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MASTER THESIS

ARTIFICIAL INTELLIGENCE IN THE AREA OF GLAMS (GALLERIES, LIBRARIES, ARCHIVES AND MUSEUMS)

Presented in view of obtaining a Master's degree in the field of Digital humanities

Field of study**:**

DIGITAL HUMANITIES (DH)

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WARNING

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DEDICATION

To my lovely parents Mr. and Mrs. NKWETI, for their love, support and efforts towards me

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ABSTRACT

This study focuses on how artificial intelligence (AI) is used in Galleries, Libraries, Archives, and Museums (GLAM) in Africa. Before getting into the topic proper, this research begins with an overview of the concept and notions of AI, the origin and existing scope of AI in Africa that is mapping the AI ecosystem in the African continent. It aims to understand the impact and implications of AI technologies on cultural heritage preservation, information management, and user engagement in GLAM institutions across Africa. The research considers the unique challenges and opportunities associated with using AI in GLAM institutions in Africa, taking into account the diverse cultural and technological environments of the region. The study explores how AI is used for managing, preserving, and providing access to cultural heritage materials in GLAM institutions and looks at how AI technologies are integrated into existing information practices and the impact on creating inclusive and accessible cultural knowledge resources for diverse audiences. It investigates how AI-driven information systems influence user engagement, accessibility, and interpretation of cultural heritage materials in GLAM settings, examines efforts to train GLAM staff to effectively use AI tools for information management and dissemination, explores partnerships between AI actors, GLAM institutions, technology developers to promote innovative approaches to AI implementation and knowledge sharing, looks at the laws and ethical guidelines that govern the use of AI in GLAM institutions, aiming to identify potential gaps and challenges in aligning AI adoption with legal and ethical standards. More so, this thesis aims to provide insights into the dynamics of AI adoption, its impact on information management and user experiences, and its implications for cultural heritage preservation in Africa. Over all, the research aims to contribute to a better understanding of how AI is used in GLAM institutions in Africa and how it can enrich the accessibility and relevance of cultural heritage materials for diverse communities across the continent.

Keywords: "Artificial Intelligence", Informational practices", "GLAM institutions"

RESUME

Cette étude se concentre sur la manière dont l'intelligence artificielle (IA) est utilisée dans les galeries, bibliothèques, archives et musées (GLAM) en Afrique. Avant d'entrer dans le vif du sujet, cette recherche commence par un aperçu du concept et des notions d'IA, de l'origine et de la portée existante de l'IA en Afrique qui cartographie l'écosystème de l'IA sur le continent africain. Il vise à comprendre l'impact et les implications des technologies d'IA sur la préservation du patrimoine culturel, la gestion de l'information et l'engagement des utilisateurs dans les institutions GLAM à travers l'Afrique. La recherche examine les défis et opportunités uniques associés à l'utilisation de l'IA dans les institutions GLAM en Afrique, en tenant compte des divers environnements culturels et technologiques de la région. L'étude explore la manière dont l'IA est utilisée pour gérer, préserver et fournir un accès aux documents du patrimoine culturel dans les institutions GLAM et examine comment les technologies d'IA sont intégrées dans les pratiques d'information existantes et l'impact sur la création de ressources de connaissances culturelles inclusives et accessibles pour divers publics. Il étudie comment les systèmes d'information basés sur l'IA influencent l'engagement des utilisateurs, l'accessibilité et l'interprétation des documents du patrimoine culturel dans les contextes GLAM, examine les efforts visant à former le personnel du GLAM à utiliser efficacement les outils d'IA pour la gestion et la diffusion de l'information, explore les partenariats entre les acteurs de l'IA, les institutions GLAM, les développeurs de technologies pour promouvoir des approches innovantes en matière de mise en œuvre de l'IA et de partage des connaissances, examine les lois et les directives éthiques qui régissent l'utilisation de l'IA dans les institutions GLAM, dans le but d'identifier les lacunes et les défis potentiels dans l'alignement de l'adoption de l'IA sur les normes juridiques et éthiques. Plus encore, cette thèse vise à fournir un aperçu de la dynamique de l'adoption de l'IA, de son impact sur la gestion de l'information et des expériences des utilisateurs, et de ses implications pour la préservation du patrimoine culturel en Afrique. Dans l'ensemble, la recherche vise à contribuer à une meilleure compréhension de la manière dont l'IA est utilisée dans les institutions GLAM en Afrique et comment elle peut enrichir l'accessibilité et la pertinence des matériaux du patrimoine culturel pour diverses communautés à travers le continent.

Mots cles : « intelligence artificielle », « pratique informationelle », « institution GLAM »

LIST OF TABLES

ACCRONYMS AND ABBREVIATION

Abbreviation and acronym	Meaning
4IR	Fourth Industrial Revolution
A4AI	Alliance For Affordable Internet
AAIM	African Art In Motion
ADH	African Digital Heritage
AGI	Artificial General Intelligence
AgTech	Agricultural Technology
AI	Artificial Intelligence
AI4D	Artificial Intelligence For Development
ANI	Artificial Narrow Intelligence
ASI	Artificial Superintelligence
AU	African Union
BERT	Bidirectional Encoder Presentations From Transformers
CaDet	Cancer Detection
CNN	Convolutional Neural Networks
ECX	Ethiopian Commodity Exchange
GDP	Gross Domestic Product
GLAM	Galleries, Libraries, Archives, and Museums
GPT	Generative Pre-Trained Transformer
GPU	Graphic Processing Unit
IBM	International Business Machine
ICT	Information and communication technology
IoT	Internet of things
IT	Internet Technology
ITU	International Telecommunication Union
Mboalab Biotech	Mboa Laboratory Biotechnology
MTN	Mobile Telecommunication Network
NER	Named Entity Recognition
NLP	Natural Language Processing

NLSA	National Library of South Africa
RNN	Recurrent Neural Network
SDG	Sustainable Development Goals
SNARC	Stochastic Neural Analog Reinforcement Calculator
SSA	Sub-Saharan Africa
STEM	Science, Technology, Engineering, And Mathematics
SVM	Vector Machine
T5	Text To Text Transfer Transformer
UNECA	United Nations Economic Commission for Africa
WHO	World Health Organization

GENERAL INTRODUCTION

The convergence of technology and cultural heritage has brought forth transformative opportunities for the preservation, management, and dissemination of diverse cultural materials within the domain of Galleries, Libraries, Archives, and Museums (GLAM). In recent years, the adoption of artificial intelligent (AI) technologies have emerged as a promising avenue for revolutionizing the informational practices within GLAM institutions, particularly in the African context. As these institutions struggle with the challenges of digitization, preservation, and accessibility of rich and diverse cultural heritage materials, the integration of AI presents both opportunities and complexities that warrant scholarly exploration.

This study seeks to dive into the informational practices of AI in the realm of GLAM institutions across Africa, aiming to unravel the multifaceted dimensions of AI adoption and implementation within the context of cultural heritage management. By examining the intersection of AI technologies and informational practices, this research endeavors to shed light on the evolving landscape of knowledge management, preservation strategies, and the dissemination of cultural heritage materials in the digital era.

The African continent boasts a wealth of cultural diversity, encompassing a myriad of traditions, languages, and historical narratives that are encapsulated within the collections of GLAM institutions. The utilization of AI technologies within these institutions holds the potential to enhance the digitization and preservation efforts, while also fostering broader accessibility to cultural materials for diverse audiences. However, this technological integration raises critical questions pertaining to ethical considerations, community engagement, capacity building, and the implications for inclusive representation of cultural heritage within an AI-driven framework.

Against this background, this research endeavors to explore the current informational practices employed by GLAM institutions in Africa as they navigate the terrain of AI adoption and implementation. By examining the challenges, opportunities, and ethical considerations associated with AI-driven informational practices, this study aims to contribute to a detailed understanding of the implications of AI technologies on knowledge management, preservation strategies, and cultural heritage dissemination within the African GLAM sector.

