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Intelligent Computing: A Technological Revolution

Dr. Saju Mathew
Assistant Professor
SNMV College of Arts and Science
Coimbatore, India

Navaneethi B
Assistant Professor
SNMV College of Arts and Science
Coimbatore, India

Abstract: A key factor in the advancement of human evolution is computing. With novel computing theories, architectures, methodologies, systems, and applications, intelligent computing is changing traditional computing and accelerating the digital revolution in the age of big data, artificial intelligence, and the internet of things. With the advent of increasingly diversified computing paradigms including perceptual intelligence, cognitive intelligence, sovereign intelligence, and human-computer fusion intelligence, intelligent computing has significantly expanded the scope of computing. The evolution and development of intelligence and computing have long followed different routes, but they have recently grown more intertwined; intelligent computing is not just intelligence-oriented, but also intelligence-driven. Intelligent computing is now successfully used in many fields, including environmental monitoring, transportation, healthcare, home, education, to make cities smart etc. This paper focuses on the review of intelligent computing; its technological foundation, properties, characteristics and application of intelligent system, advantages and disadvantages of intelligent computing and suggested the future solution for intelligent computing.

Keywords: Intelligent Computing, cognitive intelligence, artificial intelligence, intelligence-oriented, intelligent driven.

1. INTRODUCTION

The recent technological advancement, in which computing has emerged as a crucial component in creating and fostering societal progress, human civilization is transitioning into an intelligent society from information society. Traditional computing on data is far from being able to meet the growing demand for a higher level of intelligence by humans in the new era of digital civilization with the internet of all things. With the advancement of computing science, intelligent observation of the physical world, and comprehension of the cognitive mechanism of human consciousness, the growing interest in intelligent computing has raised the level of computing intelligence and sped up knowledge generation.

Due to the new technology evolution, remarkable popularity and effectiveness of machine learning, artificial intelligence (AI) and deep learning it has emerged as the next frontier in human research of machine intelligence. As a result this has led to the development of a number of ground-breaking research findings, including the convolutional neural network (CNN) suggested by Yann LeCun and advances made in the field of causal inference in deep learning made by Yoshua Bengio [1] [2] [3]. One of the pioneers of AI, Georey Hinton, proposed the backward propagation optimization algorithm and the deep belief network model in 2006. Another artificial intelligence researcher Jurgen Schmidhuber proposed Long Short-Term Memory (LSTM), which is one of the most popular recurrent neural networks (RNNs) [2].

The term "intelligent computing" describes the use of technologies like artificial intelligence, big data analytics, and computer networks to automatically sense, analyze, evaluate, and forecast environmental parameters in the real world and to provide corresponding strategies for various requirements [3]. Distributed intelligent network devices having the ability to sense, communicate, and process information are installed by intelligent computing systems at the appropriate locations in the environment. By utilizing the communication network, these devices cooperate with one another and exchange data and resources. Pervasive computing, which is focused on people, is the foundation of intelligent computing. Pervasive computing aims to effectively combine information space and physical space, making computing tools and services available everywhere [12]. Intelligent computing creates an intelligent environment where the system carried out the information gathering, analysis, processing, and assessment automatically.

In the new age of digital civilization that promotes global connection, intelligent computing can be defined as an integration of human society, the physical world and the information space that incorporates new computing theoretical techniques, architecture systems, and technical capabilities. High computing capability, energy efficiency, intelligence, and security are the goals of intelligent computing, which is also human-oriented. Intelligent computing employs the best and the appropriate algorithm that matches sufficient computational capacity to the specific actual needs, and targets computational activities with the lowest possible cost in order to produce the best results [1].

The general theoretical framework of intelligent computing, which incorporates a wide range of computer paradigms in support of the integration of human, physics, and information as shown in Figure 1 [1]. Humans will be using different methodologies such as imitation, learning, logic and self-examination and will be performing different activities such as group-environmental interaction, knowledge creation and task decomposition. The methodologies and the architecture that is

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used by the physics paradigm includes, in-memory computing, distributed computing, heterogeneous computing and performs various tasks such as clustering, hierarchical while the information paradigm includes different models generated by turning machine, DFA and neural networks. Intelligent computing has the ability to have data intelligence, cognitive intelligence and perpetual intelligence and have the wide area collaboration using heterogeneous integration. Figure 1 shows the overview of intelligent computing using the combination of human, physics and information.

