



**NILE UNIVERSITY
OF NIGERIA**

HONORIS UNITED UNIVERSITIES



2nd Inaugural Lecture

Titled

MACHINE INTELLIGENCE

vs

**HUMAN INTELLIGENCE:
CAN MACHINES OUTPERFORM
HUMANS?**

To be delivered by

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Regd Engr (Coren), MCPN, MNSE



SECOND (2ND) INAUGURAL LECTURE

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Thursday, 17th October 2024



...Beyond Degrees...

Vision:

Nile University of Nigeria visualizes itself as becoming a vanguard university that gains the respect of the world through academic excellence by providing the highest quality university education for students from around the globe.

Mission:

To provide students with opportunities of quality university education that will bring out the best in them to make them stand tall through time and ready to face the challenges of a globalized world.

NATIONAL ANTHEM

Nigeria we hail thee
Our own dear native land,
Though tribe and tongue may differ,
In brotherhood, we stand,
Nigerians all, and proud to serve
Our sovereign Motherland.

Our flag shall be a symbol
That truth and justice reign,
In peace or battle honour'd,
And this we count as gain,
To hand on to our children
A banner without stain.

O God of all creation,
Grant this our one request,
Help us to build a nation
Where no man is oppressed,
And so with peace and plenty
Nigeria may be blessed.

DEDICATION

He also brought me up out of a horrible pit, Out of the miry clay, And set my feet upon a rock, and established my steps - Psalm 40:2.

This lecture is dedicated to my Lord and savior, Jesus Christ - the Author and Finisher of my faith.

PROTOCOL

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Deans of the Faculties
Professors and other Members of the Senate
Dean of Student Affairs
Directors
Heads of Departments
Academic Staff
Members of Congregation
My family members
Great Students of the Nile University of Nigeria
Members of Alumni
My Lords, Spiritual and Temporal
Esteemed Guests, and Friends
Gentlemen of the Press
Distinguished Ladies and Gentlemen

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PREAMBLE

Vice Chancellor Sir,

It is with great pleasure that I welcome you to this inaugural lecture, where we will embark on a fascinating journey into the realm of intelligence—a concept that has captivated philosophers and scientists for centuries. Today, we stand at the intersection of human and machine intelligence, exploring how our understanding of cognition has paved the way for groundbreaking advancements in artificial intelligence. This lecture will begin by defining intelligence in both human and machine contexts, tracing its origins from cognitive psychology and neuroscience to the sophisticated algorithms that now drive modern AI systems. We will delve into how human traits such as adaptability, creativity, and emotional depth have inspired the development of brain-inspired AI, leading to machines that can learn and adapt in ways once thought impossible.

As we delve deeper, our focus will shift to the evolution of both human and machine intelligence. We will examine the rapid advancements that have characterized recent developments in AI, including large language models and computer vision technologies. These innovations have not only transformed industries such as healthcare and transportation but have also introduced new possibilities for enhancing diagnostic precision and personalizing medical treatments. The discussion will highlight the significant strides made in replicating human visual capabilities through computer vision and how these technologies are being employed to address real-world challenges, from disease detection to autonomous vehicles.

In concluding this lecture, we will explore the collaborative potential of human and machine intelligence. While machines excel in data processing and repetitive tasks, they still lack the creative and ethical dimensions of human cognition. The future lies in harnessing the strengths of both, fostering a synergy that combines human ingenuity with machine efficiency. This collaborative approach is exemplified by advances in generative AI and large language models, which are pushing the boundaries of what machines can achieve. As we reflect on these developments, we are invited to rethink our understanding of intelligence, creativity, and the transformative power of technology in shaping our future.

Professor Steve A. Adeshina

Professor of Computer Vision and Engineering

Thursday, 17th October 2024

INTRODUCTION

Mr. Vice Chancellor Sir, Inaugural lectures offer scholars a platform to bridge academia and society, sharing their research, insights, and aspirations. This lecture, titled 'Machine Intelligence vs. Human Intelligence: Can Machines Outperform Humans?' explores the transformative impact of artificial intelligence (AI) and computational intelligence on humanity. It reflects on the profound implications of these technologies and celebrates advancements in the field.

Intelligence, a concept long debated by philosophers and scientists, is now central to innovation. The evolution from understanding human intelligence to creating machines that emulate and enhance cognitive abilities is remarkable. This lecture starts by clarifying intelligence and exploring both human and machine forms.

Human intelligence, rooted in cognitive psychology, neuroscience, and philosophy, is characterized by adaptability, creativity, and emotional depth. These traits have enabled humans to dominate the natural world and build complex societies. Brain-inspired AI aims to replicate these abilities in machines, leading to systems that learn and adapt. AI, encompassing machine learning, natural language processing, and robotics, is now crucial in fields such as healthcare, finance, and transportation, performing tasks that require human-like intelligence.

Machine intelligence, a branch of AI, focuses on autonomy, enabling systems to perform tasks independently and efficiently. This includes technologies like autonomous vehicles, which make real-time decisions without human input. Augmented intelligence—the collaboration between human and machine—is a key area of exploration. It combines human strengths with machine efficiency, shaping a future where both work together to solve complex problems.

Vision, both human and machine, is a key theme. Human vision, a sophisticated process, has inspired computer vision, a field of AI that allows machines to interpret visual information. While computer vision has advanced in facial recognition and object detection, it has not yet fully replicated human vision.

One of the most promising areas of AI application is intelligence-based medicine. In this domain, AI systems are being developed to enhance diagnostic precision, personalize treatment plans, and even assist in surgical procedures through robotic systems. The potential of AI to revolutionize healthcare is immense, offering the possibility of improved patient outcomes, reduced costs, and increased accessibility to medical services.

As the lecture concludes, it emphasizes the collaborative future of human and machine intelligence. While machines excel in data processing and repetitive tasks, they lack the

creativity, empathy, and ethical judgment of humans. The future lies in collaboration, where human and machine intelligence complement each other, driving innovation and shaping society. Generative AI and large language models exemplify this future, enabling machines to engage in creative processes and assist humans in innovative tasks. As machine intelligence rapidly advances, it challenges us to rethink our understanding of intelligence, creativity, and the potential of technology.

CONCEPTUAL CLARIFICATION

INTELLIGENCE

- **Human Intelligence**

The human brain is renowned for its complexity and advanced information-processing capabilities. It contains over 86 billion neurons, each capable of forming up to 10,000 synapses with other neurons. This creates an extraordinarily intricate network that underpins human intelligence. Beyond its physiological complexity, the brain's functional capabilities are enhanced by its ability to integrate information from various sensory modalities—such as vision, hearing, and touch—into a unified perception of the world. The brain's capacity for parallel processing allows it to handle multiple streams of information simultaneously. This phenomenon, known as neuroplasticity, enables continuous learning and skill development throughout a person's life [1].

Additionally, the human brain excels in high-level cognitive functions, including problem-solving, decision-making, creativity, and abstract reasoning. These abilities are largely supported by the prefrontal cortex, a brain region particularly well-developed in humans [1].

Artificial General Intelligence (AGI) refers to a type of artificial intelligence that aims to replicate or surpass human-level intelligence across a wide range of intellectual tasks. Unlike narrow AI, which is designed for specific tasks, AGI would possess the versatility and adaptability of human cognition. The pursuit of AGI involves creating systems capable of reasoning, problem-solving, and creativity on par with human abilities [2].

The quest to develop AGI has been a long-standing goal, dating back to the mid-20th century. In the 1940s, pioneers like Alan Turing explored the concept of computing machines and their potential to emulate human thought. Since then, efforts to replicate the principles of human intelligence in artificial systems have significantly advanced AGI research and its applications [1].

- **Brain inspired AI**

In 1943, McCulloch and Pitts introduced the first mathematical model of an artificial neuron, known as the McCulloch-Pitts (MCP) Neuron [3]. Despite this early work, research in artificial neural networks stagnated until 1982, when Werbos applied the backpropagation algorithm to the multi-layer perceptron (MLP) [4]. Inspired by the brain's synaptic plasticity—its ability to modify the strength of connections between neurons to learn and improve performance—backpropagation adjusts the weights (synaptic strengths) between neurons in an artificial neural network. One major breakthrough in AI is the development of neural networks, which are inspired by the brain's structure. Artificial neural networks consist of layers of interconnected nodes, or artificial neurons, designed to simulate the way biological neurons process information. The architecture of an Artificial Neural Network is shown in Figure 1. The backpropagation algorithm, which refines these connections based

on error feedback, mimics the brain's synaptic plasticity, allowing the system to learn and improve over time [5]. Although proposed in the 1970s, backpropagation gained widespread attention only in the 1980s, when researchers like David Rumelhart, Geoffrey Hinton, and Ronald Williams demonstrated its effectiveness for training neural networks [1].

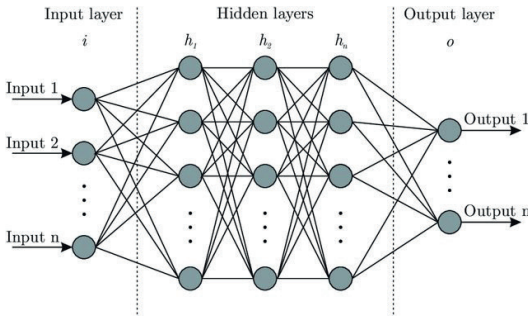


Figure 1: Artificial Neural Network Architecture [6]

Building on this foundation, Convolutional Neural Networks (CNNs) represent a significant advancement in AI, particularly in image and visual recognition. CNNs are designed to emulate the brain's visual processing hierarchy, where simple visual features are detected first before more complex patterns are identified. This hierarchical structure enhances the network's ability to analyze and interpret visual data effectively [7]. Convolutional Neural Networks (CNNs) are among the most widely used neural networks for processing visual information [8]. They draw inspiration from the hierarchical organization of the visual cortex in the brain, a concept pioneered by David Hubel and Torsten Wiesel in the 1960s [9]. In the visual cortex, neurons are arranged in layers that process visual information hierarchically. Simple cells detect edges and orientations, while more complex cells recognize shapes and textures. This hierarchical processing inspired the development of CNNs, as illustrated in Figure 2.

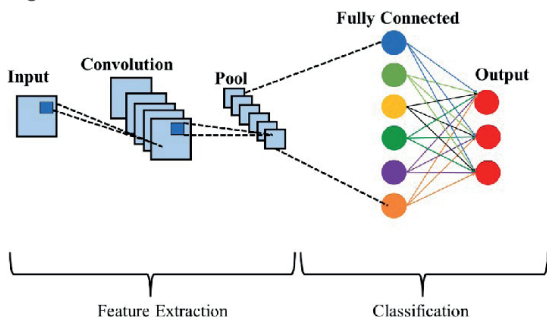


Figure 2: Convolutional Neural Network Architecture [10]

Attention mechanisms in artificial neural networks, which mimic how the human brain selectively focuses on certain sensory inputs while filtering out irrelevant details, have significantly advanced AI [11]. The Transformer model, utilizing self-attention mechanisms,

has become the foundation for many state-of-the-art neural networks like BERT [12] and GPT [13]. Vision Transformer (ViT) [14] adapts these self-attention mechanisms to image processing, achieving remarkable performance in various computer vision tasks by representing images as sequences of patches. The architecture of the transformer is shown in Figure 3. Recent innovations include brain-inspired models like the brain-inspired adversarial visual attention network (BI-AVAN), which mimics the biased competition process in human visual systems to decode visual attention [15]. The authors in [16] proposed a core-periphery principle-guided vision transformer model (CP-ViT) for enhanced image recognition and interpretability. Similarly, [17] applied the core-periphery principle to network wiring patterns and convolution operation sparsification, demonstrating the effectiveness of their core-periphery principle-guided CNNs (CP-CNNs) compared to traditional CNNs and ViT-based methods. Spiking Neural Networks (SNNs) closely emulate biological neurons' behavior, being used to map spatio-temporal brain data, decode muscle activity from electroencephalography signals, and develop brain-machine interfaces [18].

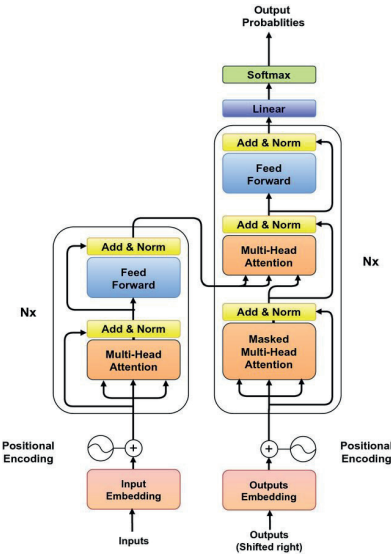


Figure 3: Transformer Architecture [19]

Current language models, such as ChatGPT and GPT-4, use reinforcement learning with human feedback (RLHF) to align their behavior with human values [20]. As research continues, the relationship between human intelligence and AGI will deepen, leading to new and exciting developments. By studying the brain and developing AI systems that mimic its architecture and function, researchers aim to create AGI that is more sophisticated and adaptable. This progress not only brings us closer to achieving machines with human-level or superior intelligence but also has the potential to enhance our understanding of human intelligence itself. This synergy is shown in Figure 4

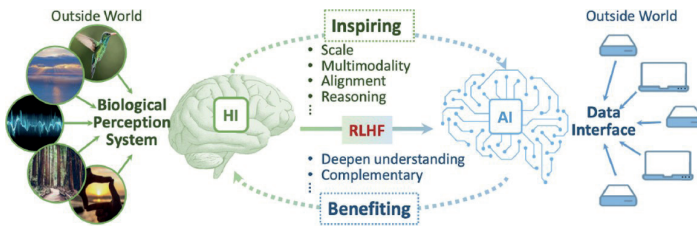


Figure 4: Human Intelligence and Artificial Intelligence [21]

• Artificial Intelligence

Artificial Intelligence (AI) and human intelligence share a profound connection, particularly through the lens of brain-inspired AI. Human intelligence, characterized by its ability to learn, reason, and adapt, serves as the primary inspiration for developing advanced AI systems [22]. The intricate architecture and functionality of the human brain—comprising over 86 billion neurons and their extensive synaptic connections—have guided the creation of AI models that mimic these biological processes [22].

Artificial Intelligence (AI) leverages insights from human intelligence to create systems capable of complex tasks. While human intelligence involves learning, reasoning, and problem-solving through the brain's intricate network of neurons, AI aims to replicate these processes using computational models [23].

Furthermore, AI has incorporated attention mechanisms, which are inspired by human cognitive processes. These mechanisms enable AI systems to focus on relevant information while filtering out less important details, much like how humans prioritize what they pay attention to. This approach has been pivotal in improving the performance of AI models in tasks such as language translation and speech recognition [24].

Recent advancements in neuromorphic and quantum computing are reshaping the landscape of AI by drawing inspiration from human brain functions. Neuromorphic chips, such as IBM's TrueNorth and Intel's Loihi, replicate brain-like processing using spiking neural networks, improving efficiency and speed through parallel and distributed processing similar to the brain [25]. Meanwhile, quantum computing introduces a revolutionary approach to processing, leveraging quantum bits (qubits) and principles of superposition and entanglement, which allow for massive computational power and the potential to solve complex AI problems far beyond the reach of classical computers [26].

Artificial Intelligence (AI) can be categorized based on its capabilities, reflecting its varying degrees of complexity and responsiveness in relation to human intelligence.