Furthermore, this research seeks to investigate how AI can be used to address specific challenges faced by GLAM institutions in Africa, such as limited resources for digitization and preservation, linguistic and cultural diversity, and the need for community-driven approaches to knowledge management. It aims to explore how AI can facilitate automated cataloging, metadata enrichment, multilingual content analysis, and personalized user experiences particular to diverse cultural contexts.

In summary, this study attempts to unravel the intricate tapestry of AI-driven informational practices within GLAM institutions in Africa, with a view towards advancing scholarly discourse and informing practical strategies for harnessing AI technologies in the service of cultural heritage preservation and accessibility. It is our hope that this research will contribute to a deeper understanding of the role of AI in shaping the future of cultural heritage management in Africa and pave the way for sustainable and inclusive approaches to preserving and sharing the continent's rich cultural legacy.

PART ONE : LITERATURE REVIEW

CHAPTER ONE : GENERAL INFORMATION ON ARTIFICIAL INTELLIGENCE

In the world, the technological and industrial revolution is accelerating by the widespread application of new generation information and communication technologies, such as AI, IoT (the Internet of Things), and blockchain technology. Artificial intelligence has attracted much attention from government, industry, and academia (Zhang & Lu, 2021). It is a broad, dynamic field of science dedicated to creating machines that are able to perform tasks and exhibit behaviors which when accomplished by humans, generally requires much time and intelligence. From problem solving and decision making to learning and understanding natural language, AI encompasses a wide range of approaches and techniques aimed at enabling machines to emulate various aspects of human cognition.

AI is a knowledge project that takes knowledge as the object, acquires knowledge, analyzes and studies the expression methods of knowledge, and employs these approaches to achieve the effect of simulating human intellectual activities (Zhang & Lu, 2021).

AI is a compilation of computer science, logic, biology, psychology, philosophy, and many other disciplines, and it has achieved remarkable results in applications such as speech recognition, image processing, natural language processing, the proving of automatic theorems, and intelligent robots. It plays an indispensable role in social development, and it has brought revolutionary results in improving labor efficiency, reducing labor costs, optimizing the structure of human resources, and creating new job demands (Zhang & Lu, 2021). The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages.[1] For the computer to be able to mimic human tasks and behaviour, AI has to take into consideration how the human mind works in reasoning, solving problems and making decisions.

[1] Definition by the OXFORD DICTIONARY

AI refers to technology that can perform tasks that require a certain level of intelligence, that is, a machine or tool that has been trained to perform work like that of a human. It is categorized into two basic types including weak and strong AI or narrow and general AI (Flowers, 2019). Weak AI portrays AI as a problem-solving tool, whereas strong AI entails the creation of a "real" mind (Flowers, 2019). AI involves Natural Language Processing (NLP), Robotics, Machine and Deep Learning, Cognitive Computing, and Reinforcement Learning.

Going deeper into the concept of AI, we'll be focusing on its origin, the various types of AI such as the Artificial narrow intelligence and the artificial general intelligence. In this chapter we'll equally be breaking down several areas of AI such as expert systems, natural language processing and machine learning just to name a few. This in order to be able to give a general tour to what AI is all about.

1. HISTORY AND EVOLUTION OF AI

Artificial intelligence, or AI, is a program that seeks to imitate human thinking through computational algorithms. Its creation enables computers to perform operations and think like a human being (Neelam, 2022). The history of artificial intelligence began in 1943, with the publication of the paper "A Logical Calculus of Ideas Immanent in Nervous Activity" by Warren McCullough and Walter Pitts (Piccinini, 2004). In this paper, the scientists present the first mathematical model for the creation of a neural network. In 1950, SNARC, the first neural network computer, was created by two Harvard students: Marvin Minsky and Dean Edmonds. During the cause of the same year, Alan Turing published the Turing Test, which is still used to evaluate AIs. This test laid the foundations for artificial intelligence, its vision and objectives: to replicate and/or simulate human intelligence in machines. It wasn't until 1956, during John McCarthy's "Dartmouth Summer Research Project on Artificial Intelligence" conference, that the term artificial intelligence was first uttered. At this event, researchers presented the goals and vision of AI, many considering this conference to be the true birth of artificial intelligence as we know it. Several years passed, and work on artificial intelligence continued. In the year 1959, Arthur Samuel came up with the term Machine Learning while working at IBM. In 1989, the Frenchman Yann LECUN developed the first neural network capable of recognizing handwritten numbers, an invention that would go on to become the basis for the development of deep learning. Ten years later, in 1997, a major event marked the history of AI. IBM's Deep Blue system triumphed over world chess champion Gary Kasparov. For the first time, the machine defeated a man.

Artificial intelligence, as a branch of science that studies and develops intelligent machines, is a significant component of the fourth industrial revolution that will lead to fundamental changes in the way people live, work, and relate to one another. From a philosophical perspective, AI has the potential to help people live more meaningful lives without having to work as hard, as well as manage the massive network of interconnected individuals, businesses, states, and nations in a way that benefits everyone; thus, the primary goal of AI is to enable computers and machines to perform cognitive functions such as problem-solving, decision making, perception, and comprehension of human communication (Sarker, 2022) .

This field of science was established in the 1950s, and during that period in time, AI was said to be the new science with the ability to methodically examine the phenomenon of intelligence. This was to be done through the use of computer stimulated intelligent processes to achieve this goal. Intelligence is viewed as a mental skill that incorporates a variety of more specialized abilities, including reasoning, planning, problem solving, concepts understanding, use of language, and learning. To test computer intelligence, in 1950, Turing and Haugeland (1950) introduced the Turing Test which is still recalled despites some critics on the poor design and under specification of the test (Gonçalves, 2023).

Artificial Intelligence is probably the most complex and astounding creations of humanity yet, and that is disregarding the fact that, the field remains largely unexplored, which means that every amazing AI application that we see today represents merely the tip of the AI iceberg, as it were (Joshi, 2019). While this fact may have been stated and restated numerous times, it is still hard to comprehensively gain perspective on the potential impact of AI in the future. The reason for this is the revolutionary impact that AI is having on society, even at such a relatively early stage in its evolution.

AI's rapid growth and powerful capabilities have made people paranoid about the inevitability and proximity of an AI takeover. Also, the transformation brought about by AI in different industries has made business leaders and the mainstream public think that we are close to achieving the peak of AI research and maxing out AI's potential (Joshi, 2019). However, understanding the types of AI that are possible and the types that exist now will give a clearer picture of existing AI capabilities and the long road ahead for AI research. Since AI research purposes are to make machines emulate human-like functioning, the degree to which an AI system can replicate human capabilities is used as the criterion for determining the types of AI. Thus, depending on how a machine compares to humans in terms of versatility and performance, AI can be classified under one, among the multiple types of AI (Joshi, 2019).

Under such a system, an AI that can perform more human-like functions with equivalent levels of proficiency will be considered as a more evolved type of AI, while an AI that has limited functionality and performance would be considered a simpler and less evolved type.

Based on this criterion, there are two ways in which Ai is generally classified. One type is based on classifying AI and AI enabled machine based on their likeness to the human mind, and their ability to "think" and perhaps even "feel" like humans. According to this system of classification, there are four types of AI or AI based systems: reactive machine, limited memory machines, theory of mind and self-aware AI.

2. TYPES OF AI

AI is generally classified into a general system of classification where in we'll be talking about types like the reactive machines, limited memory, theory of mind and self-aware. On the other hand, looking at it from an alternate system of classification, the more generally used technological jargon is the classification of this technology into; Artificial Narrow intelligence, artificial general intelligence and artificial superintelligence. Below we'll be elaborating on both the general classification system and the alternate classification system

2.1 General classification system of AI

This system of classification is made up of four components which are: reactive machines, limited memory, theory of mind and self-aware. More details will be given below.