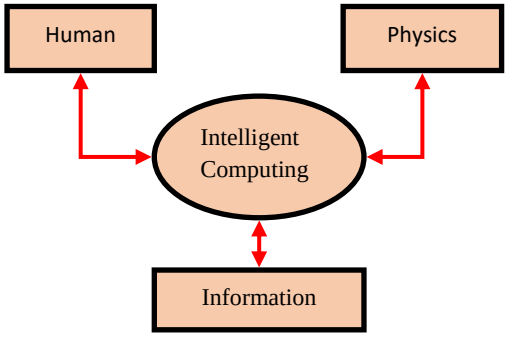

Figure 1: Overview of intelligent computing in combination with human, physics and information.

2. PROPERTIES OF INTELLIGENT SYSTEM

Intelligent systems typically use IP (Internet Protocol) technology and sensors to gather data from a particular environment and distribute it among its various components in order to accomplish a shared objective. Intelligent systems can vary greatly depending on the industry, despite the fact that they share many fundamental traits. Following are the few important properties of intelligent systems.

1. **Sensors**: The technology gathers environmental data and sends it to the intelligent core for naming and analyzing.
2. **Actuators**: They carry out the tasks that the intelligence core decides upon after real-time environment analysis.
3. **Specific environment**: The intelligent system evaluates and adapts the context. They can be considered as deterministic, episodic, static, and discrete.
4. **Intelligence Core**: The foundation of an intelligent system is made up of two important developing technologies artificial intelligence and machine learning.
5. **User Interface (UI):** An outside agent interacts with the system and modifies how they relate to one another in the manner.
6. **External Agents**: The individuals who are involved or in charge of the intelligent system's or even other artificial intelligence's processes.

Following figure 2 shows the intelligent system functionality.

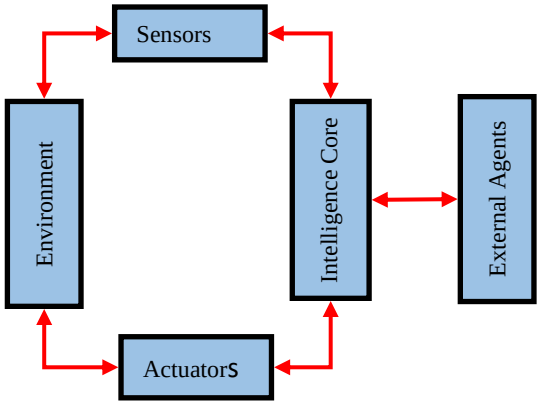

Figure 2 Intelligent System Functionality

3. CHARACTERISTIC OF INTELLIGENT SYSTEM

The main characteristic of an intelligent system are shown in the following figure 3.

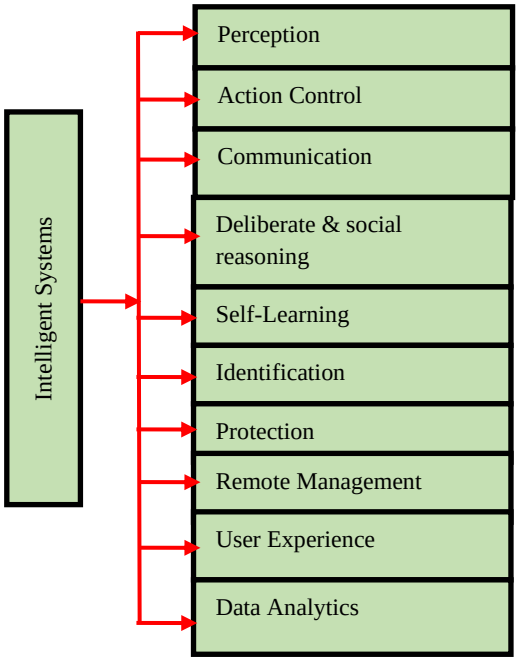

Figure 3: Characteristics of Intelligent System

1. **Perception:** In order to interact with a particular environment and carry out tasks, an intelligent system builds a representation of the world.
2. **Action Control:** To accomplish a task, an intelligent system can take action or stop action.
3. **Communication or connectivity:** An intelligent system can use a common language to put its components into communication.
4. **Deliberate and social reasoning**: The machine decides on its own to accomplish a goal and takes into account the human condition.