- a. **Classical AI:** Classical AI often referred to as "good old-fashioned AI" (GOFAI), is a traditional approach to artificial intelligence that focuses on symbolic reasoning and knowledge representation. It aims to mimic human intelligence by creating systems that can solve problems through logical deduction and rule-based systems. Examples

of classical AI applications include expert systems (e.g., medical diagnosis systems), game-playing programs (e.g., chess and checkers), and natural language processing systems (e.g., early chatbots). While classical AI has achieved significant success in certain domains, its limitations in handling uncertainty, ambiguity, and real-world complexities have led to the development of more modern AI approaches like machine learning and deep learning [27].

- b. **Narrow AI:** Also known as Weak AI, Narrow AI excels at performing specific tasks but lacks the ability to generalize beyond its programmed functions. Examples include Apple's Siri, Google Translate, and image recognition software. These systems are highly effective in their designated areas but cannot handle tasks outside their predefined scope. Despite its limitations, Narrow AI is highly practical for specialized applications, enhancing efficiency in routine tasks [28].
- c. **General AI:** Also referred to as Strong AI, this technology aspires to match human cognitive abilities. It would be capable of understanding and learning any intellectual task a human can, applying knowledge across various contexts. While no true General AI exists yet, research is ongoing. For instance, Fujitsu's K computer, one of the world's fastest supercomputers, has made strides towards Strong AI but still requires extensive computational time to simulate neural activity. The significant investment from Microsoft through OpenAI indicates that achieving General AI is an ambitious but attainable goal [28].
- d. **Super AI:** Super AI, a hypothetical type of artificial intelligence that surpasses human intelligence in all aspects, remains a futuristic concept, that is yet to be realized. Super AI would not only outperform humans in all tasks but also experience and evoke human-like emotions. It envisions an entity with its own needs and desires, a futuristic vision still confined to science fiction [28].

AI can also be categorized based on its functionalities, reflecting different levels of complexity in interaction and learning.

- a. **Reactive Machines:** The most basic form of AI, Reactive Machines respond to present stimuli without using past experiences. Examples include chatbots and IBM's Deep Blue, which defeated chess champion Garry Kasparov by reacting to the chessboard's current state without historical context. Despite their simplicity, Reactive Machines can be powerful in specific applications, such as self-driving cars [29].
- b. **Theory of Mind AI:** This concept envisions AI that can understand and interpret human emotions and thoughts. Although still largely theoretical, developments like MIT's Kismet, which mimics and recognizes emotions, are steps toward this capability. Such AI could revolutionize fields like marketing by responding to emotional states and improving user interactions [29].
- c. **Limited Memory AI:** This type utilizes recent data to make decisions but cannot retain information beyond a certain point. ChatGPT, for instance, operates within a token limit and cannot recall information beyond this capacity. Limited Memory AI is beneficial for applications where temporary data retention is crucial, such as virtual assistants and fraud detection systems [29].

- d. **Self-Aware AI:** The ultimate goal in AI development, Self-Aware AI would surpass human cognitive abilities and possess its own emotions and beliefs. While still theoretical, it raises important ethical considerations about control and the impact of creating entities that could potentially exceed human intelligence [29].

Essentially, AI continues to evolve by incorporating principles from human intelligence, enhancing its capability to perform a wide range of tasks and driving forward innovations that bridge the gap between artificial and biological cognition.

- **Computational Intelligence**

Computational intelligence represents a field within artificial intelligence that focuses on developing systems capable of learning and adapting from experience. It departs from classical AI approaches that rely on predefined models and formal logic, instead embracing methods like neural networks, fuzzy systems, and evolutionary computation. These methods allow for the creation of algorithms that can navigate uncertain environments and solve complex problems where traditional models fail [30].

Computational intelligence has seen significant growth due to its application in areas like pattern recognition, optimization, and control systems. Its ability to handle imprecise information and learn from data makes it particularly valuable in dynamic and unpredictable domains such as robotics, autonomous systems, and financial modeling. As the field evolves, the synergy between computational intelligence and other AI branches continues to expand, opening up new possibilities for intelligent systems that mimic human cognitive abilities more closely [31].

- **Machine Intelligence and Artificial Intelligence**

Machine intelligence encompasses the broader concept of endowing machines with the capability to perform tasks that typically require human intelligence. It includes a range of techniques from traditional rule-based systems to modern machine learning algorithms. Artificial intelligence, often used interchangeably with machine intelligence, is a specific branch focused on creating machines that can perform tasks like reasoning, learning, and problem-solving [32]. The distinction lies in their scope: AI is a subset of machine intelligence, which includes not only AI but also other forms of non-AI-based intelligent systems.

The interplay between machine intelligence and AI is crucial in the development of advanced technologies, as AI provides the framework for building intelligent systems that can learn from data, adapt to new situations, and make decisions autonomously [33]. The evolution of AI, driven by breakthroughs in machine learning, natural language processing, robotics, and computer vision continues to push the boundaries of what machines can achieve, bringing us closer to the vision of truly intelligent systems.

- **Augmented Intelligence**

Augmented intelligence represents a collaborative approach where human intelligence is enhanced by AI technologies. Unlike traditional AI, which aims to replace human tasks, augmented intelligence focuses on complementing and amplifying human capabilities [34]. It leverages AI tools to assist with decision-making, data analysis, and problem-solving, allowing humans to focus on more complex and creative tasks. This approach emphasizes the symbiotic relationship between humans and machines, where AI acts as an enabler rather than a replacement [35].

Augmented intelligence is particularly relevant in fields such as healthcare, finance, and education, where human judgment and expertise are crucial [36]. By enhancing human capabilities with AI, augmented intelligence seeks to improve efficiency, accuracy, and overall decision quality. As AI technologies continue to evolve, the concept of augmented intelligence is expected to play a central role in shaping the future of work and human-computer interaction, fostering a new era of collaboration between humans and machines.

- **Intelligence and Vision**

Intelligence and vision are intrinsically linked, as visual perception is a fundamental aspect of intelligent behavior. Vision provides the primary means through which humans and animals interact with the world, enabling them to recognize objects, navigate environments, and interpret complex scenes [37]. In the context of artificial intelligence, vision systems are designed to replicate this capability, allowing machines to "see" and understand visual information. This involves the development of algorithms for image processing, pattern recognition, and scene understanding, which are essential for tasks such as object detection, facial recognition, and autonomous navigation [38]. The intersection of intelligence and vision is also evident in the study of human and machine vision, where researchers explore how the brain processes visual information and how this can be emulated in AI systems. As vision technology advances, it plays a crucial role in the development of intelligent systems, enabling machines to interact with the world in ways that were once thought to be uniquely human.

- **Human Vision and Machine Intelligence**

Human vision and machine intelligence represent two distinct but increasingly intertwined domains. Human vision, a product of millions of years of evolution, is remarkably sophisticated, enabling us to interpret complex scenes, recognize faces, and perceive depth and motion with ease [38]. Machine intelligence, on the other hand, seeks to replicate these capabilities through artificial means, using algorithms and computational models [32]. The challenge lies in the fact that human vision is not just about processing visual data; it involves cognitive processes like memory, attention, and inference. Machine intelligence attempts to mimic these processes, leading to the development of computer vision systems that can analyze images and videos, recognize patterns, and make decisions based on visual input [38]. The study of human vision has greatly influenced the design of these systems, providing insights into how visual information can be processed and interpreted

by machines. As machine intelligence continues to evolve, the gap between human and machine vision narrows, leading to more sophisticated and capable vision systems that are integral to applications like autonomous vehicles, surveillance, and augmented reality [38, 32].

EVOLUTION OF HUMAN AND MACHINE INTELLIGENCE

The evolution of human and machine intelligence has followed parallel but distinct paths. Human intelligence has developed over millions of years, shaped by the need to survive, communicate, and innovate. It is characterized by cognitive abilities such as reasoning, learning, problem-solving, and creativity [39]. Machine intelligence, on the other hand, has emerged over the last few decades, driven by advances in computing and artificial intelligence. Initially, machine intelligence was limited to simple rule-based systems, but it has rapidly evolved into sophisticated algorithms capable of learning from data and making decisions autonomously [32]. The convergence of these two forms of intelligence is becoming increasingly apparent as AI systems begin to replicate more complex aspects of human cognition.

The evolution of machine intelligence has been accelerated by breakthroughs in areas like neural networks, deep learning, and natural language processing, leading to the development of systems that can understand and generate human language, recognize images, and even play strategic games at a superhuman level [40]. The future of human and machine intelligence is likely to be one of collaboration, where the strengths of both are harnessed to solve problems that neither could tackle alone.

- **Human Intelligence and Learning**

Human intelligence is deeply intertwined with the ability to learn. Learning allows humans to acquire knowledge, develop skills, and adapt to new situations. It is a dynamic process that involves the integration of sensory information, memory, and cognitive functions such as reasoning and problem-solving [22]. Human learning can occur through various means, including observation, imitation, and instruction, and is influenced by factors such as environment, experience, and motivation. Machine learning, a subset of artificial intelligence, seeks to replicate this capability in machines [41]. By using algorithms to analyze data, machines can learn patterns and make predictions or decisions without explicit programming. While human learning is highly flexible and context-dependent, machine learning is often more specialized, focused on specific tasks such as image recognition or language translation [42]. The study of human intelligence and learning continues to inform the development of machine learning algorithms, as researchers strive to create systems that can learn in more human-like ways, adapting to new challenges and environments with greater flexibility and autonomy.

- **Machine Intelligence and Machine learning**

Machine intelligence and machine learning are closely related concepts within the broader field of artificial intelligence. Machine intelligence refers to the general capability of ma-

chines to perform tasks that require human-like intelligence, such as reasoning, learning, and problem-solving. Machine learning, on the other hand, is a specific approach to achieving machine intelligence. It involves the use of algorithms that allow machines to learn from data, identifying patterns, and making decisions based on that data [32].

Unlike traditional programming, where rules are explicitly coded, machine learning enables machines to improve their performance over time by learning from experience. This approach has led to significant advancements in areas such as natural language processing, computer vision, and autonomous systems. Machine learning algorithms are now capable of tasks that were once thought to be the exclusive domain of humans, such as recognizing faces, understanding speech, and playing complex games like chess and Go [41]. The continued development of machine learning is key to the advancement of machine intelligence, as it provides the foundation for creating systems that can adapt to new challenges and operate in dynamic environments.

- **Large Language Models**

Large language models represent a significant advancement in the field of natural language processing and artificial intelligence. These models, such as GPT-3 and BERT, are trained on vast amounts of text data, enabling them to generate human-like text, understand context, and even engage in complex conversations [43]. The development of large language models has been driven by the need to create AI systems that can interact with humans in natural language, a key challenge in AI research. These models leverage deep learning techniques, particularly transformers, to process and generate text at an unprecedented scale. They are capable of tasks such as translation, summarization, sentiment analysis, and even creative writing.

However, the power of large language models also raises important ethical considerations, such as the potential for bias, misinformation, and the implications of AI-generated content [44]. As these models continue to evolve, they are likely to play an increasingly important role in a wide range of applications, from customer service and content creation to education and entertainment, reshaping the way we interact with technology.

- **Large Vision Models**

Large vision models, often powered by deep learning architectures like convolutional neural networks (CNNs) and transformers, have revolutionized the field of computer vision by achieving unprecedented accuracy in tasks such as image classification, object detection, and segmentation. These models are trained on vast datasets, sometimes consisting of millions or even billions of labeled images, enabling them to capture complex patterns and generalize well across diverse domains [45, 46]. Key advancements include Vision Transformers (ViTs), which leverage self-attention mechanisms to process visual data more efficiently than traditional CNNs, leading to breakthroughs in performance. The scale of these models also allows them to perform zero-shot or few-shot learning, where they can successfully apply knowledge from one task to a new, unseen task with minimal training.

Despite their successes, large vision models pose challenges in terms of computational cost, energy consumption, and ethical concerns related to data privacy and bias [46].

COMPUTER VISION AND HUMAN VISION

Computer vision and human vision are two distinct yet complementary concepts. Human vision is a highly complex process that involves the eyes capturing light, which is then processed by the brain to form images and recognize objects. It is an integral part of human intelligence, enabling us to navigate the world, recognize faces, and interpret visual information [47]. Computer vision, on the other hand, is a field of artificial intelligence that aims to replicate this capability in machines. It involves the development of algorithms that can process and analyze visual data, allowing machines to “see” and understand images and videos. While human vision is highly flexible and can adapt to a wide range of conditions, computer vision systems are often more specialized, designed for specific tasks such as object detection, facial recognition, or image classification [47]. The study of human vision has greatly influenced the development of computer vision, providing insights into how visual information is processed and how this can be emulated in AI systems.

- **Computer Vision as a Discipline**

Computer vision is a rapidly growing discipline within the field of artificial intelligence, focused on enabling machines to interpret and understand visual information. It combines techniques from image processing, machine learning, and pattern recognition to create systems that can analyze images and videos, recognize objects, and make decisions based on visual input [48]. The development of computer vision has been driven by advances in both hardware, such as cameras and sensors, and software, particularly machine learning algorithms that can learn from large datasets. Applications of computer vision are wide-ranging, from autonomous vehicles and robotics to medical imaging and augmented reality. As a discipline, computer vision is highly interdisciplinary, drawing on knowledge from fields such as mathematics, computer science, and cognitive science [49].

The challenges in computer vision include dealing with variations in lighting, viewpoint, and occlusion, as well as understanding complex scenes with multiple objects and interactions. Despite these challenges, the field has made significant progress in recent years, leading to the development of systems that can perform tasks such as facial recognition, object detection, and even image generation with remarkable accuracy [50]. The continued growth of computer vision as a discipline is likely to play a crucial role in the advancement of AI and its applications in the real world.

- **Artificial Intelligence, Machine Vision, Machine Learning**

Artificial intelligence, machine vision, and machine learning are three interconnected fields that together form the backbone of modern intelligent systems. Artificial intelligence encompasses the broad goal of creating machines that can perform tasks requiring human-like intelligence, such as reasoning, learning, and decision-making. Machine vision, a subset of AI, focuses specifically on enabling machines to process and interpret visual information,

allowing them to “see” and understand the world around them. Machine learning, another key subset of AI, involves the development of algorithms that enable machines to learn from data and improve their performance over time without explicit programming [49]. This interconnectivity is shown in Figure 5.

The interplay between these fields is essential for the development of advanced AI systems. For example, machine vision systems often rely on machine learning algorithms to recognize objects in images, while AI provides the overall framework for integrating visual information with other forms of data to make decisions. The combination of AI, machine vision, and machine learning has led to significant advancements in areas such as autonomous vehicles, robotics, and healthcare, where machines are increasingly able to perform complex tasks with a high degree of accuracy and autonomy.

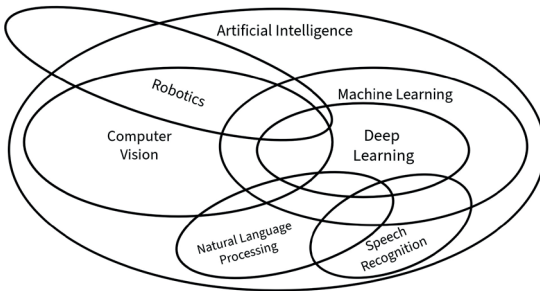


Figure 5: Fields of Artificial Intelligence [51]

TECHNIQUES OF ARTIFICIAL INTELLIGENCE AND COMPUTER VISION

The techniques used in artificial intelligence and computer vision are diverse and continue to evolve as the fields advance. In artificial intelligence, techniques such as rule-based systems, neural networks, and deep learning are commonly used to create intelligent systems.

Rule-based systems rely on predefined rules and logic to make decisions, while neural networks and deep learning algorithms learn from data, identifying patterns and making predictions. In computer vision, techniques such as image processing, feature extraction, and pattern recognition are key to enabling machines to analyze and interpret visual information. Image processing techniques involve the manipulation of images to enhance their quality or extract useful information, while feature extraction focuses on identifying specific elements within an image, such as edges, corners, or textures [52].