2.1.1 Reactive machines

These are the oldest forms of AI systems that have extremely limited capability. They emulate the human mind's ability to respond to different kinds of stimuli. These machines do not have memory-based functionality. This means such machines cannot use previously gained experiences to inform their present actions, i.e., these machines do not have the ability to "learn." They could only be used for automatically responding to a limited set or combination of inputs and cannot be used to rely on memory to improve their operations based on the same. A popular example of a reactive AI machine is IBM's Deep Blue a machine that beat chess Grandmaster Garry Kasparov in 1997.

2.1.2 Limited Memory

Limited memory machines are machines that, in addition to having the capabilities of purely reactive machines, are also capable of learning from historical data to make decisions. Nearly all existing applications that we know of, come under this category of AI. All present-day AI systems, such as those using deep learning, are trained by large volumes of training data that they store in their memory to form a reference model for solving future problems. For instance, an image recognition AI is trained using thousands of pictures and their labels to teach it to name objects it scans. When an image is scanned by such an AI, it uses the training images as references to understand the contents of the image presented to it, and based on its "learning experience" it labels new images with increasing accuracy. Almost all present-day AI applications, from chatbots and virtual assistants to self-driving vehicles are all driven by limited memory AI (Joshi, 2019)

2.1.3 Theory of Mind

While the previous two types of AI have been and are found in abundance, the next two types of AI exist, for now, either as a concept or a work in progress. Theory of mind AI is the next level of AI systems that researchers are currently engaged in innovating. A theory of mind level AI will be able to better understand the entities it is interacting with by discerning their needs, emotions, beliefs, and thought processes. While artificial emotional intelligence is already a budding industry and an area of interest for leading AI researchers, achieving Theory of mind level of AI will require development in other branches of AI as well. This is because to truly understand human needs, AI machines will have to perceive humans as individuals whose minds can be shaped by multiple factors, essentially "understanding" humans.

2.1.4 Self-aware

This is the final stage of AI development which currently exists only hypothetically. Self-aware AI, which, self explanatorily, is an AI that has evolved to be so akin to the human brain that it has developed self-awareness. Creating this type of AI, which is decades, if not centuries away from materializing, is and will always be the ultimate objective of all AI research. This type of AI will not only be able to understand and evoke emotions in those it interacts with, but also have emotions, needs, beliefs, and potentially desires of its own. And this is the type of AI that doomsayers of the technology are cautious and scared of. Although the development of self-aware can potentially boost our progress as a civilization, it can also potentially lead to catastrophe. This is because once self-aware, the AI would be capable of having ideas like self-preservation which may directly or indirectly spell the end for humanity, as such an entity could

easily outmaneuver the intellect of any human being and elaborate schemes to take over humanity (Joshi, 2019)

2.2 The Alternate classification system

The alternate system of classification that is more generally used in technology jargon is the classification of the technology into Artificial Narrow Intelligence (ANI), Artificial General Intelligence (AGI), and Artificial Superintelligence (ASI). More details below.

2.2.1 Artificial Narrow Intelligence (ANI)

This type of artificial intelligence represents all the existing AI, including even the most complicated and capable AI that has ever been created to date. Artificial narrow intelligence refers to AI systems that can only perform a specific task autonomously using human-like capabilities. These machines can do nothing more than what they are programmed to do, and thus have a very limited or narrow range of competencies. According to the aforementioned system of classification, these systems correspond to all the reactive and limited memory AI. Even the most complex AI that uses machine learning and deep learning to teach itself falls under ANI. Concrete examples of narrow AI include, google search equally just known as google; recommendation engines; facial/image recognition softwares; recommender systems used by platforms such as Netflix, amazon, Spotify; personal virtual assistants such as Alexa, Siri and others; self-driving cars; email filtering, just to name a few.

2.2.2 Artificial General Intelligence (AGI)

Artificial General Intelligence is the ability of an AI agent to learn, perceive, understand, and function completely like a human being. These systems will be able to independently build multiple competencies and form connections and generalizations across domains, massively cutting down on time needed for training. This will make AI systems just as capable as humans by replicating our multi-functional capabilities.

2.2.3 Artificial Superintelligence (ASI)

The development of Artificial Superintelligence will probably mark the pinnacle of AI research, as AGI will become by far the most capable forms of intelligence on earth. ASI, in addition to replicating the multi-faceted intelligence of human beings, will be exceedingly better at everything they do because of overwhelmingly greater memory, faster data processing and analysis, and decision-making capabilities. The development of AGI and ASI will lead to a scenario most popularly referred to as the singularity. And while the potential of having such

powerful machines at our disposal seems appealing, these machines may also threaten our existence or at the very least, our way of life (Joshi, 2019).

At this point, it is hard to picture the state of our world when more advanced types of AI come into being. However, it is clear that there is a long way to get there as the current state of AI development compared to where it is projected to go is still in its rudimentary stage. For those holding a negative outlook for the future of AI, this means that now is a little too soon to be worrying about the singularity, and there's still time to ensure AI safety. And for those who are optimistic about the future of AI, the fact that we've merely scratched the surface of AI development makes the future even more exciting.

3. AREAS OF AI

3.1 Natural language processing (NLP)

This is the capacity of a computer system to understand and decode human language (natural language) as it is spoken and written (Lutkevich, 2018), all this thanks to artificial intelligence. Compared to the human sense of taking in information, working on it and producing results, the natural languages processing follows similar processes for the computer to understand such as: programs to read and microphones to collect audios, programs to process the received input by converting them into computer understandable language or codes. Natural language processing is used for machine translation, natural language generation, text extraction, text classification (Lutkevich, 2018). And is applied in areas like automatic translation, customer feedback analysis, academic research and analysis, talent recruitment knowing well that NLP deals with massive data inputs.

NLP is a complex field with its set of challenges, including handling ambiguity, context understanding, and the nuances of language. In recent years, deep learning techniques, particularly recurrent neural networks (RNNs) and transformers, have significantly advanced the state-of-the-art in NLP, leading to breakthroughs in tasks such as language translation, text summarization, and language understanding(Crockett, 2023). Additionally, the emergence of large-scale pre-trained language models like GPT-3 has driven the development of more powerful and versatile NLP applications, while also raising considerations around ethical use, bias mitigation, and responsible AI deployment in NLP systems. NLP is continuously evolving and holds immense potential for a wide range of real-world applications, making it an exciting and impactful field within the broader landscape of AI and machine learning.

3.1.1 Table 1: Key Components of NLP

Components of NLP	
Components	**Explanation**
Tokenization	Tokenization involves breaking down text into its individual components, such as words, phrases, symbols, or other meaningful elements, often as a precursor to further analysis.
Part-of-Speech Tagging	This involves identifying the grammatical parts of speech (e.g., nouns, verbs, adjectives) for each word in a sentence. It helps in understanding the syntactic structure of a sentence.
Named Entity Recognition (NER)	NER focuses on identifying and categorizing entities within text such as names of persons, organizations, locations, date expressions, and more. This is crucial for tasks such as information extraction and content categorization.
Sentiment Analysis	Sentiment analysis involves determining the sentiment expressed in a piece of text. This is often used to gauge public opinion, customer feedback, and social media sentiments
Language Modeling	Language models are essential for predicting the probability of a word or sequence of words in a given context. They are fundamental to many NLP tasks, including machine translation and text generation.
Machine Translation	This involves the automatic translation of text from one language to another. It's a complex task that relies on a deep understanding of both source and target languages.

Source : Nkweti Christabella

3.1.2 Advancements in NLP

Transfer Learning and Pre-trained Models: Transfer learning has revolutionized NLP, where pre-trained models are fine-tuned for specific tasks. For instance, models like BERT, GPT-3, and T5 have demonstrated remarkable performance across a range of NLP tasks, from language understanding to text generation.

Multimodal NLP: Multimodal NLP integrates text with other modalities such as images, audio, and video. This has given rise to more comprehensive understanding of language in diverse contexts, enabling applications like image captioning and visual question-answering systems.

Conversational AI and Dialogue Systems: NLP plays a critical role in developing conversational AI that can engage in natural, human-like interactions. This extends to chatbots, virtual assistants, and customer service automation, where understanding and generating natural language responses is crucial.