5. **Self-Learning:** By using their own experiences as learning opportunities, intelligent systems can minimize errors and improve performance.
6. **Identification:** Intelligent systems have the ability to automatically distinguish specific information and deliver it via a variety of networks.
7. **Protection:** For an intelligent system to work correctly, its networks and communications must be protected.
8. **Remote Management:** People can communicate with an intelligent system from everywhere.
9. **User Experience (UX):** Intelligent systems need user-friendly interfaces that can be altered in order to communicate with users.
10. **Data Analytics:** One of the important characteristic of an intelligent system is that they must have the capacity to process enormous amounts of data.

4. APPLICATIONS OF INTELLIGENT SYSTEM

Intelligent systems are equipped to handle an expanding number of tasks in current culture, such as:

a) **Factory automation**: Sophisticated robotics and automation applications in industries demand technologies that can carry out challenging yet vaguely defined tasks. These activities, which are often carried out by people, are undefined in the sense that they are goal-oriented but lack specific procedures or algorithms. A combination of intelligence, a highly developed sensory system, training, and years of expertise are used by humans to perform these functions. Additionally, additional applications such as those in space, the ocean, or building will be interested in the answer to these problems.

b) **Field and service robotics**: Field robotics are non-factory machines that are often dynamic and work in challenging conditions. These environments can be on the surface of the Earth or other planets, underground, under water, in the air, or in space. Service robots are those that assist humans in their daily lives by collaborating directly with them.

c) **Assistive robotics:** An assistive robot is a machine that can recognize, analyze sensory data, and carry out tasks that aid the elderly and individuals with impairments in their daily lives. Robots with physical assistance help people whose injuries or medical ailments restrict their ability to move their upper or lower bodies. Additionally, these robots are employed in rehabilitation facilities to assist recuperating victims of spinal cord and neurological damage.

d) **Military applications:** Drones and AI can be used together to patrol territories, spot risks, and share warning alerts with the appropriate response teams. Thus, the deployment of intelligent systems enhances the battle efficiency of military personnel.

e) **Medical care**: AI in healthcare can improve patient outcomes overall, improve preventative care and quality of life, and create more precise diagnosis and treatment strategies. By examining data from the public sector, the healthcare industry, and other sources, AI can help forecast and monitor the development of contagious diseases.

f) **Education**: An intelligent tutoring system (ITS) is a computer program that tries to give students quick, personalized education or feedback, typically without the need for a teacher's intervention. By utilizing a variety of computing technologies, ITSs aim to enable meaningful and effective learning.

g) **Entertainment**: Automation of sound production processes will increase with the use of AI in the entertainment industry. AI can provide a platform that can automate tasks like script splitting, short list creation, storyboarding, schedule creation, and resource management for movies. Additionally, AI software can automatically synchronize the group-filmed video.

h) **Visual inspection**: Global clients can get reliable monitoring technology from Intelligent Monitoring Systems.

i) **Character recognition**: Modern optical character recognition (OCR) technology called intelligent character recognition (ICR) is simply described, as a technology that enables a computer to distinguish handwritten letters and translate them into text that can be read by a computer. ICR services enhance OCR systems' effectiveness by converting different handwriting slants into data that can be extracted from both structured and unstructured texts. Every time when an additional evidence is introduced to ICR, it strengthens and updates its knowledge acquisition process through artificial neural networks and adds characters to the authenticate the database with each new handwriting thereby improving the accuracy of analyzes of recognition over time.

j) **Human identification using various biometric modalities (e.g. face, fingerprint, iris, and palm):** Depending on the kind of human attribute, it accepts as input, and the biometric paradigm falls under the umbrella of a biometric system. The following biometric technologies are available: voice, handwriting recognition, iris, face, fingerprint, and hand geometry. The majority of biometrics is quantifiable, and there is no one biometric technique that is excellent while deploying of biometric system. Considering many factors, such as location, security risks, task (identification or verification), anticipated user count, user situations, previous data, etc., must be measured when incorporating a biometric device. Increasing the availability of data sample the system becomes distinctive and trustworthy. It can operate on a variety of paradigms related to behavioral patterns, measurements of a person's physique and features. Biological characteristics of the person are used to categorize the paradigms [12].

k) **Visual monitoring**: Intelligent monitoring systems (IMS) can be used as an alternative of conventional monitoring systems. In IMSs, anomalous behaviors in videos are recognized by using computer vision, pattern recognition, and artificial intelligence technologies. They discuss the advancement of real-time, intelligent surveillance technologies that are behavior-based [11].

l) **Intelligent transportation:** Modern wireless, electronic, and automated technologies are a part of intelligent transportation systems (ITS). These technologies have the ability to combine users, infrastructure, and vehicles (such as transit, trucks, and personal automobiles) (roads and transit). Computerized guideways, collision avoidance systems and precise bus docking are just a few examples of computerized and in-vehicle innovations [13].

