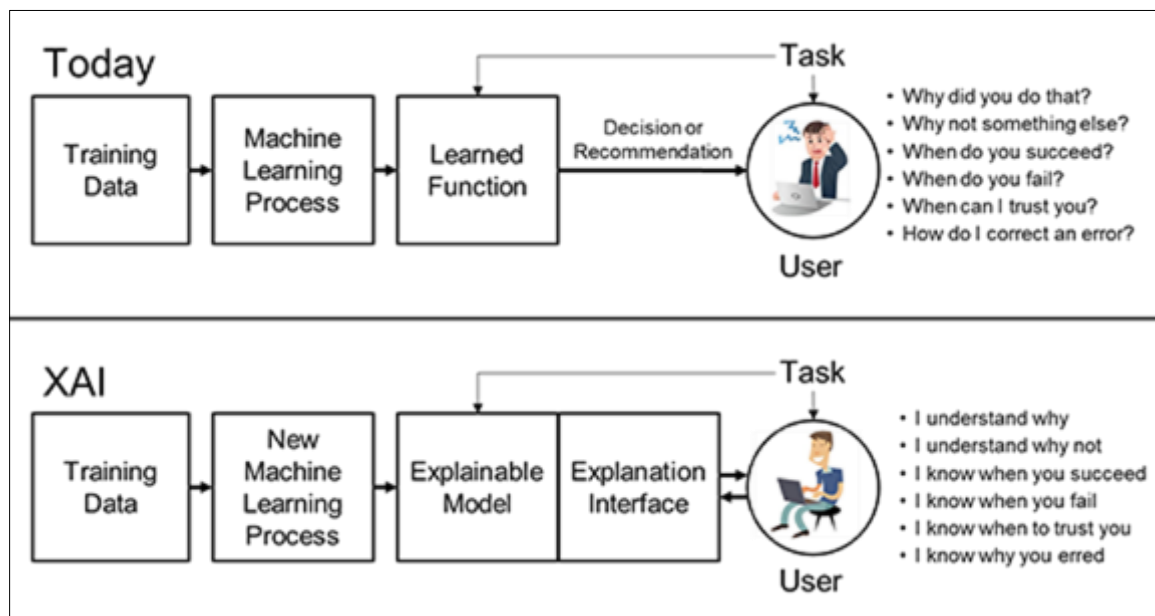


Figure 8 Explainable Artificial Intelligence

4.9. AI Ethics and Regulation

Individuals stress over the moral ramifications of artificial intelligence as it spreads because of worries about inclination, security intrusion, and employment misfortune; ethical and legitimate systems for artificial intelligence creation and arrangement have been pushed. To make artificial intelligence frameworks more open, responsible, and populist, worldwide associations and administrative specialists have created computer-based intelligence Morals Rules. Across disciplines, ethicists, policymakers, technologists, and end-clients should team up to deal with artificial intelligence's complicated moral scene. Advancement and morals should be adjusted to utilize artificial intelligence's problematic potential capably (Thakkar & Lohiya, 2020).

5. Integration of Artificial and Computational Intelligence

The information investigation has been modified with A.I. and CI. This blend creates cooperative energies and imaginative ways to address convoluted issues in various areas by joining ideas, calculations, and methodology from the two callings. The complicated connection between A.I. and CI is analyzed in this review, including cooperative energies, impediments, unique open doors, contextual analyses, applications, and possibilities.

5.1. Synergies and Complementarity

Artificial intelligence and CI collaborate a few times, helping the two methodologies and empowering all the more remarkable and productive arrangements. Artificial consciousness depends on A.I., profound learning, and mental processing for direction, prescient demonstrating, and design acknowledgment. Conversely, CI incorporates swarm knowledge, transformative calculations, and fluffy frameworks, which offer adaptable ways to deal with upgrade, control, and reason (Xu *et al.*, 2021).

The correlative idea of simulated intelligence and CI methodologies is vital to this joining. CI procedures oversee genuine intricacy, disarray, and unconventionality better than simulated intelligence frameworks with organized information and clear objectives. By consolidating artificial intelligence exactness and CI versatility, professionals might settle many difficulties, from streamlining and independent frameworks to prescient investigation and inconsistency location.