Pattern recognition is used to classify objects or scenes based on their visual features. Machine learning techniques, particularly deep learning, have also become increasingly important in computer vision, allowing machines to learn from large datasets of images and improve their accuracy in tasks such as object detection and facial recognition. As AI and computer vision techniques continue to develop, they are likely to become even more

powerful and capable, enabling machines to perform a wider range of tasks with greater precision and autonomy [49].

INTELLIGENCE BASED MEDICINE

Intelligence-based medicine is an emerging field that leverages artificial intelligence to enhance medical care and decision-making. By integrating AI technologies with healthcare, intelligence-based medicine aims to improve diagnostic accuracy, personalize treatment plans, and optimize patient outcomes [53]. AI-driven systems can analyze vast amounts of medical data, including patient records, lab results, and imaging studies, to identify patterns and make predictions about a patient's health. This approach allows for more precise and individualized care, as AI can identify risk factors and suggest treatment options based on a patient's unique profile [54].

Intelligence-based medicine also has the potential to improve the efficiency of healthcare delivery by automating routine tasks, reducing the burden on healthcare providers, and enabling faster and more accurate diagnoses. As AI continues to advance, the integration of intelligence-based medicine into clinical practice is expected to revolutionize healthcare, leading to better patient outcomes and more efficient use of resources.

- **Diagnostic Precision**

Diagnostic precision refers to the accuracy and reliability of medical diagnoses, a critical aspect of healthcare. With the advent of AI, the precision of diagnostics has seen significant improvements. AI algorithms, particularly those based on machine learning and deep learning, can analyze complex medical data, including imaging studies, lab results, and genetic information, to identify patterns that may be indicative of disease [55]. This enables earlier and more accurate detection of conditions, reducing the likelihood of misdiagnosis and improving patient outcomes. AI-driven diagnostic tools can also assist healthcare providers by offering second opinions, flagging potential issues, and suggesting further tests or treatments. The goal of diagnostic precision is to ensure that patients receive the right diagnosis at the right time, leading to more effective and personalized treatment plans [56]. As AI technology continues to evolve, its impact on diagnostic precision is expected to grow, contributing to the overall improvement of healthcare quality and patient safety.

- **Personalized Medicine**

Personalized medicine is an approach to healthcare that tailors treatment plans to an individual's unique genetic makeup, lifestyle, and environment [57]. The goal is to provide more effective and targeted therapies that are specific to each patient, rather than relying on a one-size-fits-all approach. AI plays a crucial role in the development of personalized medicine by analyzing vast amounts of data, including genetic information, medical history, and lifestyle factors, to identify patterns and predict how a patient will respond to different treatments. This enables healthcare providers to design treatment plans that are more likely to be effective for each individual patient. Personalized medicine also has the potential to improve the efficiency of healthcare by reducing the trial-and-error approach

to treatment, leading to faster and more accurate results. As AI technology continues to advance, personalized medicine is expected to become more widely adopted, leading to more precise and effective healthcare [58].

- **Virtual Health Assistant**

A virtual health assistant is an AI-powered tool designed to assist patients in managing their health and wellness [40]. These assistants can provide real-time information, answer questions, and offer guidance on a wide range of health-related topics. Virtual health assistants are often available through mobile apps or web platforms, making them easily accessible to patients. They can help with tasks such as scheduling appointments, reminding patients to take medications, and providing information about symptoms or conditions. By using natural language processing and machine learning, virtual health assistants can engage in conversations with patients, offering personalized advice and support. These tools have the potential to improve patient engagement and adherence to treatment plans, leading to better health outcomes. As AI technology continues to evolve, virtual health assistants are expected to become more sophisticated, offering even more personalized and comprehensive support to patients [59].

- **AI Robotic-Driven Systems**

AI robotic-driven systems represent the integration of artificial intelligence with robotics to create machines that can perform tasks autonomously or with minimal human intervention [60]. These systems are used in a wide range of applications, from manufacturing and logistics to healthcare and personal assistance. AI-driven robots can learn from their environment, adapt to new situations, and make decisions based on data. In healthcare, AI robotic-driven systems are being used to perform complex surgeries with high precision, assist in patient care, and even provide companionship to the elderly. In manufacturing, these systems can optimize production processes, reduce waste, and improve efficiency. The development of AI robotic-driven systems is driven by advances in machine learning, computer vision, and sensor technology, which enable robots to perceive and interact with their surroundings in more human-like ways [61]. As these systems continue to evolve, they are expected to play an increasingly important role in various industries, leading to greater automation, efficiency, and innovation.

- **Deformable Models**

Deformable models are crucial for locating objects within images, utilizing local optimization techniques to match a deformable model to an image. By incorporating prior knowledge about allowable shapes, these models can handle noise, which is often present in medical images, and manage missing or incomplete data [62, 63].

A deformable model can be defined as a system that deforms a shape to match a known object in a given image, based on an implicit or explicit optimization criterion. The application of deformable models can be categorized into several variants, including energy minimizing deformable models, dynamic deformable models, discretization and numerical simulation

variants, and probabilistic deformable models [62, 63].

- a. **Snakes (Active Contour Models):** Snakes, introduced by Kass et al., are energy-minimizing curves that represent deformable templates. The energy functional consists of internal and external terms. The internal term enforces smoothness on the curve, while the external term drives the curve towards the image edges. Improved formulations, such as those by Cohen, introduce additional forces to help the snake bypass false edges, enhancing object localization. Despite these improvements, Snakes may struggle with objects of known shape due to their reliance on smoothness constraints [62, 63].
- b. **Eigen Models:** Eigen Models are statistical models that use patches extracted from regions to represent variations in intensity. Originally developed for facial recognition using Principal Component Analysis (PCA), these models assume a fixed shape for the patches, which may not accommodate shape changes, such as those in medical images or facial expressions. Eigen Models effectively capture intensity variations, but are less suited to handle shape variability and pose changes [62, 63].
- c. **Shape Models:** Active Shape Models (ASMs), developed by Cootes et al., use statistical shape models built from a training set of annotated images. ASMs refine object localization by iteratively deforming a model to fit the image data, considering shapes from the training set. This approach is more adaptable than earlier methods and avoids restrictive functions that limit shape variability. Shape models can also include techniques like Fourier descriptors, though these are less general due to their requirement for closed curves [62, 63].
- d. **Parts-Based Models (PBM):** Parts-Based Models, or Parts+Geometry models, are used to build detailed models of complex structures and locate features in new images. PBMs can create accurate models from sparse annotations, which are then used to initialize registration algorithms. This method is particularly effective for objects with repetitive structures, such as bones in the hand, and provides a foundation for more detailed models like Active Appearance Models (AAM) [64, 65].
- e. **Statistical Models of Appearance:** To build statistical models of appearance, texture data is sampled from images and analyzed using techniques like piece-wise affine deformation with Delaunay triangulation. By warping images to align with a mean shape and sampling intensities, a model of the object's appearance can be constructed.

Principal Component Analysis (PCA) is applied to capture variations in texture and shape, resulting in a linear model that integrates both shape and appearance parameters [64, 65].

The statistical models are described by the following equations:

$$\mathbf{x} = \bar{\mathbf{x}} + \mathbf{P}_s \mathbf{B}_s \quad (1)$$

where \mathbf{x} is the shape vector, $\bar{\mathbf{x}}$ is the mean shape vector, \mathbf{P}_s represents the principal modes of shape variation, and \mathbf{B}_s are the shape parameters [64, 65].

$$\mathbf{g} = \bar{\mathbf{g}} + \mathbf{P}_g \mathbf{B}_g \quad (2)$$

where \mathbf{g} is the texture vector, $\bar{\mathbf{g}}$ is the mean texture vector, \mathbf{P}_g represents the principal modes of texture variation, and \mathbf{B}_g are the texture parameters [64, 65].

The combined model that accounts for both shape and texture variations is given by:

$$\mathbf{x} = \bar{\mathbf{x}} + \mathbf{Q}_s \mathbf{C} \quad (3)$$

$$\mathbf{g} = \bar{\mathbf{g}} + \mathbf{Q}_g \mathbf{C} \quad (4)$$

where \mathbf{Q}_s and \mathbf{Q}_g are orthogonal modes for shape and texture variations, respectively, and \mathbf{C} is the vector of combined parameters controlling both shape and appearance [64, 65].

WHAT I HAVE BEEN DOING

Mr. Vice Chancellor sir, over the course of my academic career, I have focused extensively on teaching and developing curriculum in the areas of Machine Vision, Artificial Intelligence (AI), and related computational fields. My role as an educator has been to bridge theoretical concepts with practical applications, ensuring that students not only understand the fundamental principles but also how to apply these concepts to real-world problems. My teaching philosophy emphasizes an interactive learning environment, where students are encouraged to explore, innovate, and engage with emerging technologies.

MACHINE VISION AT NILE UNIVERSITY OF NIGERIA

At Nile University of Nigeria, I have been deeply involved in teaching Machine Vision, a critical area within the field of Artificial Intelligence. My approach has been to provide students with a robust foundation in image processing, pattern recognition, and computer vision algorithms. The course is designed to cover both the theoretical underpinnings and practical implementations, enabling students to develop skills that are applicable in various industries, including robotics, autonomous systems, and medical imaging. I also incorporate project-based learning, where students work on real-world problems, applying the techniques they have learned to create innovative solutions.

In addition, I have extended my teaching of Machine Vision to students in Computer Science, Computer Engineering, Electrical Engineering, and Mechatronics Engineering. These courses are tailored to meet the specific needs of each discipline, ensuring that students understand how Machine Vision integrates with their respective fields. For instance, Computer Science students focus more on algorithm development and software implementation, while Engineering students explore hardware integration and the design of vision-based systems. This multidisciplinary approach prepares students to work collaboratively in cross-functional teams, a skill that is increasingly important in the development of intelligent systems.

TEACHING ARTIFICIAL INTELLIGENCE RELATED COURSES

My expertise in Artificial Intelligence (AI) has shaped the development and delivery of various courses for undergraduate and postgraduate students, aimed at equipping them with the skills essential for thriving in this rapidly evolving field. These courses cover both foundational principles and cutting-edge developments, spanning topics like Computational Intelligence, Machine Learning, and Computer Vision.

In Computational Intelligence, I emphasize optimization techniques like Genetic Algorithms (GA) and Particle Swarm Optimization (PSO), which are critical for solving complex problems such as neural network optimization and feature selection. Students learn how to apply these techniques to real-world challenges, such as improving machine learning models and solving intricate engineering problems.

The Machine Learning course explores Artificial Neural Networks (ANNs) and Convolutional Neural Networks (CNNs), with a focus on their application in areas like image classification and object detection. Students not only study the theoretical architecture of these networks but also gain hands-on experience using frameworks like TensorFlow and PyTorch to build and deploy AI models.

In Computer Vision, students dive into image processing, pattern recognition, and the use of deep learning for visual data interpretation. Projects often involve real-world applications such as developing navigation systems for autonomous vehicles or analyzing medical images, offering students practical skills in industries where AI and visual data intersect.

Additionally, my courses on Generative AI explore models like GANs and VAEs, preparing students to engage with innovative AI technologies that create content such as text, images, and music. I also teach Advanced Computer Networks and Architecture, focusing on the systems that support large-scale AI applications. Together, these courses provide a comprehensive education in AI, preparing students for research and industry roles.

MY HUMBLE CONTRIBUTION IN RESEARCH, INNOVATION AND DEVELOPMENT

- **Automatic determination of Skeletal Maturity with Statistical Models of Appearance**
Mr. Vice Chancellor, my research in intelligence-based medicine focuses on leveraging AI and machine learning to enhance medical diagnostics, treatment planning, and healthcare innovation. One of the earlier aspects of my work focused on the development of an automated system for assessing skeletal maturity in children and young adults, a critical task in diagnosing and monitoring growth and endocrine disorders.

Skeletal age assessment is a non-invasive procedure based on observing bone morphology in radiographs. It is commonly used due to its simplicity, low radiation exposure, and the availability of multiple ossification centers for maturity assessment. The bones of the hand and wrist offer more than 20 sequences of events upon which maturity measurements can be based, as shown in Figure 6. Although other body parts, like the knee and teeth, provide similar sequences, hand radiographs remain dominant in clinical radiology. Growth abnormalities can be detected through large deviations in skeletal age from the chronological age, and this procedure is particularly useful in diagnosing conditions like gonadal dysgenesis and planning orthopedic procedures [66, 67, 68, 69, 70, 71].

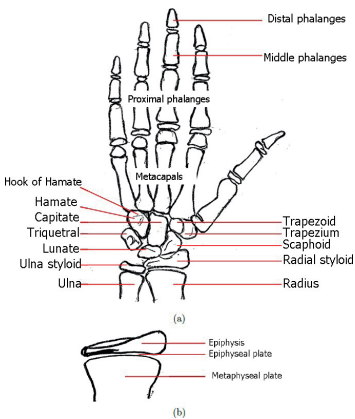


Figure 6: (a) The bones of the hand and the wrist including Carpals (Capitate, Hamate, Triquetrum, Lunate, Scaphoid, Trapezium, and Trapezoid) (b) Growth plate of the radius [66]- [71].

Current methods for skeletal maturity assessment in clinical radiology primarily include the Greulich and Pyle (GP) method and the Tanner and Whitehouse (TW2/3) method. The GP method, the most commonly used due to its simplicity, involves comparing 28 bones of the left hand with reference radiographs in an atlas, but it is highly subjective and prone to variability. The TW2/3 method is more objective, involving detailed analysis and scoring of bone development stages, but it is complex and time-consuming, with limited use in clinical practice. Both methods exhibit considerable inter- and intra-observer variability, which limits their reliability [66, 67, 68, 69, 70, 71].

Given these limitations, automating skeletal maturity assessment is highly desirable. The system developed in this study processes radiographic images similarly to radiologists, facing challenges related to image quality, anatomical structure variability, and the need to estimate ages without inheriting rater variability. The system uses models to locate bones, extract parameters, and estimate age, combining these estimates across bone structures for greater accuracy [66, 67, 68, 69, 70, 71].

Our study utilizes Statistical Models of Shape and Appearance to locate bones in radiographs and predict skeletal maturity, aiming to improve the accuracy and precision of current methods, which suffer from inter- and intra-rater variability. We constructed global models of the whole hand and local models of individual bones, applying these models to a dataset of 600 digitized radiographs of normal children. Our work demonstrated that different variants of Part+Geometry (P+G) models are sufficient to initialize an automatic registration algorithm. These models were used to locate salient bones and initialize an Active Appearance Model (AAM) that matches all the bones of the hand in a radiograph. This process is illustrated in Figure 7 and 8. By using multiple local age group models and age estimators, the study achieved significant improvements in age estimation accuracy [66, 67, 68, 69, 70, 71].

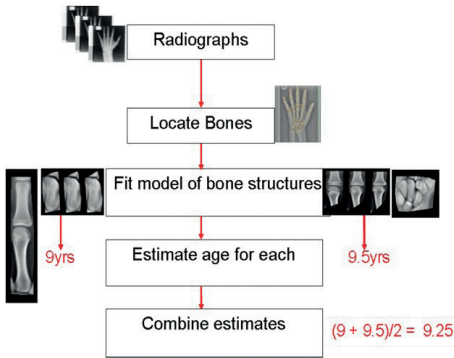


Figure 7: Process Diagram for Automatic Estimation of Skeletal Maturity using Active Appearance Models (AAM) [66]-[71].