Ethical and Fair NLP: With the increasing impact of NLP on society, there's a growing focus on ethical AI practices within NLP. This includes mitigating bias in language models, ensuring privacy in language processing, and addressing challenges related to misinformation and disinformation in natural language data.

Low-Resource Language NLP: Efforts are being made to address NLP challenges in under-resourced languages, aiming to make NLP technologies more inclusive and representative of diverse linguistic and cultural contexts.

In the African context, NLP has the potential to facilitate language preservation, local content generation, and communication in multilingual societies. Challenges such as low-resource language processing and dialectal diversity provide opportunities for NLP innovation that caters to the unique linguistic landscape of the continent. As NLP continues to evolve, it has the potential to revolutionize communication, break down language barriers, and empower individuals and communities through enhanced access to information and knowledge. Considering the wide diversity of languages and cultures within Africa, NLP can play a pivotal role in preserving and promoting linguistic heritage while fostering technological advancement and inclusion.

3.2 Machine learning

Unlike deep learning, algorithms are developed to be able to learn from existing data and improvement of performances over time. Machine learning is used in fields such as predictive analytics, fraud detection, personalized marketing. It is one of the fields that researchers and practitioners have applied broadly, using it for data analysis. Machine learning was first mentioned in 1959 by Arthur Samuel, who defined it as a process that enables computers to learn without being explicitly programmed. (Chen et al., 2020). Nowadays, machine learning has made it possible for a computer to classify or predict outcomes from an extensive database. This processing system was later significantly improved with the breakthrough of deep learning, which enabled the computer to process numerous algorithms effortlessly with graphics processing units (GPU) (Chen et al., 2020). It makes use of computational techniques to enable systems learn from data or experience. It employs a set of statistical methods to find

patterns in existing data and to then use patterns to make predictions on production data. In traditional computer programming, a programmer specifies the logic to solve a given problem by specifying exact computational steps using a programming language. In contrast, the logic of a machine learning model is in part dependent on the data used to train the model. Thus, the computations, or steps, needed to solve the problem are not determined a priori. Also, in contrast to traditional computer programming, machine learning models can improve over time without being re-written by being re-trained on new, additional data and by using techniques to optimize model parameters and data features (ISO/IEC, 2022) It plays a pivotal role in various industry domains, from healthcare and finance to robotics and natural language processing, revolutionizing how systems analyze information and make decisions. Machine learning continues to shape the landscape of AI and technology, driving innovations and impact across a wide spectrum of domains and applications. Let's explore the foundational concepts, key techniques and popular algorithms, applications, and future implications of machine learning.

3.2.1 Table 2: Foundational Concepts

CONCEPTS	EXPLANATION
Supervised Learning	In supervised learning, models are trained on labeled data, where the input features are mapped to known output labels. Supervised learning is used for tasks such as classification (assigning categories to data) and regression (predicting continuous values).
Unsupervised Learning	Unsupervised learning involves training models on unlabeled data to discover patterns, structures, or clusters within the data. Clustering and dimensionality reduction are common applications of unsupervised learning algorithms.
Reinforcement Learning	Reinforcement learning focuses on training agents to make sequential decisions in an environment by learning from feedback in the form of rewards and penalties. It's widely used in areas like robotics, gaming, and autonomous systems.
Feature Engineering	Feature engineering involves selecting, transforming, and creating input features to improve the performance of machine learning models. It's a critical aspect of enhancing model accuracy and robustness.

Source: Nkweti Christabella

3.2.2 Key Techniques and Algorithms

Decision Trees and Random Forests: Decision trees are used for classification and regression tasks, while random forest uses learning to improve prediction accuracy and handle complex data structures.

Support Vector Machines (SVM): SVM is a powerful algorithm for both classification and regression tasks, capable of handling high-dimensional data and non-linear relationships through kernel functions.

Neural Networks and Deep Learning: Neural networks, particularly deep learning architectures, have gained prominence in areas like image recognition, natural language processing, and speech synthesis, enabling complex pattern recognition and representation learning.

Clustering Algorithms: Clustering algorithms, such as k-means and hierarchical clustering, are used for unsupervised learning tasks and are essential in identifying natural groupings within data.

Recommender Systems: Techniques like collaborative filtering and matrix factorization are employed to build recommender systems that provide personalized recommendations based on user preferences and historical interactions.

3.3 Deep learning

Deep learning is a fascinating and rapidly evolving field within machine learning, marked by its ability to learn from data in increasingly intricate and abstract ways. As a subset of artificial intelligence, deep learning has revolutionized a diverse range of applications, from image and speech recognition to medical diagnostics and natural language understanding. Talking on deep learning, we'll tarry on the extensive exploration of deep learning, covering its core concepts, techniques, renowned architectures, prominent applications, challenges, and futuristic directions.

3.3.1 Fundamental Concepts of Deep Learning

Neural Networks: Central to deep learning, neural networks are computational models inspired by the human brain, composed of interconnected nodes (neurons) that process and transform data to produce complex mappings and representations.

Backpropagation and Gradient Descent: Backpropagation, combined with optimization algorithms like gradient descent, enables neural networks to iteratively learn from data, adjusting their parameters to minimize errors and improve their predictive capabilities.

Network Architectures: Deep learning models often comprise deep neural network architectures, featuring multiple hidden layers, which enable the automatic extraction of hierarchical features from input data.

3.3.2 Core Techniques and Architectures

Convolutional Neural Networks (CNNs): CNNs specialize in processing grid-structured data, excelling in image recognition, object detection, and image generation, leveraging techniques such as convolution and pooling layers.

Recurrent Neural Networks (RNNs): RNNs are powerful for processing sequential data, enabling tasks like time-series prediction, language modeling, and speech recognition, leveraging their ability to capture temporal dependencies.

Transformers and Attention Mechanisms: The advent of transformers, employing self-attention mechanisms, has revolutionized natural language processing, leading to advancements in tasks such as language translation and information retrieval.

Deep learning continues to empower transformative advancements across a diversity of fields, propelling innovation, shaping technological landscapes, and driving solutions to complex challenges.

3.4 Expert systems

When talking about expert systems, reference is being made on the type of artificial intelligence that uses knowledge and rules to solve problems that would normally require human expertise. It's more like having a virtual expert on hand to help out. It is then said to be a computer program that makes use of AI to simulate human or organizational judgement and behaviors with expertise and experience in a given field. These expert systems do not have an intention of replacing human expertise but rather to compliment them for more efficiency (Buchanan & Smith, 1988). The expertise system having three main components which are:

the knowledge base, where the information (from external sources) drawn by the expert system is stored. There it more about collection of facts rules and heuristics;

the inference engine, which collects information from the knowledge base to solve user's problems. It makes or takes decisions from the available information which every demonstration to its users of every step taken. It is a correct demonstration of input equal to output. This level deals more with logical reasoning for proper decision making and conclusions. And lastly,

the user interface, which is the part of the system where end users interact with to get solutions and answers to their questions.

Expert systems can be used in the areas of agriculture, healthcare (for example MYCIN for bacteria identification and recommendation of drugs, CaDet for cancer identification in its earliest stages; demonstrating the potential of expert systems in specialized domains (Jackson, 1986)), telecommunication, transportation, financial services, law and even mechanical engineering. They are especially useful in situations where human expertise is scarce or where consistent decision making is required. Today, with the advancements in machine learning and data-driven approaches, expert systems have evolved and are often integrated with other AI techniques to create more powerful applications. It's fascinating to see how they continue to be relevant in our rapidly advancing technological landscape (Buchanan & Smith, 1988).

3.4.1 Table 3: Components of an Expert System

COMPONENTS	EXPLANATION
Knowledge Base	This is where all the domain-specific information is stored. It includes facts, rules, and heuristics. Facts are pieces of specific information about the domain, while rules are logical statements that define the relationships between these facts. Heuristics are guidelines or strategies for problem-solving. the knowledge base is the core of the expert system, storing both the static and dynamic knowledge used for decision making (Lucas, n.d.).
Inference Engine	The inference engine is the core of the expert system. It's the part that processes and manipulates the information stored in the knowledge base to arrive at conclusions or make decisions. It uses logical reasoning, which can include techniques like deduction, abduction, and induction.