Artificial intelligence and CI permit scholastics from complex frameworks like hypothesis, brain science, and neuroscience to collaborate on difficulties. This exciting and enhanced approach grows the methods pool and yields novel arrangements above ideal models (Berhil *et al.*, 2020).

5.2. Future Directions

With computer-based intelligence and CI, information investigation will definitely move. Future exploration ought to zero in on half-breed models that consolidate A.I. Furthermore, CI can upgrade their advantages and cut off their drawbacks. Because of expanded worry over incorporated frameworks' moral and cultural results, A.I. and CI arrangement rules are required.

Blockchain, neuromorphic, and quantum processing empower clever figuring extensions. Quantum mechanics-roused calculations dramatically speed up streamlining and A.I., while neuromorphic figuring models imitate the mind's parallelism and effectiveness for low-power, ongoing tactile info handling. Blockchain ensures information quality and dependability in CI and A.I. frameworks through decentralized, changeless information approval and trade.

A.I. Moreover, CI changes information examination, opens new business sectors, and cultivates advancement in various ventures. Shrewd processing can take care of intricate social issues and construct an additional economical and fair future if we benefit from cooperative energies, defeat snags, concentrate on applications, and plan (Ribeiro *et al.*, 2021).

6. Ethical and Social Implications

The quick development of A.I. has changed numerous parts of progress, including information and data examination. A.I. and prescient examination have made complex datasets more obvious and draw surmisings from them. Notwithstanding, these developments' moral and social impacts should be inspected. The article focuses on society, the economy, inclination, equity, protection, and security.

6.1. Privacy and Security Concerns

A.I. raises protection and security concerns. As calculations further develop in assessing individual information, security concerns emerge. Information breaks, unapproved access, and snooping are genuine issues as information-driven frameworks develop. Enormous volumes of information from changed sources can re-distinguish individuals, even anonymized information. A break of security can harm information investigation. To maintain patient trust and conform to HIPAA, medical services foundations should keep clinical records hidden while utilizing A.I. for determination. Monetary establishments' credit scoring frameworks should shield client security and lessen segregation.

A.I. framework decisions are undermined by ill-disposed assaults that change contributions to hoodwink A.I. calculations. Astute registering in basic framework and independent frameworks increments security takes a chance that can prompt monetary robbery or actual mischief. Mechanical, lawful, and moral arrangements are required for protection and security. Information security can be fortified without losing information examination esteem by using encryption, differential protection, and combined learning. Secure turn of events and interruption recognition strategies safeguard A.I. frameworks. To adjust security and development, legislators ought to uphold information assurance rules and all rights insubordination (Zeb *et al.*, 2022).

7. Conclusion

Canny processing has introduced another age in software engineering that will change fake and computational knowledge. A definite landscape evaluation has uncovered significant experiences into these imaginative innovations' turn of events, uses, and likely future pathways. As we explore the convoluted information and data investigation organization, our discoveries enlighten the various open doors and difficulties that remain and feature the uncommon headway made.

Our A.I. and C.S. research has prompted numerous essential disclosures enlightening astute registering's intricacy. A.I. reproduces human astuteness with cutting-edge calculations and models and supports current computational standards. Our examination of A.I. and profound learning has demonstrated its extraordinary capacity to tackle complex issues in numerous areas.

Our audit likewise showed how computational insight further develops customary registering techniques. Fluffy rationale, transformative calculations, and brain networks let computational insight handle equivocalness and make

more astute choices. Combining these techniques with new ideal models like counterfeit life and multitude insight shows shrewd registering's unfathomable potential.

As indicated by our examination, wise figuring influences society's past innovation. A.I. is accelerating phenomenal change in the medical services conclusion and monetary market, streamlining businesses. Democratizing these advancements through cooperative stages and open-source exercises empowers development and gives people admittance to shrewd figuring. Our A.I. writing concentrates on bringing new perspectives and builds our insight in more ways than one. The primary stage is summing up scholars', businesses', and examination viewpoints on the present and eventual fate of A.I. and computational knowledge.