The methodology was further extended to analyze a separate dataset of 324 digitized radiographs of infants (0-7 years), focusing on estimating skeletal age from the Carpals bones. The system achieved a high accuracy, with a sub-millimeter precision, in locating bones and annotating new radiographs. Specifically, the skeletal maturity methodology yielded an accuracy of 0.15 ± 0.01 years for females and 0.16 ± 0.01 years for males using the first dataset (5-18 years). For the second dataset (0-7 years), the texture model of the Carpals provided the best correlation with skeletal age, with mean absolute errors of 0.42 and 0.53 years for females and males, respectively [66, 67, 68, 69, 70, 71].

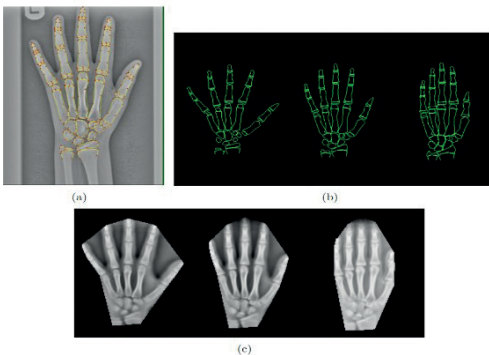


Figure 8: (a) Radiograph with manually annotated points. (b) First mode of shape model from manual points. (c) First mode of appearance model from the manual points [66]-[71].

The study identified challenges such as difficulty in delineating bone borders due to limited anatomical points, variability in bone visibility across age groups, and differentiating bone merger stages in older children. Additionally, varying hand orientations and finger placements in radiographs, along with the absence of radiologist readings, added complexity. A key innovation was the development of an automatic method for placing anatomical marks at

major joints, enabling accurate bone location and image alignment. This advancement is crucial for the automated skeletal maturity system, offering reliable age assessments for diagnosing and managing growth and endocrine disorders in clinical settings [66, 67, 68, 69, 70, 71].

- **Cervical Cancer detection with deep learning**

Cervical cancer, primarily caused by Human Papilloma Virus (HPV), develops in the cervix and can take 10 to 20 years to progress from pre-cancerous lesions, known as Cervical Intraepithelial Neoplasia (CIN), to invasive cancer. These lesions, categorized by severity into CIN 1 (mild), CIN 2 (moderate), and CIN 3 (severe), are critical to detect early through screening, as early detection significantly reduces the prevalence of cervical cancer. Visual Inspection with Acetic acid involves inspecting the cervix with the naked eyes for the presence of abnormalities (Aceto-white lesion) on the cervix. Developed countries have seen a reduction of more than 70% in cervical cancer cases due to organized screening programs. However, many women in resource-limited settings are diagnosed at advanced stages of the disease, leading to higher mortality rates. This is largely due to barriers such as lack of awareness, inadequate healthcare infrastructure, and limited access to regular screenings. These regions also suffer from a low ratio of skilled healthcare personnel to the population, making it challenging to deliver timely and accurate diagnoses. Given these constraints—limited resources, high costs, and inadequate healthcare infrastructure—there is an urgent need for automated, real-time screening methods that are affordable and accessible, helping to improve early detection and reduce cervical cancer mortality rates in underserved areas.

In response to these challenges, our work has focused on advancing intelligent-based medicine through the application of deep learning techniques to improve cervical cancer detection. By transforming conventional diagnostic methods into processes that are more accurate, efficient, and accessible, I have collaborated with a group of researchers to develop intelligent systems that enhance the accuracy and accessibility of cervical cancer screening. These innovations are particularly crucial for resource-limited settings, where they can help overcome the barriers to early detection and treatment, ultimately reducing mortality rates and improving health outcomes for women worldwide.

- a. **Intelligent Cervix Type Classification Using SqueezeNet**

To enhance cervical cancer detection, our research in [72] focused on classifying cervix types based on the position of the transformation zone, where pre-cancerous changes typically occur. Recognizing the challenges that health practitioners face, particularly in low-resource settings, we employed SqueezeNet, a lightweight Convolutional Neural Network (CNN). SqueezeNet was chosen for its efficiency, offering accuracy comparable to larger models like AlexNet, while requiring significantly less computational power. This makes it ideal for deployment on mobile devices, enabling real-time, accessible screening in underserved regions. The architecture of this technique is shown in Figure 9.

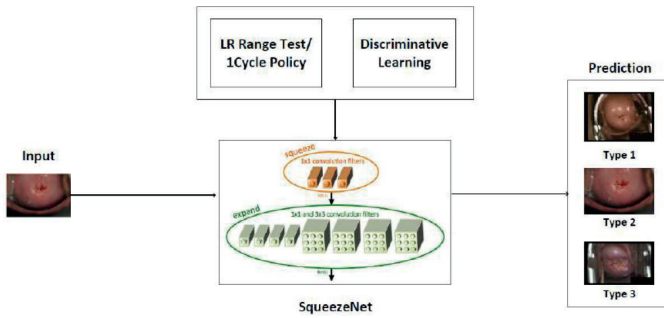


Figure 9: SqueezeNet Architecture for Cervix Type Classification [72]

The cervix type classification is crucial because the location of the transformation zone (whether it is fully visible, partially visible, or not visible at all) determines the appropriate follow-up procedures and treatments. For instance, when the transformation zone is not fully visible, as in Type II and Type III cervix types, more invasive procedures like Endocervical curettage or LEEP might be necessary. Therefore, accurate classification of cervix types using SqueezeNet not only aids in detecting pre-cancerous conditions but also guides health practitioners in making informed decisions about the next steps in patient care, ultimately improving outcomes in cervical cancer screening and treatment.

b. Advancing Cervical Cancer Detection Through Fine-Tuned CNN Models

Our research has made significant strides in cervical cancer detection by developing and refining Convolutional Neural Network (CNN) models specifically designed to classify cervical images based on the severity of Cervical Intraepithelial Neoplasia (CIN). In the study Classification of Cervical Intraepithelial Neoplasia (CIN) using Fine-Tuned Convolutional Neural Networks, we introduced an optimized DenseNet model that achieved remarkable accuracy in categorizing cervix images into CIN grades 1, 2, 3, and cancerous stages. The architecture of this technique is shown in Figure 10.

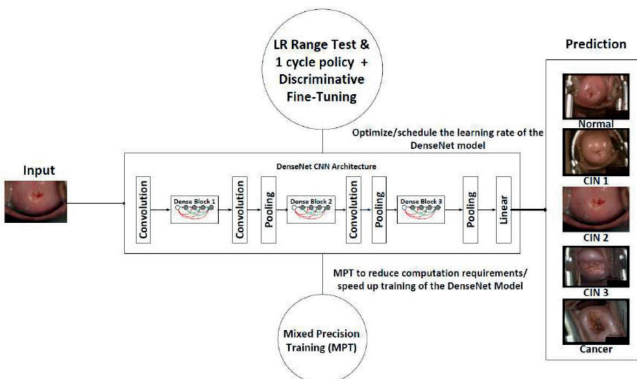


Figure 10: DenseNet Architecture for Cervix Type Classification [72]

The model was enhanced through techniques such as Data Augmentation, Discriminative Fine-Tuning, and Mixed Precision Training, resulting in an accuracy of 96.3%, with a sensitivity of 94.97% and a specificity of 98.86%. These advancements provided a strong foundation for practical applications, leading to the development of a mobile app prototype. These results are presented in Table 1.

Table 1: Performance Evaluation of each class based on out-sample data [72]

Class	M.Sens (%)	M.Space (%)	PPV (%)	NPV (%)	F1 Scoren (%)	Acc. (%)
Normal	94.97	98.62	95.13	98.57	95.04	97.75
CIN 1	93.27	98.84	94.33	98.61	93.97	96.68
CIN 2	92.53	98.96	93.98	98.37	93.24	97.95
CIN 3	94.37	98.15	93.19	98.46	93.77	96.16
Cancer	99.69	99.72	98.91	99.92	99.29	99.64

Building on the successful CNN model, we developed a prototype mobile application designed to bring this advanced cervical cancer screening technology closer to health-care workers, especially in low-resource settings. The mobile app prototype was created to classify cervix images by leveraging the fine-tuned CNN model, enabling real-time analysis of the transformation zone and the severity of pre-cancerous lesions. An illustration of the prototype and mobile application is presented in Figure 11.



Figure 11: Prototype for Cervical Cancer Screening [72, 73]

Our exploration of mobile-based solutions for cervical cancer screening through the development of a prototype application has demonstrated significant potential to address healthcare challenges in low-resource settings. By utilizing a fine-tuned CNN model, this mobile app offers real-time analysis of cervical images, facilitating early detection and classification of pre-cancerous lesions. While this prototype showcases the feasibility of deploying advanced AI-driven solutions on accessible platforms, the broader role of AI in healthcare, particularly in achieving Sustainable Development Goals (SDGs), cannot be overlooked [72, 73, 74].

- **Breast Cancer Detection from Mammogram**

Breast cancer is one of the most diagnosed cancers and the leading cause of death among

women globally, second only to lung cancer. Mammographic screening has been highly successful, detecting up to 90% of breast cancers before a lump can be felt. However, mammograms are low-intensity images, and the heterogeneous nature of the breast, especially in women with dense breast tissue (ages 40-44), can cause healthy tissue to appear cancerous. The sensitivity of early breast cancer detection from mammograms is estimated at 85-90%. Deep Convolutional Neural Networks (CNNs) can improve this, but they require large datasets, whereas mammographic datasets are often limited [75, 76]. The architecture of this technique is shown in Figure 12.

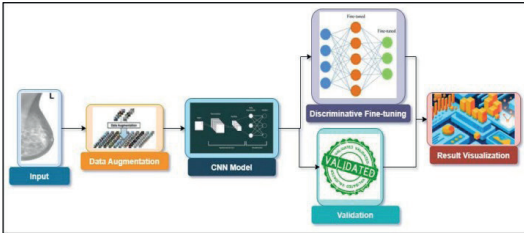


Figure 12: Architecture of Deep Learning Model [76]

Our research in this domain presents a method for training deep CNNs with smaller datasets, using augmentation techniques to increase both dataset size and variance. Five state-of-the-art models were trained, with DenseNet achieving the highest accuracy (99.01% training, 99.99% validation), while SqueezeNet also showed promise for deployment in microcontroller and FPGA-based clinical applications. [75, 76]. These results are presented in Table 2.

Table 2: Training and Validation Accuracy for Various Models [76, 75]

Model Name	Training Accuracy (%)	Validation Accuracy (%)
AlexNet	94.5	81.11
SqueezeNet	95.3	77.78
VGG	98.68	96.67
ResNet	98.39	99.99
DenseNet	99.01	99.99

Building on this, we also focused on augmenting the breast mammogram dataset, which originally contained only 161 pairs of mammograms. Without augmentation, any deep-learning model would likely overfit this small dataset. By applying our data augmentation techniques, we tested five state-of-the-art deep learning models and achieved impressive results. Our approach prevented overfitting, as shown by the consistent training and validation accuracy. Compared to existing literature, our method significantly outperformed previous techniques, demonstrating the effectiveness of our data augmentation and deep learning strategies in breast cancer diagnosis.

- **Breast Cancer detection from histopathology images**

Breast cancer diagnosis using histopathology images is critical but complex, requiring expert radiologists to identify anomalies at a cellular level, often leading to time-intensive processes with high false positive rates and low accuracy. This motivated our research to explore the potential of deep learning, which has shown promise in image processing but faced limitations in breast cancer histopathology applications, including the need for preprocessing, feature engineering, and low accuracy on public datasets. We proposed a novel deep-learning architecture for breast cancer detection from histopathology images, training the model from scratch without relying on transfer learning, feature engineering, or additional preprocessing [77].

Initially, the model underperformed due to hardware constraints, leading to underfitting. To overcome this, we employed ensemble training, training five models with different seeds and using a majority vote for the final prediction, which significantly improved the results. Our model achieved a state-of-the-art accuracy of 91.5% on the BreakHis dataset, surpassing the previous binary classification accuracy of 93%. This achievement remained the highest accuracy on the dataset for over two years. The impact of this research is reflected in its 46 citations, demonstrating its significance in the field of medical image analysis and its contribution to advancing breast cancer detection methods using deep learning [77]. Figure 13 illustrates the model's ability to detect malignant breast tumors.

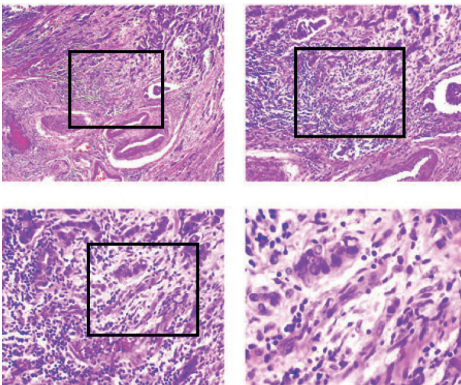


Figure 13: Breast Malignant Tumors [75]

- **COVID-19 Detection from X-Rays**

During the COVID-19 pandemic, our research focused on using medical AI to help in diagnosing the disease. One of our works addresses the challenges of using deep learning models for COVID-19 chest X-ray classification, focusing on issues like limited datasets, high computational requirements, and the black-box nature of these models. The study highlights the difficulties faced by researchers, particularly in developing countries, where access to large datasets and computational power is limited. Additionally, it emphasizes the need for transparency in deep learning models used for critical medical decisions [78].

To tackle these challenges, the research introduces several contributions. First, it presents a data-efficient method for training deep convolutional neural networks (CNNs) to maximize the use of scarce public datasets. Second, it proposes an algorithm that enhances rapid convergence by using memory-efficient mixed-precision training techniques, addressing the issue of high computational demands. Finally, to counter the black-box nature of deep CNNs, the study implements a technique that improves the reliability of model inference by providing visual clues to aid the screening process [78]. The results of this study are presented in Tables 3 and 4.

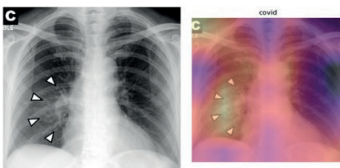
Table 3: Accuracy Results with and without Augmentation [78]

Model Name	Accuracy (%)
DenseNet	94.17
ResNet	94.17
ResNet + augmentation	95.43
DenseNet + augmentation	96.83
DenseNet	99.01

Table 4: Performance Comparison of DFT with Traditional Transfer Learning Methods [78]

Model	Accuracy (%)	No of Epoch	Time (Hr)
ResNet	92.28	104	52
DenseNet	92.85	98	49
ResNet + DFT	95.43	20	5
DenseNet + DFT	96.83	20	4.67

The main contribution of the work is the introduction of a novel deep learning fine-tuning technique called Discriminative Fine-Tuning (DFT). This technique involves layer-wise fine-tuning, where each layer of the network is updated with different learning rates to optimize convergence. The earlier layers are tuned with smaller learning rates, while later layers, particularly the final one, are updated with larger rates to speed up network convergence. The study also extends the concept of Cyclical Learning Rate (CLR) to dynamically adjust the learning rate and momentum during training, ensuring faster convergence and avoiding pitfalls like getting stuck in saddle points. This approach aims to make deep learning models more efficient and reliable for COVID-19 chest X-ray classification [78]. This classification is illustrated in Figure 14.



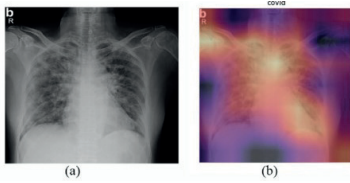


Figure 14: Visualisation of Model Output using Gradient Activation Map [78]

In addition, during the COVID pandemic, we collaborated with Worcester Polytechnic Institute, USA, to deploy a bedside lung ultrasound emergency robot. Specifically, we developed a deep learning technique for automatically classifying COVID-19 from lung ultrasound [79]. The robot design is presented in Figure 15.