User Interface	This is the part of the system that allows interaction with the user. It can take various forms such as text-based, voice interactions or graphical interfaces, depending on the system's design and its job is to communicate with the user, gather input, and present the system's conclusions.
Explanatory Facility	Sometimes, it's essential for an expert system to explain its reasoning process and the basis for its conclusions. This helps users understand the system's recommendations and build trust in its decisions.

Source: Nkweti Christabella

3.4.2 Types of expert systems

Rule-Based Systems: These are the most common type, where the knowledge base is primarily comprised of a set of rules. When a problem is presented, the system matches the facts against these rules to reach a conclusion.

Case-Based Reasoning Systems: In this type, the system works by comparing the current problem with similar cases in its memory and then adapting the solutions of those past cases to fit the current situation.

Model-Based Systems: These systems use a model of the problem domain, incorporating scientific principles and mathematical models. They typically work well for problems with a strong theoretical foundation, such as engineering and physics.

Hybrid Systems: As the name suggests, these systems combine elements from different types of expert systems or integrate expert systems with other technologies such as machine learning or natural language processing.

Artificial intelligence encompasses a diverse range of technologies and applications that are shaping the future of numerous industries and aspects of daily life, from the various types of AI including narrow and weak AI, general and super intelligence, these different types of AI have the potential to revolutionise various fields and industries. As this type of AI continue to expand, it is important to sink deep into understanding and analysing the various ethical implications on their adoption. Issues such as privacy concerns, displacement or revision of human labour requires careful consideration and surveillance that these technologies are used properly and responsibly. Despites all the considerations required, the various types of AI and their areas of implication hold a great role in addressing real world challenges and progress.

We cannot talk on generalities on AI without making mention of the different fields of AI application. Chapter two of this work outlines the various fields of AI such as AI in healthcare, banking and finance, Agriculture, transport sector and in communication,

CHAPTER TWO : FIELDS OF AI APPLICATION

Artificial intelligence is massively gaining ground. the application of AI is vast and covers a wide range of fields. The various areas of reach are in healthcare, agriculture, finance, transportation just to name a few. The more technology continuous to advance, the more potentials for AI to drive innovation and create new opportunities across industries is great.

1. Artificial intelligence used in healthcare

Ever since deep learning came into contact with the medical sector, the role of AI in this field has greatly increased. It is now possible to obtain a precise diagnosis, which requires the intervention of an entire team of specialists and many hours of analysis. This ability to implement operational Big Data to refine medical knowledge is quite innovative, and promises even more spectacular advances. In some cases, for example, an algorithm is capable of predicting a potential risk of triggering a particular disease at a very early stage. The role of the doctor is thus taken over by the machine, which can process data in record time. It can also relate the data to all new discoveries, giving it a considerable head start over the cognitive capacities of the human brain. Perhaps the greatest revolution of recent years has been the ability to detect cancer by analyzing all the elements and a huge amount of data. Here, deep learning is showing one of its most impressive applications, especially as new discoveries are constantly adding to the panoply of means of analysis.

Healthcare and Medical Diagnostics: Machine learning is integral to medical imaging analysis, disease diagnosis, personalized treatment recommendations, and drug discovery.

Healthcare and Medical Imaging: Deep learning has significantly impacted medical imaging analysis, disease diagnosis, personalized treatment recommendations, and drug discovery in healthcare.

2. AI used in Agricultural Optimization

AI-driven solutions are revolutionizing agriculture through precision farming, crop yield optimization, pest management, and climate-resilient farming practices, contributing to food security and sustainable agribusiness. This are some of the areas where technology is impacting

Precision Farming: AI technologies, such as machine learning algorithms and computer vision, are used to analyze data from satellites, drones, and sensors to provide farmers with insights into soil health, crop growth, and pest infestations. This enables precision farming practices, including targeted irrigation, fertilization, and pesticide application, leading to optimized resource utilization and increased crop yields.

Crop Monitoring and Management: AI-powered systems can analyze data from various sources, including remote sensing, weather forecasts, and historical data, to monitor crop health, detect diseases, and predict yield outcomes. This information helps farmers make informed decisions about planting, harvesting, and managing their crops more effectively.

Yield Prediction: AI algorithms can analyze historical and real-time data to predict crop yields based on factors such as weather patterns, soil conditions, and crop health. This enables farmers to anticipate production levels, plan for market demands, and optimize their supply chain management.

Autonomous Farming Equipment: AI is being integrated into agricultural machinery to enable autonomous operations such as planting, harvesting, and weeding. These smart machines use AI algorithms to navigate fields, identify crops and weeds, and perform tasks with precision, reducing the need for manual labor and improving efficiency.

Supply Chain Optimization: AI technologies are used to optimize the agricultural supply chain by predicting demand, managing inventory, and improving logistics. This helps minimize food waste, reduce transportation costs, and ensure that produce reaches consumers in a timely manner.

Livestock Monitoring: AI-powered systems can monitor the health and behavior of livestock using sensor data and computer vision. This allows farmers to detect signs of illness, optimize feeding schedules, and improve overall animal welfare.

Above all, the application of AI in agriculture has the potential to increase productivity, reduce environmental impact, and contribute to sustainable farming practices by enabling data-driven decision-making and automation of various farming processes.

3. AI used in Banking and finance

Thanks to its performance in automatic data processing, artificial intelligence has long since found its way into the banking sector. This makes it possible to cross-check data very quickly,

particularly data that may be supplied by a customer. The response is almost instantaneous, and the efficiency of the process has contributed to its success. In a similar vein, financial professionals have turned to next-generation algorithms to provide real-time market status and rebounds. Here again, machine learning is at the service of a cutting-edge field that relies on almost immediate reactivity. Foresight is also greatly enhanced by the intervention of AI, which can anticipate and imagine scenarios. Here, AI puts into practice what it was designed to do, by establishing perspectives based on elements that sometimes escape human knowledge. In any case, it does so in record time, which is a great help.

Fintech and Financial Inclusion: the area of digital financial inclusion has drastically gained ground and it has become the talk of everyone. Debates on how to include both the financially able and disabled population are currently on going. Banks and non-banking institutes are building ways in which to improve access to people who were formerly served through the former systems which involved papers and physical presence. Through AI banks are innovating. Financial technology innovations powered by AI are fostering financial inclusion, credit assessment, risk management, and innovative digital payment solutions tailored to diverse consumer needs though the risk these innovations are facing is not to be ignored, but so far much is being done.

Financial Modeling and Risk Assessment: In finance, machine learning is used for fraud detection, credit scoring, portfolio optimization, and predictive analytics for market trends.

E-commerce and Recommendation Systems: Electronic commerce platforms leverage machine learning to provide personalized product recommendations, improve customer experience, and optimize marketing strategies.

4. Artificial intelligence used in the transport sector

Automobiles have long been equipped with AI of varying degrees of sophistication. Today, the trend is towards greater vehicle autonomy, as demonstrated by the first cabs on the road in some US cities. In France, some urban areas are equipped with autonomous shuttles that can anticipate and avoid accidents. This field is still in its infancy, but artificial intelligence as we know it already exists in the transport sector. The automatic piloting of a plane or a high-speed train is fully within this field. The machine's predictive capacity is such that it is a great help in the event of the slightest human failure. What's more, here too, applications are still in their infancy, as the transport sector is one of constant inventiveness. The automotive sector is banking heavily on these innovations, installing on-board computers that act as true co-pilots.

In some cases, they have demonstrated their ability to anticipate what, even the most vigilant driver cannot always foresee.

Autonomous Vehicles and Robotics: Machine learning is crucial for developing self-driving vehicles, robotic automation, and intelligent control systems in industrial settings.

Autonomous Systems and Robotics: AI-driven robots, autonomous vehicles, and intelligent control systems utilize deep learning for perception, decision-making, and environmental understanding.