Our discoveries show that A.I. supplements information science, advanced mechanics, and network protection. We explore interdisciplinary applications and cross-slicing research ventures to exhibit the progressive capability of blending insightful processing procedures into different spaces, which could prompt advancement and social effect. Furthermore, our investigation shows the moral issues related to broad A.I. reception. Executing A.I. Furthermore, CI frameworks in true settings have a few socio-specialized impacts, from algorithmic predispositions to protection issues. In this associated world, we want significant discussions and proper A.I. practices to utilize A.I. for good.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

- [1] Adly, A.S., A.S. Adly and M.S. Adly. (2020). Approaches based on artificial intelligence and the Internet of intelligent things to prevent the spread of COVID-19: a scoping review. *J. Med. Internet Res.* 22:e19104.
- [2] Al-Hashedi, K.G. and P. Magalingam. 2021. Financial fraud detection applying data mining techniques: A comprehensive review from 2009 to 2019. *Comput. Sci. Rev.* 40:100402.
- [3] Alam, A. and A. Mohanty. 2022. Foundation for the Future of Higher Education or 'Misplaced Optimism'? Being Human in the Age of Artificial Intelligence. In: *Communications in Computer and Information Science*, Springer, 17–29.
- [4] Ali, M. and M.K. Abdel-Haq. 2021. Bibliographical analysis of artificial intelligence learning in Higher Education: Is the role of the human educator and educated a thing of the past? In: *Fostering Communication and Learning with Underutilized Technologies in Higher Education*, IGI Global, 36–52.
- [5] Babu, N.V. and E.G.M. Kanaga. 2022. Sentiment analysis in social media data for depression detection using artificial intelligence: a review. *S.N. Comput. Sci.* 3:74.
- [6] Berhil, S., H. Benlahmar and N. Labani. 2020. A review paper on artificial intelligence at the service of human resources management. *Indonesia. J. Electr. Eng. Comput. Sci.* 18:32–40.
- [7] Bhatti, U.A., H. Tang, G. Wu, S. Marjan and A. Hussain. 2023. Deep learning with graph convolutional networks: An overview and latest applications in computational intelligence. *Int. J. Intell. Syst.* 2023:1–28.
- [8] Cai, H. (2022). Promoting Regional Economic Transformation Forecast Based on Intelligent Computing Technology. *Comput. Intell. Neurosci.* 2022.
- [9] Górriz, J.M., J. Ramírez, A. Ortíz, F.J. Martínez-Murcia, F. Segovia, J. Suckling, M. Leming, Y.D. Zhang, J.R. Álvarez-Sánchez, G. Bologna, P. Bonomini, F.E. Casado, D. Charte, F. Charte, R. Contreras, A. Cuesta-Infante, R.J. Duro, A. Fernández-Caballero, et al. 2020. Artificial intelligence within the interplay between natural and artificial computation: Advances in data science, trends, and applications. *Neurocomputing.* 410:237–270.
- [10] Gu, X., Z. Cao, A. Jolfaei, P. Xu, D. Wu, T.-P. Jung and C.-T. Lin. (2021). EEG-based brain-computer interfaces (BCIs): A survey of recent studies on signal sensing technologies, computational intelligence approaches, and their applications. *IEEE/ACM Trans. Comput. Biol. Bioinforma.* 18:1645–1666.