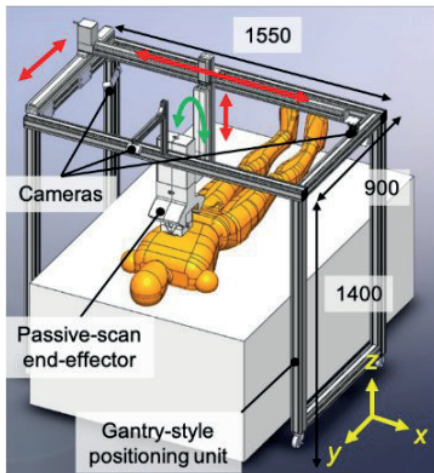


Figure 15: Design of Robotic System [79]

We employed the DFT algorithm and data augmentation techniques we developed, and the performance was quite satisfactory. The data augmentation was used to increase the dataset so that the deep learning model would not overfit. In addition, the DFT algorithm allowed faster training of deep learning models whose performance was superior [79].

- **Deep learning method for genomic data prediction**

Our research also aimed to explore the potential of deep learning methodologies to enhance genomic research by addressing the challenges posed by the complexity and vastness of genomic data. Machine and deep learning models are increasingly used to solve prediction problems in biomedical data analysis, particularly in DNA sequence prediction—a critical issue in the biomedical field. These advanced techniques have proven to be more accurate than traditional regression-based models. Predicting gene sequences associated with cancerous diseases, such as prostate cancer, is especially important. One of the most

challenging tasks is identifying the key features within a gene sequence and extracting its components to gain insights into gene mutations. This information is essential for effective drug design and advancing personalized medicine [80, 81].

In our work, we extracted exons from various prostate gene sequences and employed a bidirectional Long Short-Term Memory (bi-LSTM) model for prediction, using k-mer encoding for the DNA sequences and one-hot encoding for class labels. The bi-LSTM model was evaluated using several classification metrics. Our experimental results demonstrate that the model achieved a training accuracy of 95% and a validation accuracy of 91%, highlighting its potential in gene sequence prediction and its possible applications in enhancing cancer treatment and precision medicine development [80, 81].

- **Hepatitis C stage classification**

Our research also focused on the challenge of improving the accuracy and efficiency of machine learning models for classifying Hepatitis C stages. Hepatitis, a liver inflammation commonly caused by viral infections, remains a global health concern leading to significant mortality. While machine learning methods have shown promise in diagnosing hepatitis, the performance of these models varies depending on the algorithms and features used. The study focuses on using a Genetic Algorithm (GA) for feature selection to enhance model performance and reduce execution time.

In metaheuristic algorithms like GA, the initial population plays a crucial role as it can significantly affect both the time taken to find an optimal solution and the quality of the solution itself. Traditionally, GA generates an initial population randomly, which can lead to variability in the outcomes and longer execution times. To address this, the paper introduces the use of the Chi-square (χ^2) statistical algorithm to perform feature relevance checks before applying the GA. By considering the p-values of conditional independence, features with low p-values are discarded, and a more relevant subset of features is selected for the GA process. This approach ensures that the initial population in the GA is more likely to contain features with higher predictive power, leading to better performance and faster convergence [82, 83].

The study applied this method to a dataset of 1,385 samples from an Egyptian dataset obtained from the UCI repository, focusing on Hepatitis C stage classification. Three classifiers—Support Vector Machines (SVM), K-Nearest Neighbors (KNN), and Logistic Regression—were used to evaluate the performance of the selected features. The GA was run for ten generations, resulting in the selection of ten out of nineteen features for the classification task. The results demonstrated that the KNN classifier outperformed the others, achieving a performance accuracy improvement from 56% to 63%. Moreover, the use of the χ^2 algorithm in conjunction with GA led to a reduction in execution time, confirming the effectiveness of this approach in enhancing both the efficiency and accuracy of Hepatitis C stage classification models [82, 83].

• Osteoporosis Classification in knee Radiograph

Our research in medical AI additionally focuses on the application of deep learning techniques, specifically deep convolutional neural networks (CNNs), to classify osteoporosis in knee radiographs. Osteoporosis, a significant public health concern, leads to reduced bone mass, degeneration of bone tissue microarchitecture, and an increased risk of fractures. Traditionally, osteoporosis diagnosis has relied on techniques like Dual-Energy X-ray Absorptiometry (DXA), but this research explores the potential of using 2D knee x-ray images for detection [84, 85, 86]. A visualisation of a knee afflicted with Osteoporosis and a normal knee is shown in Figure 16.

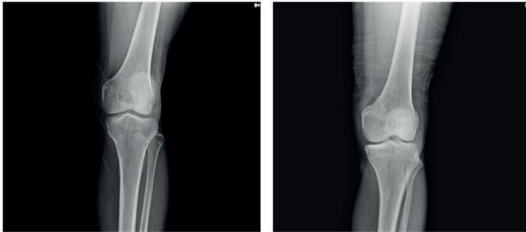


Figure 16: Visualisation of Osteoporosis Case and Normal Case [85]

The study evaluates the performance of several deep learning models, including VGG-16, GoogLeNet, and ResNet50, with an emphasis on the effectiveness of transfer learning and fine-tuning in enhancing model accuracy. A dataset of knee radiographs was split into grayscale and RGB image subcategories, and the models were trained on these subsets to compare their performance. The training times were also compared, with GoogLeNet and VGG-16 taking 42 and 37 minutes, respectively, for grayscale images, and 50 and 44 minutes for RGB images. [84, 85, 86]. This performance evaluation is presented in Table 5.

Table 5: Comparison of Methods for Osteoporosis Classification [86]

Paper	Method	Ac	Se	Sp
Our Work [86]	GoogLeNet	0.90	0.91	0.90
Our Work [86]	VGG-16	0.87	0.86	0.86
[87]	ResNet-18	0.79	0.86	0.86
[87]	ResNet-34	0.84	0.88	0.86
[88]	VGG-16-Fine-Tuning	0.84	0.90	0.81
[88]	CNN with 3 layers	0.66	0.68	0.65
[89]	ResNet-50	0.83	0.75	0.90

The results demonstrate that fine-tuning significantly improved the VGG-16 model's accuracy, achieving an 88% overall accuracy, compared to 80% without fine-tuning. The GoogLeNet model achieved the highest accuracy at 90%, showing its robustness in classifying osteoporosis from knee radiographs. The study concludes that transfer learning

and finetuning are effective strategies for enhancing the diagnostic performance of deep learning models in medical imaging, particularly for osteoporosis detection in knee radiographs. The successful application of these models highlights the potential for AI to contribute to more efficient and accurate osteoporosis diagnosis, ultimately reducing the disease’s impact on public health. [84, 85, 86].

• **Medical Imaging Data and Research**

Our research titled 'AfriBiobank: Empowering Africa’s Medical Imaging Research and Practice Through Data Sharing and Governance' addresses a crucial challenge in the African healthcare system: the scarcity of medical imaging datasets. Medical imaging plays a pivotal role in diagnosing and treating various health conditions, yet the limited availability of such data in Africa hinders progress in both research and clinical practice. The research underscores the critical issue of restricted access to medical imaging data in Africa, which impairs the capacity for comprehensive research and the enhancement of patient care. By emphasizing the importance of data sharing and governance, the study lays the groundwork for overcoming this significant barrier [90].

A key contribution of this work is the proposal of 'AfriBiobank', a centralized medical imaging biobank intended to serve the entire African continent. AfriBiobank aims to provide a multisectorally owned data center that facilitates cross-regional data storage and access, thereby significantly improving the availability and interoperability of medical imaging data across Africa. The study highlights the necessity for robust data governance policies to ensure the ethical and secure sharing of medical imaging data. By integrating advanced technologies such as blockchain for enhanced cybersecurity and a distributed hardware architecture, AfriBiobank is envisioned as a secure and scalable solution for managing medical data [90]. The architecture of AfriBiobank is presented in Figure 17.

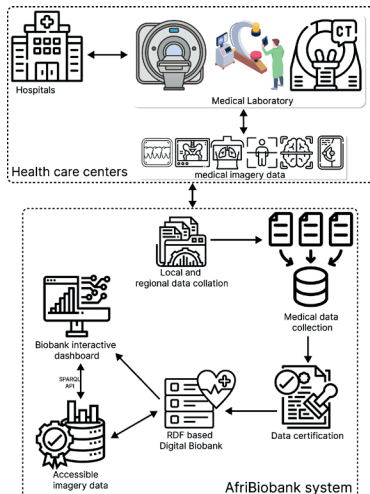


Figure 17: AfriBiobank Architecture [90]

The research advocates for the application of federated learning techniques and a semantic layer within the biobank's infrastructure. This approach not only enhances data interoperability and integration but also facilitates more sophisticated analyses, paving the way for more accurate and comprehensive research outcomes. By establishing a centralized and secure repository for medical imaging data, the study aims to position Africa as a significant contributor to global healthcare research. AfriBiobank could become a vital resource for researchers worldwide, promoting collaboration and accelerating scientific discoveries.

- **Autonomous Vehicles**

In the rapidly advancing field of autonomous vehicles (AVs), research has focused on addressing key challenges, especially in complex and unstructured environments like those in many global regions, including Nigeria. The high incidence of road accidents, often caused by human errors such as speeding, drowsiness, and loss of concentration, highlights the potential of AVs to reduce such incidents by minimizing human error in driving.

Our research has emphasized developing AVs capable of detecting and navigating road anomalies, particularly in regions with deteriorating road infrastructure. Another vital area of research has been advancing AV perception and localization technologies, which are essential for understanding surroundings and safe navigation [91, 92]. A particular focus has been on Visual Simultaneous Localization and Mapping (V-SLAM), a technique that allows AVs to create 3D maps of their environment while tracking their position. A review of V-SLAM techniques revealed their strengths and limitations, especially in real-world deployments. This research highlighted the need to improve the accuracy and reliability of these systems, crucial for deploying AVs in complex environments [93].

To further enhance the environmental awareness of AVs, a specialized deep learning model based on the YOLO v4 algorithm was introduced. This model is capable of detecting and profiling road surfaces, identifying anomalies with a high degree of accuracy, as evidenced by a mean average precision (mAP@0.5) of 95.34%. In addition, the developed model showed improved recall, F-1 score, and mAP@0.5, with values of 94%, 91%, and 95.34% respectively, when compared to similar existing works. The integration of this model with an enhanced V-SLAM system, termed RA-SLAM, significantly improved the vehicle's ability to detect and navigate road anomalies. The enhanced RA-SLAM technique outperformed its ORB-SLAM variant with an average RMSE of 0.2335 and average MAE of 0.2331 in eight test sequences. These advancements underscore the potential for integrating these technologies into AV systems to ensure safer and more efficient navigation across intricate road terrains [94]. This road anomaly detection and scene mapping abilities are shown in Figures 18 and 19 respectively.

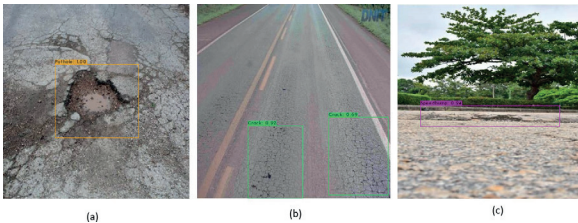


Figure 18: Road Anomaly Detection with Deep Learning: (a) detected pothole, (b) detected cracks, (c) detected speed bumps. [94]

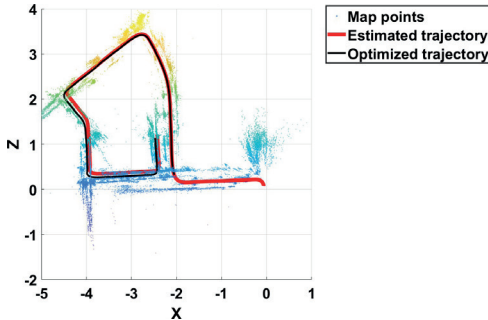


Figure 19: RA-SLAM Pose Graph Generated from KITTI Sequence 7 [94]

Trajectory tracking has been recognized as a cornerstone for ensuring the safety and precision of AVs. Traditional linear control methods often fall short in addressing the challenges posed by complex urban environments and defective roads that AVs must navigate. Research in this area led to the integration of Nonlinear Model Predictive Control (NMPC) for trajectory tracking, which has shown significant improvements in tracking accuracy and adaptability in diverse scenarios. The results from simulations and real-world tests demonstrated that NMPC could set a new benchmark for trajectory tracking in AVs, ultimately pushing the boundaries of what these vehicles can achieve in terms of safety and performance [95]. The setup of the AV is presented in Figure 20.



Figure 20: Model AV Setup

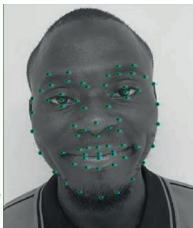
The culmination of these research efforts has resulted in a comprehensive suite of technologies and methodologies that enhance the capabilities of autonomous vehicles, particularly in navigating challenging road conditions. The integration of advanced computer vision techniques, deep learning models, and nonlinear control schemes has shown significant potential in addressing the limitations of existing AV systems. These contributions are poised to advance the field of autonomous vehicles while significantly improving road safety and driving conditions in environments where road infrastructure is less than ideal [96].

- **Facial identification and verification**

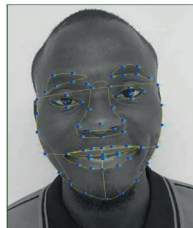
In the aspect of facial recognition, our research introduces an innovative framework designed to revolutionize the learning experience by integrating adaptive multimedia learning with facial recognition technology. The framework aims to create a smart learning environment that responds to individual student needs in real-time, thereby enhancing the effectiveness of the educational process [97].

A significant contribution of this research is the personalized learning experience it offers. As part of a broader Smart Learning Framework, which includes Multimedia Module Contents (MMC) and Learning Style Index (LSI), this module focuses on tailoring educational content to each student's needs. The system uses facial recognition technology to analyze students' facial expressions via a smartphone application, accurately gauging their emotional state and engagement levels during learning sessions. This data allows the system to make real-time adjustments to the learning content, ensuring it aligns with the specific requirements of each student [97].

The framework also introduces real-time learner behavior analysis, a critical advancement in educational technology. By employing the Affectiva SDK, the facial recognition system captures and interprets students' expressions to understand their emotional responses during the learning process. This real-time analysis enables adaptive decisions that help maintain student enthusiasm, promote sustained engagement, and enhance overall comprehension [97]. The facial feature marking and architecture of the framework are shown in Figures 21 and 22 respectively.



(a) Facial marking using AAM tool



(b) Facial feature shapes

Figure 21: Facial Image Feature Marking and Model Building [97]

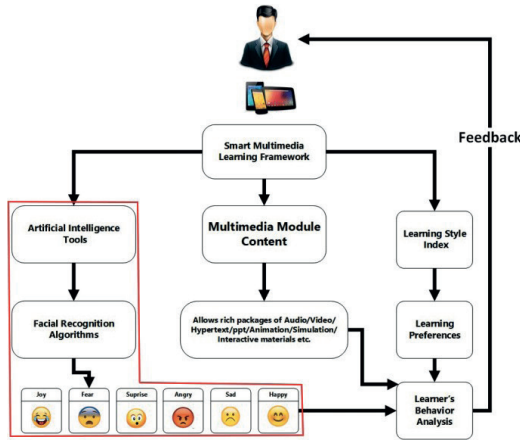


Figure 22: Adaptive Learning Framework - Facial Recognition Architecture [97]

In addition, in another aspect of our work, we address the issue of underage registration and voting in Nigeria’s electoral system, a persistent challenge undermining free and fair elections since the country’s shift to democracy. We utilized a pretrained VGG-16 Deep Convolutional Neural Network (CNN) to tackle this problem, employing two optimization algorithms without image preprocessing. The CNN extracts features from images of prospective voters and classifies them based on age groups to determine their eligibility to vote. Our approach classifies individuals as either eligible or ineligible to exercise their civil rights. The model achieved a classification accuracy of 77.67%, demonstrating its potential for practical application in enhancing the integrity of the electoral process in Nigeria by mitigating underage participation.