5. Education Technology

The educational system is no exception to the changes that are currently ongoing thanks to AI. AI-based educational platforms, adaptive learning systems, and language translation services are enhancing educational accessibility, personalized learning experiences, and the delivery of quality education. By enabling educational accessibility and personalized learning, and skill development, AI is gradually addressing the challenges of limited access to quality education and overcrowded classrooms. Below are some areas of impact of AI in education.

Personalized Learning: AI-powered platforms can analyze vast amounts of student data to identify individual learning patterns, preferences, and areas of struggle. This allows for the creation of personalized learning paths and content tailored to each student's needs, enabling them to learn at their own pace and in a way that suits their unique learning style.

Intelligent Tutoring Systems: AI-driven tutoring systems provide students with personalized support, offering real-time feedback, guidance, and assistance. These systems can adapt to the student's progress, providing targeted interventions and additional resources as needed.

Automation of Administrative Tasks: AI can streamline administrative tasks such as grading, scheduling, and record-keeping, freeing up educators to focus more on teaching and mentoring students. This automation also helps in reducing the burden of repetitive administrative work on teachers and staff.

Enhanced Content Creation: AI technologies can be utilized to create adaptive learning materials and educational content that is tailored to individual students' needs and learning styles. This includes interactive simulations, virtual reality experiences, and personalized study materials.

Predictive Analytics: AI can analyze large sets of data to identify patterns and trends, helping educators make informed decisions about student performance, resource allocation, and

curriculum development. This can lead to more targeted interventions and improved learning outcomes.

Accessibility: AI tools can help make education more accessible to students with disabilities by providing personalized learning support and accessibility features. For example, AI-powered speech recognition and text-to-speech technologies can assist students with visual or auditory impairments.

Overall, AI in education technology holds immense potential for revolutionizing the way we teach and learn. By harnessing the power of AI, educators can provide more personalized, adaptive, and inclusive learning experiences that cater to the diverse needs of today's students. As AI continues to advance, its impact on education technology is likely to grow, driving further innovation and improvement in the field of education.

6. AI used in Commerce and services

Finally, commerce and services also call on the skills of artificial intelligence. When an e-commerce site tries to boost its sales and visibility, it involves a direct application of what AI is capable of. Even the major retailers have taken the plunge, particularly in inventory management (Ade-Ibijola & Okonkwo, 2023).

In fact, a robot can very well be put in charge of drawing up an inventory, where this job used to be assigned to an employee. The aim is to save time and boost performance by making automatic tasks easier to perform. The use of Big Data also makes it possible to target customers according to their expectations, which is always more relevant. Clearly, the service and retail sectors are in great demand of AI. The role of a researcher here is to respond as effectively as possible to the imperatives of these areas of activity.

To a certain extent, we can consider that we are still witnessing the beginnings of what will become a generality in the coming decades. Sectors that were initially more hesitant are now rethinking their strategies, and are increasingly turning to high tech as a sector in the making. AI professionals are constantly redefining their objectives, as the sectors in which they intervene multiply every day. It's no coincidence, then, that an AI conference is held every year to award prizes to the most creative and to reflect on the challenges of tomorrow.

7. AI used in Security

Security is another key area where AI is being used on a daily basis. Facial recognition software is one of the tools used on a daily basis to cross-check information. On another level, AI is also

at work in web data protection. Indeed, machine learning has the means to predict cyber-attacks and, therefore, block them before they happen. When it comes to security, then, it's important to design the way data is connected so as to protect individuals and businesses alike. In our daily lives, we all have to deal with AI, if only by unlocking our cell phone with our fingerprint. Voice recognition also comes into play all the time, whether at the workplace or in our personal communications. This security-focused sector is also growing fast, as demand increases with the development of new technologies.

8. AI used in Information and communication

We are in an era where human activities done manually are being crushed by the advent of AI in order to simplify tasks and activities. Haven said informational practices are ways and methods people use to remain updated, information practices are leading to the growth and advancement in the area of AI. Involving information practices in the area of artificial intelligence, it can be said that these are all ways in which individuals/persons, institutions, organizations, cooperate bodies, create, use, share and diffuse information related to AI be it in use and/or development. It’s more of a system life cycle from creation to diffusion or communication/diffusion or sharing; training systems to creating/collecting, Analysing, sharing and also for decision making which is an important phase in the entire process. Data collected is analyzed and processed in order to be used to make important decisions and contribute in knowledge growth.

Several information practices thus exist in the area of Artificial intelligence and all these practices are important for an organized, proper and better use of Artificial intelligence. Some of these practices are:

- **Interaction and Collaboration with community**

AI systems are increasingly being designed to interact and cooperate with humans in a variety of contexts, such as customer service, healthcare, and education. Information practices related to human-AI interaction include designing interfaces that are intuitive and user-friendly, as well as developing guidelines for how humans and AI systems should interact in different situations. AI development is a collaborative process that involves experts from a variety of disciplines, including computer science, statistics, and domain-specific fields. Effective collaboration and knowledge sharing practices are essential to ensure that AI systems are developed and deployed effectively and efficiently. This includes developing tools and platforms for collaboration, as well as promoting knowledge sharing and open communication among different users and

communities. If AI systems are developed with input from a diverse range of users from different backgrounds and organizations, then the AI systems designed can be able to meet the needs of a broad range of users. And to be able to build trust from these communities and organizations, and to ensure that the system is being used responsibly, there is also a need for openness/transparency in AI systems and space be given to the different users to give suggestions and feedbacks concerning the systems in place. Organizations should teach or train the different communities on how to use and implement AI systems. This will help in raising awareness and understanding of the AI systems. Not only the benefits but the risk equally which can easily be corrected. AI organizations that collaborate with its different users and communities can always easily identify areas where AI needs to be used to solve societal challenges and problems and for public benefit; making AI beneficial to society. this communication should also be extended to accountability, where inquiries are made on the impact of the different AI systems on society and how to address the negative impacts (can be done through implementing mechanisms for feedback as well as through regular evaluations of the systems).

- **Ethical standard regulation and governance:**

Developing and using AI technologies are subject to a variety of legal and regulatory frameworks. Data governance practices are there to ensure that data is accurate, reliable, and secure. Information practices related to regulation and governance includes developing policies and procedures for data collection, storage, and use, understanding and complying with relevant laws and regulations in place, as well as working with policymakers and other stakeholders to be informed on the development of new regulations and policies. AI raises important ethical issues especially when it comes to privacy, security and responsibilities. Practices related to ethics include selecting and implementing ethical standards to guide the use and development of AI.

The development and deployment of AI technologies have already demonstrated significant impact across sectors. In healthcare, AI is revolutionizing diagnostics, treatment planning, and patient care. In finance, AI is driving advancements in fraud detection, risk assessment, and algorithmic trading. The transportation industry is witnessing the rise of autonomous vehicles and smart traffic management systems powered by AI.

PART TWO : PROBLEM STATEMENT

CHAPTER THREE : ADVANCEMENT OF AI IN AFRICA

While AI in Africa has gained significant momentum in recent years, the historical narrative of AI's presence on the continent is rooted in a timeline that reflects the intersection of technological advancement, academic research, innovation, and the quest for impactful applications tailored to local contexts. Let's explore the historical evolution of AI in Africa, tracing key milestones, initiatives, and contributions.

In the latter half of the 20th century, African universities and research institutions began engaging with the foundational concepts of AI, primarily through academic programs, research projects, and collaborations with international institutions. Early contributions from African scholars to AI research and development, spanning areas such as robotics, machine learning, and natural language processing, laid the groundwork for the emergence of local expertise in AI-related disciplines. The establishment of AI research centers, technology incubators, and innovation hubs across African countries, including South Africa, Kenya, Nigeria, and Rwanda, has played a pivotal role in fostering AI-focused research, collaboration, and industry partnerships (Gadzala, 2018). The collaboration between academia, industry, and government entities has driven knowledge exchange, technology transfer, and the localization of AI-oriented solutions tailored to African contexts. African researchers, academics, and practitioners have increasingly participated in international AI conferences, symposia, and collaborative initiatives, contributing to the global discourse and exchange of AI knowledge and innovations.