5. ADVANTAGES OF INTELLIGENT SYSTEM

An intelligent system has the capacity to explain its activities, has sophisticated decision-making processes, and is knowledgeable in a certain field. The ability of an intelligent system to communicate with humans to instruct or support

sophisticated information processing is its most crucial feature [7].

1. An intelligent system functions in a setting where there are other agents,
2. Comprises cognitive skills such language usage, analytical reasoning, action control, and observation.
3. Respects behavioral guidelines based on reason and traditional conventions and
4. Has the ability to learn and adapt.

6. DISADVANTAGES OF INTELLIGENT SYSTEM AND ITS SOLUTION

Following are disadvantages of intelligent system and its solution.

1. **Mapping:** A significant amount of information is lost when switching from the 3-Dimensional to the 2-Dimensional environment. Clustering objects with intra- and inter-class variation, adjustments in viewpoint, illumination, and scale, complex background, and animation are difficulties for computer vision [11].
   Solution: Integrated device management system can be deployed using the artificial intelligence applications irrespective of the device type and its framework. New artificial intelligence algorithms and models can be developed to scale to computer vision issues.
2. **Computing Power**: Since developing the algorithms and models, consume more power. Since machine learning and deep learning are the cornerstones of contemporary AI, and in order for them to perform well, they both require a growing number of cores and GPUs.
   Solution: Deep learning frameworks can be applied to a wide range of tasks, including as tracking celestial bodies, providing healthcare, and monitoring asteroids.
3. Time-consuming computation: To identify the most efficient path to a destination, it takes a significant amount of effort and resource to search within an extremely large state space. The drawback of excess time spent on computing is that if the world changes during that period, the computed approach will become obsolete.
   Solution: To overcome the time consumption computation method, an intelligent real time scheduling can be introduced which is based on the artificial intelligence methods such as Artificial Neural Networks (ANN), Reinforcement learning, Fuzzy logic, Artificial Immune system, Swarm intelligence etc.
4. **Trust Deficit:** One of the most important issues that worries artificial intelligence is the uncertain nature of how deep learning models forecast the output. It can be difficult for the typical person to understand how a certain set of inputs might offer a solution to a variety of problems. Many people around the world have no idea what artificial intelligence is, what it can do, and how it has been implemented into devices they use every day like smartphones, smart TVs, banking systems, and even cars (at some level of automation).
   Solution: The gap can be addressed through the utilization of good data, the key competencies such as right expertise, leadership support, and productive collaboration between data scientists and end users. Proper models, coupled with experimental methods, guides the choice of the best modelling approach that satisfies the following requirements:
   a) Transparent: The system may describe how the system will operates and the necessity why specific predictions are made.
   b) Reliable: The system can manage various real-world circumstances an requires no ongoing supervision.
   c) Self-Explanatory: The system should communicate the required details about its central workings system, the correlations it discovers, and the outcomes it produces.
5. **Limited Knowledge:** Although there are multiple areas in the industry where artificial intelligence can be used as a superior replacement for conventional technologies. The knowledge of artificial intelligence is the true issue. Only a small percentage of individuals, excluding computer enthusiasts, college students, and researchers, are aware of the possibilities of AI.
   Solution: The developed system should be transparent and self-explanatory, explaining the central working of the system, the outcomes and why the particular decisions or predictions are made.
6. **Human-level:** One of the biggest challenges in artificial intelligence is to enhance artificial intelligence services for enterprises and start-ups. Humans are still superior in every situation. Humans are capable of learning and using broad knowledge to address issues in a wide range of areas. The ability to switch effortlessly through one learning assignment to the next when necessary to enable problem solving is a function of general intelligence.
   Solution: In the recent years, artificial intelligence has gained a huge importance and progress tremendously. By using machine, learning and deep learning, which are the branches of artificial intelligence, can act as the catalyst for quick learning activity. Different algorithms and models can be developed in machine learning and deep learning for quick learning process. For a deep learning system to behave effectively, with extremely fine customization, hyper-parameter enhancement, a huge sample, an accurate and well-defined procedure, as well as substantial computational resources, continuous training on train data, and evaluation on test data.
7. **Data Privacy and Security:** The main factor on which all deep and machine learning models are based is the access to data and resources to train these models. There is tremendous amount of data, which is generated by heterogeneous users around the world, and there is a high possibility that it could be mishandled. Internet activity, corporate behavior, and governmental decisions all prioritize privacy issues. This is primarily a reaction towards the controversies, hacks, and disclosures of confidential communications that already have damaged public trust in technology and information systems. Three important data privacy principles data accuracy, data protection and data control needs to be focused.
   For example: A medical service provider who is serving a city, different categories of people and maintains a huge database which includes the wide range of details of all the users which includes the details about their illness, health problems, medical histories etc. A cyberattack on this database may result in the leakage of all the private data's of everyone and which will land in the hands of dark web.
   Solution: Data privacy can be obtained by;
   a) Sanitization of good data: Only the necessary data types required to build the artificial intelligent system should be gathered, and those should be adequately protected and preserved to achieve the goal.
   b) Use of good statistical data: Developers of artificial intelligence should utilize reliable, impartial and