• **Gait identification**

One area of particular interest to researchers is human identification. Traditionally, human intelligence has relied on visual observation and intuition for identification. However, machine intelligence, particularly deep learning techniques, offers a powerful tool for identifying individuals through gait analysis. Gait analysis, the study of how people walk, provides a unique way to identify individuals. Unlike facial recognition, which can be disrupted by disguises or angles, gait is harder to alter. Our research has focused on leveraging machine intelligence to develop robust systems for human identification through gait analysis.

Our research has made significant contributions in this area, including developing a hybrid CNN-LSTM model for gait-based human identification. This model has demonstrated superior performance compared to traditional methods, particularly in scenarios where temporal information plays a crucial role. The table below compares the accuracy of various deep learning methods for person identification using gait analysis. The proposed method, CRNN, achieves the highest accuracy of 91% for half-body gait and 82.08% for full-body gait. Other methods, such as TCNN and CNN-MLT, also achieve high accuracy rates.

The choice of dataset and method affects overall accuracy [98]. The architecture of the technique and its performance evaluation is presented in Figure 23 and Table 6 respectively.

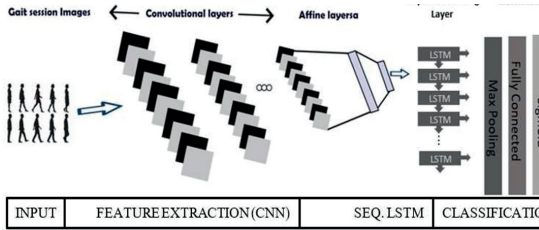


Figure 23: Deep Learning Based Gait Analysis Architecture [98]

Table 6: Comparative Performance of Gait Analysis [98]

Methodology	Dataset	Full/Half	Accuracy %
Our method 91% (half)	CRNN	Primary; Person	Half and Full
CRNN	iLIDS-VID, PRIDS	Full	80%
TCNN: Two branch CNN	CASIA-B, OU-ISIR LP	Full	94.7%
CNN (softmax)	OU-ISIR-B	Full	91.38%
CNN-MLT	CASIA-B	Full	95.88%
G.Net (CNN based)	OU-ISIR	Full	89.7% (best view)

The applications of our research extend to various domains, including security, surveillance, and healthcare. Our gait analysis models can be used to monitor public spaces, identify suspects in forensic investigations, and track the progress of patients with neurological disorders.

• Video Compression

In the field of video compression, our comprehensive analysis on Video Compression Optimization explores advancements in video compression techniques, emphasizing the balance between computational efficiency and high-definition video quality. As high-resolution video demands more sophisticated and resource-intensive compression algorithms, this review provides an overview of current methods and highlights the potential of artificial intelligence in future compression standards [99].

A detailed examination of various research approaches covers video preprocessing techniques aimed at optimizing compression efficiency, such as frame recompression and object detection to enhance data quality in regions of interest. The review also addresses parameter optimization, where methods like linear regression and machine learning are employed to determine optimal quantization parameters for better bitrate control [99]. The pipeline of video compression is shown in Figure 24.

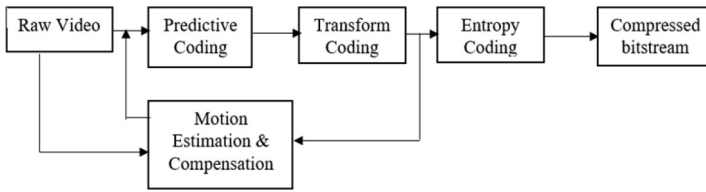


Figure 24: Video Compression Pipeline [99]

Significant emphasis is placed on deep learning-based methods. These include innovations such as deep neural networks for inter-frame prediction and advanced architectures that replace traditional block-based motion estimation. For instance, techniques proposed by Begaint et al. and Pessoa et al. demonstrate improvements in compression efficiency and reduced artifact visibility [99].

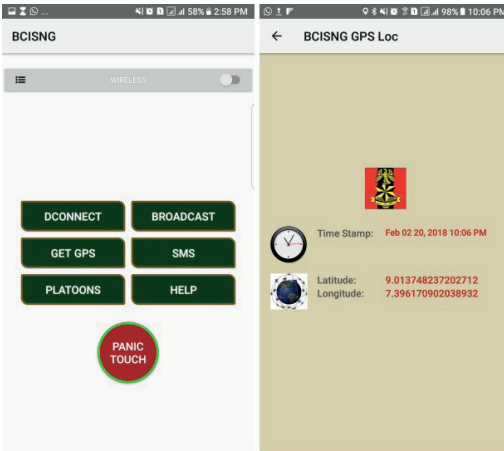
The study concludes that while traditional methods have laid a strong foundation, deep learning approaches offer the most promising advancements for future video compression standards. Ongoing research into methods like Probabilistic Graphical Models and Support Vector Machines is anticipated to further enhance compression algorithms, meeting the evolving demands of high-definition video.

• Communication in LIFI-WIFI Networks

In the area of WIFI communication, one of our research focuses was on optimizing the Battlefield Combat Identification System (BCIS) through decentralized wireless communication, specifically using Wi-Fi. The BCIS is a critical tool used by military personnel to distinguish between friend and foe in combat situations, thereby reducing the risk of fratricide—the accidental killing of one’s own forces. The study offers significant advancements by developing a decentralized communication system that operates over a local wireless network (Intranet) using Wi-Fi. This approach contrasts with traditional BCIS systems that rely on centralized satellite communication, allowing for direct, localized communication between soldiers on the battlefield. Such decentralization reduces dependence on central infrastructure, which can often be a bottleneck or a single point of failure in critical situations [100].

One of the main contributions of this research is the cost-effectiveness and enhanced security provided by the decentralized system. Traditional BCIS systems, which depend on satellite communication, are often expensive and vulnerable to disruption by adversaries. By using a local Wi-Fi network, the system becomes less costly to deploy and less susceptible to external interference, offering a more secure and reliable option for military operations. Additionally, the research introduces an Android application compatible with various devices, including mobile phones, tablets, and smartwatches. This application enables soldiers to communicate seamlessly within the local network, facilitating quick decision-making to determine if a subject is a friend or foe. The system also includes backup modules that can help locate missing soldiers or those in danger, ensuring prompt assistance [100].

A crucial impact of this research is its potential to significantly reduce military fratricide. The ability to quickly and accurately identify friendly forces through a reliable communication medium is essential in combat scenarios. The research demonstrates that a decentralized Wi-Fi-based BCIS can minimize the risk of fratricide, potentially saving lives and enhancing the overall effectiveness of military operations. Implementing this decentralized communication system is expected to improve the quality and reliability of communication between soldiers in combat, leading to faster, more accurate identification of friendly forces and reducing the likelihood of tragic mistakes in the heat of battle [100]. The user interface of the BCIS is presented in Figure 25.



(a) Home Screen

(b) GPS Location

Figure 25: BCIS User Interface [100]

Beyond its immediate military applications, this research offers potential benefits in other fields where reliable, local communication networks are essential. For instance, the decentralized communication system could be adapted for disaster response or humanitarian aid efforts in remote or conflict-affected areas. The ability to quickly establish a local communication network could be invaluable in coordinating rescue and relief operations, particularly in environments where traditional communication infrastructure is unavailable or compromised. Similarly, the principles of this research could be applied in security and surveillance operations, where secure, decentralized communication is necessary. Law enforcement agencies or private security firms could use similar systems to coordinate teams in the field without relying on vulnerable or expensive infrastructure.

- **Hotspots detection in Power equipment**

Optimum condition of power equipment for safe and stable operation is very important to utilities because every equipment in the network is a valuable resource of the power system. Hotspots contribute to most of the underlying problems in a power system. One problem with hotspots is that they can remain invisible to eye and may later

degenerate overtime into a catastrophic fire incident or explosion, especially when they occur near flammable liquids or gases. In IRT technique for monitoring hotspots lies in the possibility that virtually all installed power equipment operates above absolute zero and produce heat. And the thermal profile within the system would be an important indication of the status or health of each equipment, whether it is electrical or mechanical unit connected to the system. The common symptoms associated with faults in the system are overheating components (hotspots), fatigued insulators, arcing between conductors, etc. Because it is difficult to predict with certainty when and where hotspot faults would occur in the system.

In most cases, they occur due to loose connections, component failure, overloading, unbalanced loading and corroded points. The most successful means for detecting hotspots in installations are state-of-the-art technologies in infrared testing and thermal imaging [101]. An illustration of a power plant with it corresponding thermal image is shown in Figure 26.

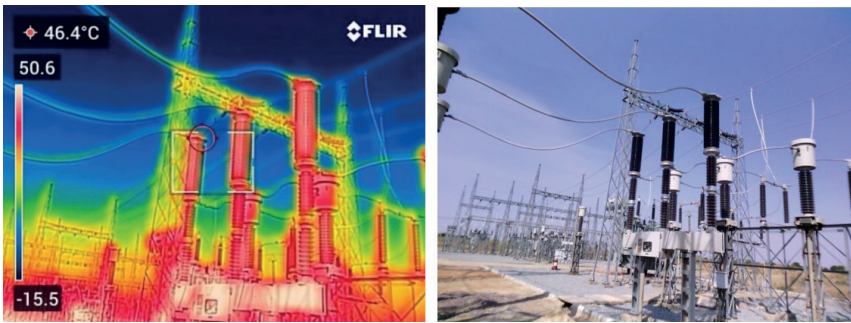


Figure 26: Power Plant and Thermal Image [102]

Our research focuses on developing a deep learning based infrared thermal imaging method for condition monitoring of power equipment for timely and accurate condition monitoring of electrical power equipment with the view of identifying abnormal phenomena in the form of hotspots which are usually associated with electrical faults. Firstly, IR images of live operating equipment were acquired during normal and abnormal conditions.

Thereafter, the data containing IR images of power equipment during faulty conditions were distinguished from IR images under normal operating condition by means of a deep learning neural network to isolated faulty locations shown as hotspots. The implemented model was tested with unfamiliar IR data from a power utility. The final simulation showed good accuracy in identifying hotspot faults through the instrumentality of data augmentation and deep learning model [102]. Figure 27 shows the architecture of the deep learning model for hotspot detection.

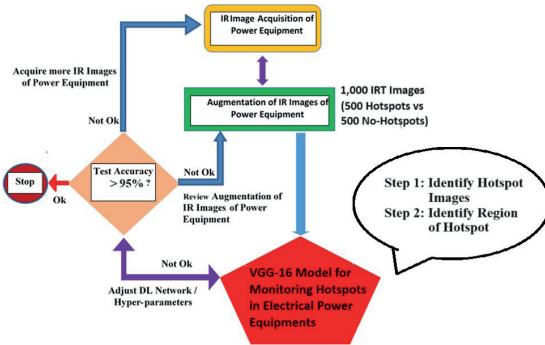


Figure 27: Deep Learning based Hotspot Detection Architecture [102]

The model recorded performance of 99.98% accuracy when implemented with the Adam optimizer using a learning rate of 0.0001. This is because reducing the learning rate improves the pixel-to-pixel discriminating ability of the model. Careful choice of the 16.3°C to 150°C thermal range together with the rainbow colour palette made for standardized IR training images that helps the models to easily pinpoint the hotspots within the electrical power system. Another spectacular feature of the model is that it can figure out very tiny hotspots that may not be visible to the human visual system, which is one of the essences of computer vision. The developed solution was geared towards prompt recognition of the fault, by localizing the point of occurrence. This is to ensure proper and timely intervention scheme could be implemented to forestall its further degeneration and ultimately restore the equipment / part to normal operating condition [102].

The presented approach converges within finite time, with low computational complexity, and would reduce the dependency on power system experts for timely identification of hotspots in electrical installations. It can be applied for multiple hotspot detection in most types of electrical / electronic devices or installations like rotating machines, solar power equipment, power electronics, etc. It has wide application for observing anomalies in many fields. However, limitations exist in that the model depends on training with carefully taken IR images using cautiously selected thermal range to make it easy for the model to pinpoint any anomaly therein.

• Electronic Governance

Our work on e-governance, specifically the adoption and implementation of e-voting in Nigeria, addresses the complex challenges faced in transitioning to digital voting systems. The 2011 Nigerian General Elections provided a unique context to study the socio-political, organizational, and individual factors that influence e-voting adoption. Through an ethnographic approach and a multi-level Innovation Adoption Framework, we analysed the obstacles and drivers that shaped the implementation of e-voting. Key findings include the significant role of the socio-political environment, technical challenges, and organizational readiness in determining the success or failure of such systems [103].

In addition to highlighting factors affecting e-voting adoption, we explored the potential of blockchain technology to improve voting integrity, especially in developing countries. Blockchain’s ability to ensure transparency, auditability, and anonymity was evaluated against the backdrop of both online and offline voting. Our research identified the integrity requirements that blockchain can support, offering insights into how this technology could address electoral fraud and enhance trust in voting processes [104].

Furthermore, we addressed the design imperatives for e-voting as a socio-technical system (STS), emphasizing the need for an interdisciplinary approach that considers human, environmental, and technical factors. This approach ensures that e-voting systems are adaptable to diverse cultural, geographical, and political contexts, particularly in countries like Nigeria. By integrating stakeholder participation and iterative design processes, the STS framework enhances the robustness and usability of e-voting systems. However, operational challenges, such as resource constraints and the need for ongoing stakeholder involvement, must be carefully managed in developing countries [105]. The e-Voting adoption model is presented in Figure 28.

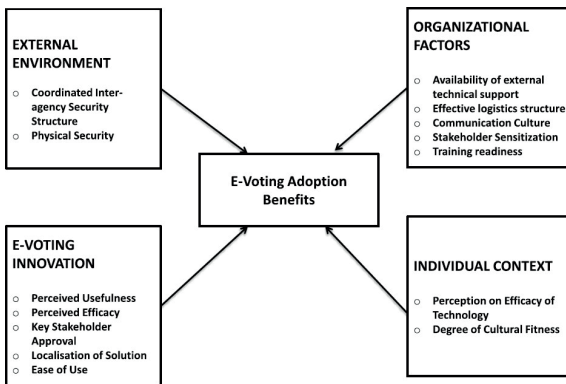


Figure 28: e-Voting Adoption model [105]

Our research contributes to theory-building in e-voting adoption and provides practical recommendations for policymakers and electoral authorities. These insights not only help in refining e-voting systems but also offer a roadmap for navigating the socio-political complexities that come with digital governance. Through a comprehensive analysis of technological and human factors, we aim to support the adoption of secure, transparent, and reliable e-voting systems that can promote democratic integrity in Nigeria and similar environments [106].

• **Electronic Voting**

In the aspect of electronic voting, a vital part of our research focused on local and global election result collation and transmission. This research presents an innovative system designed to address the challenges of collating and transmitting election results in densely

populated areas where the number of voters exceeds 2,000. Traditional electronic balloting systems work well for smaller populations but struggle with scalability, leading to issues in local collation and potential delays in larger settings [107].