Collaborative efforts with international AI organizations, academic consortia, and industry stakeholders have facilitated knowledge-sharing, capacity-building, and collaborative projects centered on AI research and development in Africa (Chinganya, 2023)

Efforts to adapt AI technologies for solving local challenges, such as healthcare accessibility, agricultural optimization, language preservation, and infrastructure management, have highlighted the significance of AI for social good in African communities. Grassroots initiatives and projects, spearheaded by local innovators, researchers, and entrepreneurs, have contributed to the development of AI applications tailored to the diverse linguistic, cultural, and societal

contexts within Africa. The exploration of ethical AI frameworks, data privacy regulations, and responsible AI deployment in African settings has become increasingly prominent, with efforts aimed at ensuring that AI technologies are aligned with ethical principles and address local societal needs. Several African governments have recognized the potential of AI for economic growth, innovation, and social impact, leading to the formulation of AI-related policies, investment strategies, and supportive measures for fostering AI ecosystems.

As AI adoption continues to expand, the focus is on using AI to address societal challenges, promote economic growth, and drive positive impact across diverse industry sectors and communities. Initiatives centered on community-driven innovation, inclusive AI development, and collaboration with local stakeholders aim to cultivate a diverse and representative AI landscape that caters to the unique needs and aspirations of African societies. The history of AI in Africa is marked by a trajectory of academic endeavors, industry partnerships, local innovation, and ethical considerations that have paved the way for the continent to harness the potential of AI for sustainable and inclusive growth.

Artificial intelligence is a constant presence in our daily lives. From a connected device that broadcasts a playlist based on previous listens to our purchases, technology is advancing on many levels. The fields of adoption and use are constantly diversifying, from medical to transport and security, as well as, education, commerce and finance (Arakpogun et al., 2021).

1. Areas of advancements

1.1 AI in Healthcare

AI is making significant inroads in healthcare, with applications in medical imaging analysis, disease diagnosis, telemedicine, and personalized treatment recommendations, aimed at improving access to quality healthcare services. For instance, in Rwanda, drone companies such as Charis UAS use AI to power drones that deliver medical supplies to patients in remote areas (Kenneth, 2021). Medical institutions in Morocco, Cameroon and South Africa have integrated SOPHiA artificial intelligence for clinical genomics into their clinical workflow to improve patients' care (Abardazzou, 2017). Let's take for instance that every examination or diagnosis was to be made by persons in the medical sector, looking at the rate at which diseases are present in the African continent, and also knowing that humans are prone to mistakes if over exercised, we would not imagine the number of errors and prescription of wrong medications to the wrong patients. With the shortage of able trained medical personals, AI at this point is of great importance, through machine learning, machines are trained on being able to identify infections.

This makes work easier and hence, more satisfaction at the level of the patients. Looking at the medical sector in Africa, AI is gradually being accepted and adopted. As an example of AI making progress in Africa, we have the Mboalab BioTech in Cameroon, known for their involvement in proposing solutions that meet the needs of the community through local knowledge and open digital technologies and also facilitating access to basic health cares. It is a laboratory which is interested in synthetic biology, artificial and electromechanical intelligence. It is important to highlight the concept of information at this point, AI will only be accepted if much information and communication has been done on the topic. People need to know what they are getting involved in. So far, communication and television programmes are being hosted to create awareness in communities. For instance, the monthly podcast by NEJM AI editors Arjim (Raj) Manrai, Ph.D. and Andrew Beam, Ph.D., on AI Grand Rounds brings to the audience casual conversations with a diverse range of experts exploring the deep issues at the intersection of artificial intelligence, machine learning and medicine. Another podcast on AI and medicine is the MedxTek Africa.

1.2 Agriculture

Agriculture is considered to be the backbone for growth and development of the African continent(Kenneth, 2021). Nigerian farmers have embraced smart farming practices with help of AgTech startups such as Zenvus and rural farmers Hub (Adams, 2022), to improve yield and optimize the use of resources. In 2015, the Ethiopian commodity exchange (ECX) teamed up with IBM and IBM business partner Wavetec, to build a coffee traceability solution (ECX e-Trading platform) based on state-of-the-art analytics, mobile and internet of things (IoT) technology so as to track coffee through all stages of the supply chain. Also, the Aeroview platform was developed in Cape town to assist farmers and help them in the yield through analyzing processed maps to identify problem areas in crops (Abardazzou, 2017). In Cameroon, Adamou NCHANGE KOUOTOU developed Agrix Tech, which is an application focused on recognizing diseases and pests from photographs and videos provided by farmers. The agricultural sector is fast growing due to the equally fast-growing population and the demand for agricultural produce is equally fast growing. The use of this fast-growing technology in the area of agriculture is thud in favour of the demand on the market.

1.3 AI in Banking and Finance

Artificial intelligence has become one of the most promising sectors as far as the banking and finance is concerned. However, in Africa, AI's growth has been very slow compared to other continents, though it is gaining momentum. This caused by a number of factors including lack or shortage of skills in the domain, lack of regulation and low technology adoption in the finance sector. These factors are fast changing as some banks have begun integrating AI into their business models, notably to optimize their loan portfolios, enhancing their customer experience, detecting fraud and improving their business performances (Takyar, 2023).

The AI ecosystem in Africa especially in the sector of banking and finance has undergone significant development in recent years. This is because African countries have begun recognizing the potentials of AI improving the financial services. The adoption of AI in banking and finance in Africa offers great opportunities. African banks are now able to offer personalized, faster and more efficient financial services, enhance transaction security and facilitate financial inclusion to their clients while contributing to the economic development of their countries. In most African countries, the traditional banking service is often inaccessible to a large proportion of the population due to either financial or geographical constraints/hindrances. Overcoming these barriers can be done through AI powered mobile devices for banking services, fraud detection and automated decision making (Lambert & Deyganto, 2023). Some countries have gone ahead to adopting policies for technological innovations, leading to the emergence of startups/companies specialized in AI for banking and financial activities; which have helped stimulate investments in research and development of AI solutions as a response to local needs (Oriji et al., 2023). As an example of this assertion, AI powered applications are being used in mobile payments services in Africa to facilitate transactions so as to enable people with no bank accounts to access financial services. Customers are now able to levy their queries and receive fast responses through AI powered chatbots as customer service.

The AI ecosystem in Africa in the sector of banking and finance offers significant opportunities as earlier mentioned. So far in the African continent so much has been done in the banking and finance sector (Oriji et al., 2023). Leading players in Africa AI banking and finance such as: Financial technology startups and innovators (flutter wave, paga and Interswitch) are using AI to create innovative payment solutions, digital lending platforms and financial inclusion services for the African market. Also, commercial banks and financial institutions have established banks and financial institutions for integrating AI for personalised customer services, fraud detection, risk management and digital banking experience, for example the

Kenyan equity bank, the south African standard bank, the pan African Ecobank, the Jumo and discovery bank in south Africa, the Dreamoval and Nvoicia companies in Ghana, the bank of Kigali in Rwanda, the piggyvest and Carbon platforms in Nigeria, and the M-Shwari platform in Kenya, just to name a few.

One of the prominent examples of the AI ecosystems lies within our area of reach. When talking on the African AI ecosystem it is but crucial for us to discuss on examples which are at our area of reach. it is crucial to consider the specific contribution and impact of prominent platforms such as MTN mobile money and Orange mobile money within the context of Cameroon. These platforms have been central to the digitalization of financial services, boosting financial inclusion and advancing the adoption of mobile centric banking solutions across the country. MTN mobile money has been a pivotal mobile financial service provider in Cameroon, offering a range of solutions that intersect with Ai initiatives within the banking and financial sector. Through the usage of AI and advanced analytics, MTN Mobile Money has been able to gain insights into customer behavior, transaction patterns, and usage trends. This has facilitated the development of tailored financial products and enhanced user experiences based on individual preferences and needs. Leveraging AI technologies, MTN Mobile Money has fortified its platform with advanced fraud detection and security measures. AI-powered algorithms are utilized to detect anomalies in transactions, identify potential risks, and ensure the integrity and security of financial transactions for users. Also, Machine learning and AI-driven recommendation systems have played a role in offering personalized financial services to MTN Mobile Money users. Through the analysis of transaction histories and user preferences, these platforms can provide tailored recommendations for savings, investment opportunities, and other financial products.