comprehensive data sources. Programmers should create artificial intelligence algorithms that checks similar algorithms quality, reliability and effectiveness.

c) Giving users the control: Individuals should to be aware of how personal data is being utilized, whether artificial intelligence is being used to draw conclusion regarding them, or whether their information is being utilized to build AI. Additionally, they should be offered the option to agree to the usage of their data.

d) Reduce algorithm bias: When training artificial intelligence, make sure that the data source are extensive and diverse. Technological prejudice presents issues most frequently for populations who make up a small part of technology workforce, such as women, minorities and the senior individuals. Proper artificial intelligence and machine learning models can be developed to control cybercrimes and other data security issues. Some of the areas where the artificial intelligence and machine learning models are beneficial.

a) Detecting and Responses
b) Online Rackets
c) Advanced Certification and Endorsement
d) Individual screening
e) Surveillance of larger scale for individuals

8. **The Bias Problem:** An AI system's quality is largely determined by the volume of data it has been trained on. Therefore, the capacity to gather high-quality data will be essential for creating future AI systems that work effectively. The real data that the businesses collect on a regular basis, however, is poor and has no inherent value. They are prejudiced and only serve to characterise the traits of a select few people who, in terms of race, religion, ethnicity, gender, and other variables, have comparable interests. Real change won't happen until certain algorithms are developed that can track these problems with accuracy.
9. **Data Scarcity:** Many global businesses are being accused of utilizing user data collected unethically; many growing nations are implementing tough information technology regulations to limit the flow. These businesses are now faced with the challenge of designing applications for the global market utilizing local data, which would be biased. Since data is a crucial component of artificial intelligence, and labelled data is used to teach computers how to comprehend and forecast the future. Despite the lack of data, several businesses are working to develop novel approaches and artificial intelligence models that can produce reliable findings. The system may become problematic if the data were skewed.

Solutions: If the proper data privacy and security are maintained for the individual's data then, the trust deficit from the individuals mind will be removed and they will be shared data and thus the data scarcity can be controlled. Algorithms are developed that can track these problems with accuracy.

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7. CONCLUSION

Present development in the human growth is making the crucial switch from the information society to the intelligent society, which integrates human-physics-information. Computing technologies are undergoing revolution and potentially devastating, improvements have taken place during this changeover. The prospects of computing is thought to rest in intelligent computing, including both intelligently directed and intelligently enabled computing. In this well-equipped smart society, it will offer universal, affordable, private, independent, dependable, and accessible computational services to facilitate large-scale and complicated computational operations. Unfortunately, computational intelligence technologies are neither extremely portable nor economical due to their sheer complexity and abundance of sensors. Future advancements in intelligent computing' architecture and multi-mode hybrid classification technologies might lower costs and enhance mobility, adaptability, and dependability. Additional growth strategy would involve fusing sophisticated computation with other cutting-edge technologies to further progress.

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