- [11] Hemachandran, K., P. Verma, P. Pareek, N. Arora, K. V. Rajesh Kumar, T.A. Ahanger, A.A. Pise and R. Ratna. (2022). Artificial Intelligence: A Universal Virtual Tool to Augment Tutoring in Higher Education. *Comput. Intell. Neurosci.* 2022.
- [12] Iqbal, R., F. Doctor, B. More, S. Mahmud and U. Yousuf. 2020a. Big data analytics: Computational intelligence techniques and application areas. *Technol. Forecast. Soc. Change.* 153:119253.
- [13] Iqbal, R., F. Doctor, B. More, S. Mahmud and U. Yousuf. 2020b. Big Data Analytics and Computational Intelligence for Cyber-Physical Systems: Recent Trends and State of the art Applications. *Futur. Gener. Comput. Syst.* 105:766–778.
- [14] Ji, B., Y. Wang, K. Song, C. Li, H. Wen, V.G. Menon and S. Mumtaz. 2021. A survey of computational intelligence for 6G: Key technologies, applications, and trends. *IEEE Trans. Ind. Informatics.* 17:7145–7154.
- [15] M Abd El-Aziz, R., R. Alanazi, O. R Shahin, A. Elhadad, A. Abozeid, A. I Taloba & R. Alshalabi. (2022). An Effective Data Science Technique for IoT-Assisted Healthcare Monitoring System with a Rapid Adoption of Cloud Computing. *Comput. Intell. Neurosci.* 2022.
- [16] Nawaz , H., Ali, M. A., Rai, S. I., & Maqsood, M. (2024). Comparative Analysis of Cloud based SDN and NFV in 5g Networks. *The Asian Bulletin of Big Data Management*, 4(1). <https://doi.org/10.62019/abbdm.v4i1.114>
- [17] Nawaz, H., Maqsood, M., Ghafoor , A. H., Ali , S., Maqsood , A., & Maqsood , A. (2024). Huawei Pakistan Providing Cloud Solutions for Banking Industry: A Data Driven Study. *The Asian Bulletin of Big Data Management*, 4(1), 89–107. <https://doi.org/10.62019/abbdm.v4i1.122>
- [18] Ribeiro, J., R. Lima, T. Eckhardt and S. Paiva. 2021. Robotic process automation and artificial intelligence in industry 4.0—a literature review. *Procedia Comput. Sci.* 181:51–58.
- [19] Sarker, I.H. (2021). Data science and analytics: An overview from data-driven innovative computing, decision-making, and applications perspective. *S.N. Comput. Sci.* 2:377.
- [20] Sarker, I.H. (2022). AI-based modeling: techniques, applications and research issues towards automation, intelligent and innovative systems. *S.N. Comput. Sci.* 3:158.
- [21] Sarker, I.H., M.H. Furhad and R. Nowrozy. 2021. Ai-driven cybersecurity: An overview, security intelligence modeling, and research directions. *S.N. Comput. Sci.* 2:173.
- [22] Shamshirband, S., M. Fathi, A.T. Chronopoulos, A. Montieri, F. Palumbo & A. Pescapè. (2020). Computational intelligence intrusion detection techniques in mobile cloud computing environments: Review, taxonomy, and open research issues. *J. Inf. Secure. Appl.* 55:102582.
- [23] Sharma, A. & U. Ghose. (2020). Sentimental analysis of Twitter data concerning general elections in India. *Procedia Comput. Sci.* 173:325–334.
- [24] Sun, Z., M. Anbarasan and D. Praveen Kumar. 2021. Design of an online intelligent English teaching platform based on artificial intelligence techniques. *Comput. Intell.* 37:1166–1180.
- [25] Swapnarekha, H., H.S. Behera, J. Nayak and B. Naik. 2020. Role of intelligent computing in COVID-19 prognosis: A state-of-the-art review. *Chaos, Solitons and Fractals.* 138:109947.
- [26] Tang, S., L. Chen, K. He, J. Xia, L. Fan and A. Nallanathan. 2023. Computational Intelligence and Deep Learning for Next-Generation Edge-Enabled Industrial IoT. *IEEE Trans. Netw. Sci. Eng.* 10:2881–2893.
- [27] Thakkar, A. and R. Lohiya. 2020. A review of the advancement in intrusion detection datasets. *Procedia Comput. Sci.* 167:636–645.
- [28] Tong, Z., F. Ye, M. Yan, H. Liu and S. Basodi. 2021. A survey on algorithms for intelligent computing and innovative city applications. *Big Data Min. Anal.* 4:155–172.
- [29] Xu, Y., X. Liu, X. Cao, C. Huang, E. Liu, S. Qian, X. Liu, Y. Wu, F. Dong, C.W. Qiu, J. Qiu, K. Hua, W. Su, J. Wu, H. Xu, Y. Han, C. Fu, Z. Yin, et al. 2021. Artificial intelligence: A powerful paradigm for scientific research. *Innovation.* 2.
- [30] Zeb, S., A. Mahmood, S.A. Hassan, M.D.J. Piran, M. Gidlund and M. Guizani. 2022. Industrial digital twins at the nexus of NextG wireless networks and computational intelligence: A survey. *J. Netw. Comput. Appl.* 200:103309.