The system introduces an administrative device that facilitates local result collation from multiple electronic balloting devices at various voting points. This ensures accurate and efficient collection of results even in areas with large voter populations, addressing a significant gap in existing systems. The innovation allows for scalability, making it suitable for elections in regions with thousands of voters [107].

Once results are collated locally, the system enables their transmission to a central collation centre. This two-tier process ensures that results are aggregated centrally after being locally announced, which aligns with legal requirements such as those in Nigeria. This approach not only enhances transparency but also reduces congestion and errors during transmission, thus improving the overall efficiency and accuracy of the process. The system is designed to comply with legal requirements that mandate the local display of election results at polling units. By enabling the announcement of results before their transmission to the central collation centre, the system bolsters the integrity of the electoral process and builds voter confidence. This compliance is crucial for maintaining transparency and public trust in elections [107].

In addition, our research titled “Design and Implementation of Electronic Balloting System: A Case Study of Nigeria” addresses the significant challenges associated with traditional voting methods, such as electoral fraud, high costs, and inefficiencies. The study proposes an innovative solution by developing an Android tablet-based electronic voting system that utilizes a touchscreen interface, making the voting process more accessible and user-friendly. This system eliminates the need for physical ballots and manual counting, leading to greater accuracy and reduced costs. Moreover, the integration of a Voter Verified Audit Trail (VVAT) ensures that votes can be verified and recounted, if necessary, thereby enhancing the transparency and trustworthiness of the election process [108].

The electronic balloting system is expected to improve the voting process in several key ways. It increases accuracy by minimizing human errors that are common in manual voting systems. The user-friendly touchscreen interface is likely to boost voter participation by simplifying the voting process. Additionally, the system is cost-effective, reducing the need for paper ballots and associated costs such as printing, distribution, and manual counting. The VVAT feature provides a reliable method for recounts, further enhancing the credibility of election results [108]. The interface for the e-voting application is presented in Figure 29.

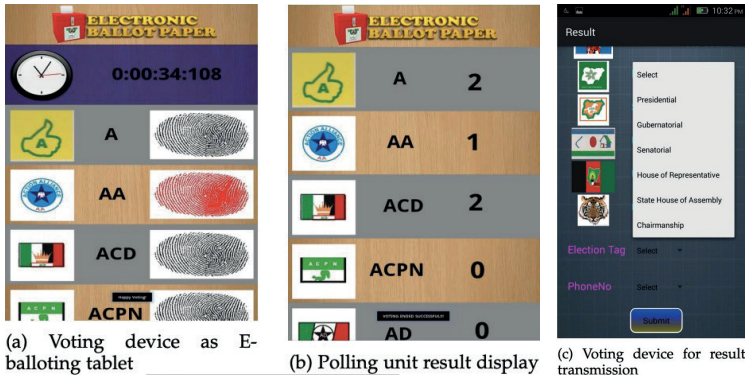


Figure 29: e-Voting Application Interface [108]

- **Age determination from facial images**

In the aspect of Facial Age Estimation, our research sought to address the increasing problem of children’s exposure to harmful online content, particularly in Nigeria. Age estimation from facial images is a crucial component of protecting minors from accessing explicit content and gambling sites. The research aimed to develop a deep learning-based system capable of accurately estimating the ages of children and adolescents in real-time using facial imagery [109, 110].

The study employed convolutional neural networks (CNNs) to classify and predict age from facial images. A multi-task CNN model was proposed, which simultaneously performed both regression (predicting exact age) and classification (categorizing individuals into age groups). The research utilized a combination of local and publicly available datasets, including the CASIA Face Africa dataset, to train and validate the model. Data augmentation techniques were employed to address the limited availability of training data, especially for younger age groups [109, 110].

The multi-task CNN model outperformed single-task models in terms of accuracy and mean absolute error (MAE). The multi-task model achieved a Mean Absolute Error (MAE) of 0.64 years and a classification accuracy of 96%, while the single-task model achieved an MAE of 0.47 years and a classification accuracy of 98%. Data augmentation significantly improved the model’s performance, especially for the younger age group. The custom multi- task model, after data augmentation, had an MAE of 0.95 and a classification accuracy of 94%, while the single-task model achieved a classification accuracy of 99% and an MAE of 0.65 [109, 110]. The facial age estimation output is presented in Figure 30.

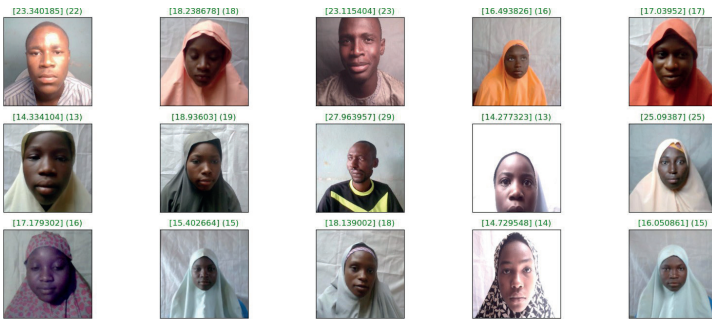


Figure 30: Results of Facial Age Estimation [109, 110]

The research contributes to the development of more effective age verification systems, which can be applied in various domains, such as online content regulation, access control, and preventing underage voting. The study's findings have implications for improving the safety and well-being of children and adolescents online. The study demonstrates the potential of deep learning techniques for accurate facial age prediction. The proposed multi-task CNN model, combined with data augmentation and transfer learning, offers a promising approach for protecting minors from harmful online content.

MY CONTRIBUTION: MENTORING AND COMMUNITY SOCIAL RESPONSIBILITY

Throughout my career, I have placed great emphasis on mentoring and community social responsibility, recognizing that the impact of education extends far beyond the classroom. As an educator and researcher, my dedication to guiding the next generation of leaders and innovators has been a fundamental part of my work. This commitment is evident in my teaching and in the various roles I have held, as well as through extensive collaborations with numerous institutions.

In my role as General Manager at Nile Consult, I was responsible for overseeing projects that intersected with technological and engineering advancements. My position afforded me the opportunity to mentor young professionals, guiding them through the complexities of the industry. I provided personalized advice and support, helping them develop critical thinking skills and foster their professional growth. These experiences, dealing with real-world challenges, enriched my ability to offer practical insights and career guidance, thereby enhancing the overall learning experience for my mentees.

As Dean of the Faculty of Engineering, I played a crucial role in shaping the academic and research environment within the faculty. I was particularly focused on integrating cutting-edge technologies into the curriculum, including Genetic Algorithms (GA), Artificial Neural Networks (ANNs), Convolutional Neural Networks (CNNs), and Particle Swarm Optimization (PSO). By incorporating these technologies into various courses, I ensured that students were exposed to the latest advancements in AI and machine learning. My role

also involved fostering a culture of innovation and collaboration, mentoring both faculty and students, encouraging interdisciplinary research, and promoting initiatives that bridged theoretical knowledge with practical applications.

My commitment to community social responsibility has been further demonstrated through my collaborations with institutions such as the Federal University of Technology, Minna, where I have engaged with the Advanced Engineering Innovation Research Group. These collaborations have allowed me to contribute to research that addresses critical engineering challenges while promoting technological advancement. Similarly, my work with Summit University Offa and National Open University of Nigeria (NOUN) involved organizing joint workshops and training sessions that enhanced the technical skills of students and professionals in the region.

Additionally, my partnerships with organizations such as the Independent National Electoral Commission (INEC), the National Information Technology Development Agency (NITDA), and the Nigerian Communications Commission (NCC) have provided opportunities to apply my expertise in AI and computational methods to real-world problems. Through these collaborations, I contributed to projects aimed at improving electoral processes and advancing national technology infrastructure. These initiatives included developing AI-driven solutions for data analysis and decision-making, underscoring my commitment to leveraging technology for societal benefit.

As part of my outreach efforts, I have organized workshops, seminars, and training sessions aimed at promoting STEM education among underserved populations. These programs are designed to equip young people with the skills necessary to succeed in a technology-driven world, reflecting my belief that education is a powerful tool for societal change. By fostering a sense of responsibility and social consciousness among students, I hope to inspire them to use their knowledge and skills for the greater good.

I have also been involved in developing innovative systems such as the electronic ballot system used for student union elections, which was operational for several years. I have given talks at esteemed platforms including ISACA, NSE, APWEN, and ACCA Africa. Additionally, I was invited to speak at the African Workshop on Cancer at Princeton University, where I presented New Algorithms for Cancer Detection, and served as a keynote speaker at Suleyman Demirel University, Kazakhstan.

Over the course of my career, I have worked across various roles, starting as a Graduate Assistant at the University of Ilorin, followed by positions at Datastar International Limited as a Systems Engineer and Bitcom Systems (Nig.) Limited as a Systems Consultant. My experience deepened when I became General Manager at Logica Solutions Limited, where I managed significant technological projects. I later transitioned into a long-standing relationship with the Independent National Electoral Commission (INEC), serving as Director of ICT. My academic journey also saw me pursuing research at the University

of Manchester in the United Kingdom. Upon returning to academia, I joined the Nigerian Turkish Nile University as a Lecturer, eventually becoming a Senior Lecturer, Head of Department, and ultimately, an Associate Professor and Deputy Vice Chancellor. My academic career at Nile University culminated in my appointment as Professor of Computer Vision and Engineering. I have also engaged in numerous international efforts, representing Nigeria in delegations to countries like India, South Africa, France, and the United States, to study election technologies and systems. I was involved in discussions on democracy and the information revolution at international institutes and participated in study tours of election commissions in Ghana and India.

In academia, I have supervised a considerable number of undergraduate and postgraduate projects in Computer Science, Electrical and Electronics Engineering, and Computer Engineering. I have also supervised doctoral candidates and served as an external assessor for promotions to full professorships at universities in Nigeria. My teaching spans undergraduate and postgraduate courses, covering topics such as C++ programming, computational science, digital image processing, and advanced AI and machine learning techniques.

My industry experience includes software development, network design, and election technology innovations. I am passionate about open-source software and have integrated it into various projects. My research focuses on applying artificial intelligence to analyse medical images, and I've contributed to the use of new technologies in electronic voting to promote fair elections. Throughout my career, I've been committed to leveraging technology and education for societal progress and innovation.

BEYOND NOW

MAJOR FOCUS IN COMPUTER VISION

As Computer Vision evolves, the focus is on advancing beyond current capabilities and exploring new horizons. Central to this progress are sophisticated algorithms designed for complex visual tasks with greater accuracy and efficiency. Technologies such as deep learning, Generative Artificial Intelligence (Gen AI), and advanced Convolutional Neural Networks (CNNs) drive this evolution.

Deep learning has already transformed Computer Vision, enabling machines to recognize and interpret images with unprecedented precision. Gen AI, in particular, is set to revolutionize the field by generating highly realistic images and videos, impacting content creation, simulation, and virtual reality. The ability to create synthetic visual data opens new possibilities for model training and enhancement.

Advanced CNNs are also gaining proficiency in handling complex image and video analysis tasks. These networks can recognize intricate patterns, vital for applications like autonomous driving, where real-time decision-making is essential. As CNNs integrate with real-time systems, the accuracy and reliability of autonomous vehicles will improve significantly.

Medical imaging is poised for transformation as Computer Vision algorithms enhance diagnostics and early disease detection. Similarly, augmented reality systems will benefit from these advancements, providing more immersive experiences.

Our research is dedicated to pushing the boundaries of Computer Vision, aiming to address both current and future challenges through innovative technologies.

OUR DREAM – COMPUTER VISION AS A DISCIPLINE

We envision Computer Vision as a cornerstone of technological advancement, integrated into diverse applications to improve quality of life and system efficiency. It can enhance public safety through advanced surveillance systems and enrich user experiences through personalized, adaptive technologies.

Achieving this vision requires fostering interdisciplinary research and collaboration. By uniting experts from computer science, engineering, medicine, and other fields, we aim to build a robust framework that supports Computer Vision's growth and application in real-world challenges.

We also emphasize ethical considerations, ensuring the technology evolves responsibly. Privacy, security, and equitable benefits are crucial as we develop solutions that are both technically advanced and ethically sound. By prioritizing both excellence and responsibility, we aim to position Computer Vision as a key driver of innovation with a positive societal impact.

CURRICULUM DEVELOPMENT AND BOOKS

Curriculum development and educational materials are critical for advancing Computer Vision. The rapid pace of technological progress necessitates that academic curricula incorporate the latest tools and methodologies, preparing students to handle real-world challenges. Curricula in Computer Vision should emphasize emerging technologies such as deep learning, Generative Adversarial Networks (GANs), and CNNs. Textbooks and resources should cover both theoretical foundations and practical applications, from algorithm development to real-world uses like autonomous driving and medical imaging.

Moreover, curricula should address ethical considerations, ensuring that students understand privacy, security, and fairness in the deployment of Computer Vision technologies. This prepares them to design systems that are both innovative and responsible.

The goal is to foster interdisciplinary collaboration by integrating diverse fields into the learning process. This holistic approach ensures that Computer Vision remains at the forefront of technological advancement and continues to drive innovation globally.

MANPOWER DEVELOPMENT

The growth of Computer Vision depends on skilled professionals who can innovate and implement advanced technologies. Investing in manpower development is essential to equipping individuals with the expertise to thrive in this evolving field.

Specialized training programs focusing on practical applications are key to building a strong workforce. These programs should include hands-on workshops, certifications, and advanced courses on topics like deep learning, image processing, and real-time visual analysis. Practical skills ensure that professionals can address real-world challenges effectively.

Collaboration with industry, academia, and research organizations plays a crucial role in creating a comprehensive training ecosystem. Industry partners provide insights into emerging trends, while academic institutions offer theoretical foundations and research opportunities. Research organizations drive innovation and offer platforms for practical experience. This collaboration aligns educational programs with industry needs.

Internships, research projects, and job placements further enhance practical experience, helping individuals gain career development support. By prioritizing manpower development, we aim to cultivate a capable workforce that will drive innovation in Computer Vision and meet future challenges.

This strategic focus on education and training will ensure the continued success of Computer Vision, preparing the next generation of experts to contribute to its growth and impact across industries.

MACHINE INTELLIGENCE VS HUMAN INTELLIGENCE

GENERATIVE AI AND LARGE LANGUAGE MODELS

Generative AI, especially with large language models (LLMs), has advanced natural language processing significantly. Beyond text generation, its impact extends to computer vision, enabling computers to understand and interpret visual information.

Generative Adversarial Networks (GANs) are key techniques in generative AI for computer vision. GANs use two neural networks: a generator that creates new data samples and a discriminator that evaluates their authenticity. This adversarial process helps the generator produce increasingly realistic images or videos, leading to breakthroughs in image super-resolution, image-to-image translation, and style transfer.

Generative AI is also used for creating entirely new images or videos, benefiting fields such as art, design, and entertainment. Artists and filmmakers can leverage these models for unique artistic creations and realistic special effects. Data augmentation, by generating synthetic data similar to real data, enhances training sets, improving model performance, especially when obtaining large amounts of labelled data is difficult. Generative AI enables advanced image editing and manipulation, such as object removal or style alteration, with applications in photo editing, restoration, and forensics.

In medical imaging, generative AI generates synthetic images to train deep learning models for disease diagnosis and treatment planning. It also enhances image quality, aiding doctors in interpretation. As generative AI advances, it will drive innovations in autonomous vehicles, robotics, and augmented reality.

EVOLUTION OF HUMAN INTELLIGENCE

Human intelligence, shaped by biological, social, and cultural factors, has evolved from early cognitive functions essential for survival to complex capacities for problem-solving, abstract reasoning, and emotional understanding. Language development has been crucial, allowing us to share ideas and knowledge, fostering collaboration and innovation.

Culture, encompassing shared beliefs and practices, influences intellectual development by providing educational, social, and technological contexts. Technological advancements, such as writing and computers, have transformed information processing and knowledge systems, enhancing problem-solving and creativity. Human intelligence's evolution reflects our adaptability and capacity for learning and innovation.

EVOLUTION OF MACHINE INTELLIGENCE

Machine intelligence, the ability of machines to perform tasks requiring human-like intelligence, has advanced dramatically due to increased computational power, data

availability, and algorithmic innovations. Early systems relied on predefined rules, but machine learning and deep learning have revolutionized the field. Machine learning enables machines to learn from data, identify patterns, and make predictions, while deep learning uses neural networks to learn complex data relationships.

Modern machine intelligence excels in tasks like data analysis, pattern recognition, and decision-making. Neural networks are effective in image and speech recognition, natural language processing, and generative modelling. Reinforcement learning allows machines to learn from environmental interactions, optimizing behaviour based on rewards or punishments. Machine intelligence impacts various industries: autonomous vehicles use machine learning and computer vision for transportation; healthcare benefits from algorithms for disease diagnosis and medical image analysis; natural language processing facilitates human-computer interaction through virtual assistants and translation. Ethical considerations are vital as machine intelligence evolves, ensuring responsible development and deployment.

AREAS WHERE HUMAN INTELLIGENCE EXCELS

Human intelligence excels in creativity, emotional intelligence, and complex social interactions. We generate nuanced emotional expressions and empathy, forming deep connections and navigating social complexities. Our creativity leads to novel ideas and artistic expressions, driving innovation across fields. Humans reason with common sense, adapting to unpredictable situations using a broad understanding of context and experience.

Machine intelligence, despite its advancements, struggles with these aspects. Machines process information quickly but lack nuanced understanding of human language, emotion, and social interaction. They also lack creativity and adaptability, which are crucial for solving complex problems and handling unpredictable situations.

AREAS WHERE MACHINE INTELLIGENCE EXCELS

Machine intelligence, driven by AI advancements, excels in processing large data volumes quickly and accurately. It is effective in data analysis, pattern recognition, and automating repetitive tasks. Machines handle precision tasks, such as image recognition and language translation, with consistency and without fatigue or bias.

This capability transforms industries: finance benefits from market trend analysis and fraud detection; healthcare uses machine learning for disease diagnosis and treatment planning; logistics improves supply chain management and demand prediction. Machine intelligence enhances efficiency, decision-making, and productivity across sectors by automating tasks and providing data insights.

COLLABORATIVE INTELLIGENCE OR AUGMENTED INTELLIGENCE

Collaborative intelligence, or augmented intelligence, leverages the strengths of both human and machine intelligence. This synergy enhances decision-making and problem-solving by combining human creativity, intuition, and contextual understanding with machine efficiency, data processing power, and analytical capabilities.

Humans excel in tasks requiring creativity and emotional intelligence, while machines process large data sets quickly and accurately. Collaborative intelligence leads to informed decisions and innovative solutions. In healthcare, AI systems analyze medical data to assist doctors in diagnosing diseases and developing personalized treatments. In business, machine learning insights improve customer service and marketing.

Collaborative intelligence has transformative potential across industries, offering more efficient and innovative solutions. As this field evolves, we can expect further advancements in human-machine collaboration.

ARTIFICIAL COLLABORATIVE INTELLIGENCE

Artificial Collaborative Intelligence (ACI) embodies a revolutionary approach where humans and AI systems synergistically work together to achieve outcomes beyond their individual capabilities. Unlike traditional AI systems, which often operate independently, ACI emphasizes a collaborative framework that leverages the strengths of both human and machine intelligence. This partnership integrates AI's formidable computational power with human attributes such as creativity, ethical reasoning, and contextual understanding.

The foundation of ACI is built upon significant advancements in several key areas of artificial intelligence, including natural language processing (NLP), deep learning, and reinforcement learning. These technologies enable AI systems to interpret and analyse complex datasets, offering valuable insights that aid human experts across various fields. For instance, in healthcare, AI systems can efficiently analyse and process medical images to detect early signs of diseases, while human doctors use their expertise to interpret these results and make informed treatment decisions, thus enhancing patient outcomes.

In the realm of autonomous systems, such as self-driving cars, ACI plays a crucial role in ensuring safety and efficiency. While AI systems handle real-time data processing and vehicle control with high precision, human judgment is essential for making ethical decisions, particularly in unpredictable scenarios where moral considerations come into play. This collaborative approach helps create autonomous technologies that are both safe and aligned with human values.

The development of curricula for ACI is vital for preparing future professionals to navigate this evolving landscape. Educational programs must encompass aspects of human-AI interaction, ethical design, and interdisciplinary research to equip students with the necessary skills and understanding. Ethical considerations are particularly important to ensure that AI systems respect human autonomy and avoid biases, fostering fairness and inclusivity. ACI represents the frontier of AI development, combining human creativity and contextual awareness with the analytical power of AI. This partnership has the potential to transform industries, drive innovation, and improve quality of life. As we advance towards a future characterized by human-machine collaboration, it is essential to develop educational frameworks and ethical guidelines that will enable future leaders to harness the full potential of ACI effectively.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSION

In exploring the integration of human and machine capabilities, it becomes clear that both forms of intelligence possess distinct strengths and limitations. Human intelligence excels in creativity, ethical judgment, and nuanced decision-making due to its deep cognitive abilities and emotional understanding. Conversely, machine intelligence, particularly through advancements in artificial intelligence (AI), has demonstrated exceptional capabilities in processing large datasets, recognizing patterns, and performing tasks with unprecedented speed and precision.

The evolution of AI, driven by technologies such as deep learning, Generative AI, and Convolutional Neural Networks (CNNs), has notably advanced Computer Vision, allowing machines to interpret and interact with visual data in increasingly sophisticated ways. These advancements have opened new possibilities in various fields, including autonomous vehicles, medical imaging, and personalized user experiences. However, as we continue to explore the boundaries of what machine intelligence can achieve, it is imperative to emphasize the role of Artificial Collaborative Intelligence (ACI). ACI leverages the strengths of both human and machine intelligence to address complex challenges more effectively, ensuring that technological advancements are accompanied by human oversight and ethical considerations.

My research and practical initiatives at Nile University of Nigeria highlight our commitment to advancing both theoretical and applied aspects of AI and Computer Vision. By fostering interdisciplinary collaboration, innovating in curriculum development, and investing in talent development, we aim to establish Computer Vision and ACI as foundational elements of future technological progress.

RECOMMENDATIONS

Mr. Vice Chancellor Sir, in order to drive technological progress in machine intelligence and Computer Vision, the following recommendations are made:

- a. **Ethical Framework Development:** With the continued evolution of AI and machine intelligence, it is crucial to develop comprehensive ethical frameworks. These frameworks should address privacy, data security, and potential biases in AI systems to ensure that advancements are equitable and beneficial for all segments of society.
- b. **Interdisciplinary Collaboration:** To harness the full potential of AI and Computer Vision, there must be a strong emphasis on interdisciplinary collaboration. Bringing together experts from computer science, engineering, social sciences, and ethics will lead to more holistic and effective solutions to complex problems.

- c. E-Voting Systems Development and Adoption:** The development and adoption of a home-grown e-voting systems should be promoted to enhance the efficiency and security of electoral processes. Research and implementation efforts should focus on creating secure, transparent, and accessible e-voting platforms that increase public trust and participation in democratic processes. In this regard, the Integrity of our electoral systems can benefit from AI and related technologies. Results transmission can be secured with distributed ledger such as Blockchain and underage voters can be removed from the Voters register with Age classification and verification systems. Nigeria is ripe for full electronic Voting Systems, but it must be based on our local peculiarities. An imported Electronic Voting system without local modifications WILL fail woefully.
- d. Adoption of Medical AI Systems:** The integration of AI technologies into the medical field holds tremendous potential for transforming healthcare. It is recommended that healthcare providers and institutions adopt AI systems to enhance diagnostic accuracy, personalize treatment plans and streamline administrative processes. This includes investing in AI-powered diagnostic tools, patient monitoring systems, and decision support systems. Emphasis should be placed on ensuring these systems are rigorously tested, validated, and integrated in ways that complement and augment human expertise. Additionally, establishing guidelines for ethical considerations, data privacy, and patient consent is crucial for the responsible implementation of medical AI technologies.
- e. Adoption of a framework for collection and integration of medical data:** Availability of medical data for research in (Nigeria and indeed Africa) is at its infancy. As shown in one of our works, most of the existing Models were trained with, images of Caucasians, Asians and Hispanics. Research has shown that, there are significant differences in physiological, anatomical and genetical make-up between races. As a result, Nigeria and indeed Africa would need a framework to collect its own data and use same to fine tune models for disease diagnosis.
- f. AI could be used to solve some of our security problems:** Advances in visual recognition systems as discussed in some of our works could help counter security challenges in Nigeria. Real time earth imagery could be obtained either through the Satellite or Drones launched in certain areas. These images can be processed by AI (such as CNN) to identify certain unusual patterns. This can proactively identify usual movements of bandits, insurgents, terrorists and oil thieves. In the metropolis CCTV footages can also be analysed for unusual pattern to identify robbery and kidnapping. Facial/Gait/Vehicular recognition systems installed in public places and retrofitted with AI could help identify Criminals.
- g. Artificial Collaborative Intelligence (ACI) Research:** To advance the field of Artificial Collaborative Intelligence, it is essential to promote research that explores the synergy between human and machine intelligence. This research should focus on developing

frameworks that enhance collaborative problem-solving, decision-making, and creativity. Investing in projects that investigate how AI can augment human capabilities and improve collaborative processes across various domains is recommended. This includes fostering interdisciplinary research that integrates insights from computer science, cognitive psychology, and organizational behaviour. Supporting initiatives that examine the ethical implications and societal impacts of ACI will also be crucial in ensuring these technologies are developed and utilized in ways that are beneficial and equitable.

By implementing these recommendations, we can ensure that the evolution of machine intelligence and Computer Vision not only fosters technological innovation but also contributes meaningfully to societal advancement and the betterment of global communities.

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BRIEF PROFILE OF THE INAUGURAL LECTURER

Steve Adetunji Adeshina was born in October 18th 1961 to the family of Mr Jacob and Mrs Felicia Adeshina at a small village then called Aha at Saki local Government where his father was a teacher at the time. He had his primary education at the African Baptist Primary School, Saki, then at Baptist Primary School, Okaka and later at the Baptist Primary School, Tede all located at the Oyo North region of Oyo state. The constant movement was due to the fact of regular transfer of his father, which was typical of teachers at the time. He hails from Okaka, which is located at Itesiwaju Local Government Area of Oyo state.

The young Tunji was enrolled at the Baptist High School, Saki in 1972 and graduated in 1976. In 1977, he was one of the four candidates from Oyo State who were successful at the Nigerian Defense Academy (NDA), 22nd Regular course entrance examination and interview. He was in NDA from 1977 to 1979 when fate took him off the trajectory of a military (Naval) career. He later enrolled at the University of Ilorin in 1981 to study Electrical/Electronic Engineering and graduated in 1986. He served as a Graduate Assistant at the same University and finished his National Youth Service (NYSC) in 1987. Giving his interest in Information technology (IT) at the time, he joined an IT company called Datastar International Ltd as a Systems' Engineer, where he worked on Personal Computers - assembling and repairing computers. He commenced learning programming in Dbase II, Dbase III plus and others. The software systems that Datastar sold at the time were developed in-house and were based on the Database systems mentioned above. At Datastar, he was later posted to the Lagos office. He left Datastar to co-found Bitcom Systems Ltd in 1990 and served as a Systems Consultant for 1 year at Bitcom Systems. He left Bitcom Systems to start his own IT firm in 1991 named Logica Solutions Ltd (an IT Consulting and Contracting firm) and served there as General Manager. At Logica, he led the development of several bespoke software for the financial industry using Oracle relational databases and Xenix (a Unix based platform). He was one of the pioneers of Local Area Networking in Nigeria using Arcnet, Bus based Ethernet and later star-based Ethernet and Novel Netware as the Network Operating System. Logica, under his watch had several Banks and other blue-chip companies as customers. As one of the first set technology experts to work on Fibre Optic cable (FOCs), he led the installation of LANs and WANs with FOCs for several blue-chip companies at the time. At the height of his FOC exploration, he had to personally rescue Mobil Oil Producing in connecting their platforms in Mobil OZO 2 Hook-up project offshore Eket in 1999. He was at Logica till 2000 when he was invited start an ICT department at the Independent National Electoral Commission (INEC) head office at Abuja. While leading Logical, he found some time to acquire a Master of Information Science (M.Inf. Sc) degree at the University of Ibadan (1994-1996).

As an Assistant Director (ICT) and head, he pioneered several ICT initiatives at INEC. The linking of all State offices of INEC with Very Small Aperture Terminals (VSATs) was carried

out under his watch. He led the compilation of Electronic Voters' register at INEC which led to the printing of Voters Card. The database also forms the platform for the Smart Card Reader (SCR) and the Bimodal Voters Authentication System (BVAS). He was at INEC from year 2000 to 2011. Tunji received several awards at INEC and was promoted twice as an appreciation of his diligence. In 2016 he was retained as a Consultant, Databases and Networks, by INEC for 2 years.

During his stint at INEC, he obtained a study leave for his Doctoral degree at the prestigious University of Manchester, Manchester, UK. He commenced his Ph.D. program in Computer Vision from year 2007 and finished in 2010 – one of the earliest finishers in the Department. He adopted his first name Steve at Manchester for obvious reasons. At Manchester he worked on Bone Ageing otherwise known as Skeletal Maturity. Essentially using Computer Vision techniques to read the Radiographs of the hand of children and young adults to determine the age of their bones. A significant disparity between chronological age and bone age is an indication growth abnormality. After submitting his Thesis in August 2010, he returned home to INEC and was asked by the new INEC administration to lead the efforts to compile a new register and print Voter's card. He left INEC in October 2011 after serving meritoriously as Director (ICT) for 8 years.

He joined Nile University as a Lecturer I in October 2011 in the Faculty of Science and Engineering. He rose to become a full Professor in January 2018. During the journey at Nile, he was Director of Academic Planning (DAP), he was two times Deputy Vice Chancellor (Admin) (2014-2020) and (2022), Member, Governing Council (2014-2020), Dean, Faculty of Engineering (2019 – 2023) Head of Department (Mechatronics) and General Manager, Nile Consult (2022 – 2024). He is well published and was twice recognized as amongst 100 most productive researchers in Nigeria by Scopus, Elsevier. He has published over 100 articles in high impact journals and conferences. At Nile he has supervised and graduated 5 Ph.Ds, over 30 Masters, 20 Undergraduate students.

He is a Senior Member, Institute of Electrical and Electronics Engineers (IEEE), Member, Nigerian Society of Engineers (NSE), Member, Nigerian Computer Society (NCS), and a Registered Engineer with the Council for the Regulation of Engineering in Nigeria (COREN). Professor Steve Adeshina pioneered the starting of Nile Christian Fellowship (NCF) in 2018 and currently serves as the Patron. Steve is a teacher of the word and a Pastor at the New Covenant Church, Abuja.

His hobbies are Reading, Footballing, travelling, listening to music and watching the waves.

Professor Steve A. Adeshina is happily married to Dr. Anike Adeshina and they are blessed with 3 boys – (Engr. Victor AdeOluwa, Great IreOluwa and Immanuel OreOluwa) and an adult daughter (Dr. IkeOluwa Osei-Owusu).

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