Similarly, Orange Money in Cameroon has contributed to the landscape of AI initiatives within the banking and financial domain through various strategic implementations. Orange Money has integrated AI-powered chatbots and virtual assistants to enhance customer support and engagement. These chatbots leverage natural language processing and AI-driven capabilities to facilitate seamless user interactions, address inquiries, and provide real-time assistance. The integration of AI for credit scoring and risk assessment has allowed Orange Money to expand access to financial services, including microloans and insurance products, based on AI-powered evaluations of user data and financial behaviors. AI-driven analyses of transactional data have enabled Orange Money to gain valuable insights into customer preferences, spending habits, and financial needs. These insights have informed the development of tailored financial

solutions and the optimization of service offerings to better serve the needs of users in Cameroon.

The integration of AI within mobile money platforms like MTN Mobile Money and Orange Money in Cameroon has significantly shaped the financial services ecosystem, paving the way for enhanced digital transactions, improved customer experiences, and broader access to financial solutions for individuals and businesses across the country. These initiatives not only reflect the commitment of mobile money operators to harness innovative technologies but also demonstrate the transformative impact of AI in catalyzing financial inclusion, promoting secure transactions, and enhancing the accessibility of diverse financial services for the people of Cameroon. Given the pivotal role of MTN Mobile Money and Orange Money in the evolution of digital finance in Cameroon, their alignment with AI-driven initiatives underscores the catalytic influence of mobile money platforms in driving innovative solutions and shaping the future of financial services across the country.

While there are still challenges to be tackled with, the AI ecosystem in the African banking and financial sector is fast growing and promising. If rightful measures/investments are put in place, with a good regulatory framework then Africa is good to go as far as the banking and financial sector is concerned.

1.4 AI in the Transport sector

In the transport sector, several concrete AI initiatives have emerged across Africa, driving impactful innovations and advancements aimed at improving transportation efficiency, safety, and sustainability. These initiatives leverage artificial intelligence to address various challenges and transform the landscape of transportation and mobility. The African AI ecosystem in the transport sector is growing and evolving with several key applications and developments. AI is being used to develop autonomous vehicles that use sensors, cameras, and machine learning algorithms to navigate roads and make decisions without human intervention (Mullane, 2023). AI algorithms are also deployed to predict traffic patterns and optimize traffic flow by analyzing sensors on roads and public transit systems (Mullane, 2023). African innovators on the other hand are creating local solutions to meet local challenges with countries like South Africa, Kenya, Egypt, Nigeria, as the leading AI countries in the transport sector (AI4G, 2022). Some countries are developing Ai strategies to support their economies for instance, Mauritius has published an AI strategy focusing on its ocean economy which is aimed at investing in Mauritius Internet of Things and establishing an Ai council to advise the government on supports its ecosystem. This strategy is also to improve public transport (Mubarik, 2020). AI

applications for traffic accident prediction, detection of dangerous driving behavior, and road safety analysis contribute to enhanced road safety measures and accident prevention, promoting safer transportation infrastructure. Mapping the African AI ecosystem in the transport sector is such an exciting topic, and there's been quite a bit happening in this space. Let's take a closer look at some concrete AI initiatives that have been making waves in Africa's transport sector and their impact so far. In South Africa, there have been initiatives to implement AI-powered predictive maintenance systems for public transportation fleets. These systems utilize AI algorithms to analyze vehicle data and predict maintenance needs, reducing downtime and improving overall fleet reliability. This initiative has led to cost savings for transportation companies and improved service reliability for passengers. By addressing maintenance issues before they become critical, transportation companies can effectively manage their fleet and provide more reliable services. In Kenya, AI is being employed to optimize traffic management in urban areas. By using AI algorithms to analyze traffic patterns and adjust signal timings dynamically, cities like Nairobi are working towards reducing congestion and improving the flow of traffic. This initiative has the potential to significantly reduce commute times, fuel consumption, and environmental pollution. Additionally, it can lead to smoother traffic flow, benefiting both commuters and businesses reliant on efficient supply chains. In Ghana, there have been pilot projects exploring autonomous minibus services in certain urban areas. These projects aim to use AI and sensor technologies to enable safe and efficient autonomous transportation in densely populated areas. If successful, these initiatives could potentially transform urban transportation by offering more efficient and cost-effective mobility solutions. This could have a substantial impact on public transportation accessibility and overall urban mobility. In Nigeria, there are initiatives aimed at developing AI-powered smart public transit routing systems. These systems utilize AI algorithms to optimize bus routes and schedules, taking into account real-time traffic data and passenger demand patterns. By improving the efficiency of public transit routes, this initiative can lead to reduced travel times, increased reliability, and enhanced accessibility for passengers. This has the potential to positively impact the daily commutes and overall mobility of urban residents. In Egypt, AI initiatives are being implemented to enhance road safety and prevent accidents. AI-powered systems analyze various data sources, including traffic patterns and driver behavior, to identify high-risk areas and develop proactive strategies to reduce accidents. This initiative has the potential to save lives and reduce the economic burden of road accidents. By leveraging AI for proactive accident prevention, it can contribute to creating safer road infrastructure and promoting responsible driving behavior. In Rwanda, there have been initiatives exploring the use of AI for autonomous

delivery systems, particularly in urban and remote areas. These systems aim to autonomously deliver goods and essential supplies, leveraging AI for route optimization and adaptive navigation. By introducing autonomous delivery systems, this initiative could significantly improve logistics and supply chain efficiency, especially in areas with limited access to traditional transportation infrastructure. It has the potential to facilitate faster and more reliable delivery of goods, potentially impacting sectors ranging from e-commerce to healthcare.

Though these initiatives come with a lot of promises, there are also challenges and considerations to address, such as data privacy, infrastructural development, and ensuring equitable access to AI-enabled transportation services. These concrete AI initiatives in Africa's transport sector are already making a positive impact in various countries, and they represent just a few examples of the exciting developments taking place in the intersection of AI and transportation. These initiatives, alongside many others, are contributing to a growing ecosystem of AI-driven solutions in the African transport sector, with the potential to bring about transformative changes in mobility, safety, and accessibility. The diversity of these initiatives reflects the innovative approaches being taken to address transportation challenges across the continent.

1.5 AI in Education

AI and education are a field that explores how AI can enhance, transform, and empower education systems and practices. AI offers various benefits for education in Africa, such as improving access, quality, equity, and relevance of education, as well as supporting teachers and learners in their development of AI competencies. There are several concrete initiatives that have been taken or proposed by various educational bodies in Africa to adopt and integrate AI in education. For instance, the Association of African Universities (AAU) organized the African Universities' Day in 2023, with the theme "Artificial Intelligence in African Higher Education". The event aimed to present a platform for critical dialogue among stakeholders on how AI could be used to enhance education, empower teachers, and enhance teaching (UNESCO, 2021); UNESCO, in cooperation with China, held the International Forum on AI and Education in 2022, with the participation of representatives from government, academia, and industry from Africa and other regions. The forum discussed the national strategies, ethical principles, gender equality, AI competencies, and AI-informed pedagogies for AI and education (UNESCO, 2023). Also, the African Institute for Mathematical Sciences (AIMS) launched the African Masters in Machine Intelligence (AMMI) program in 2018, which is a novel and unique master's program that provides advanced training in machine learning and AI to students from

across Africa. The program is supported by Facebook and Google and is hosted at AIMS centers in Rwanda and Ghana(Kiemde & Kora, 2022).

1.6 AI in commerce and service

Artificial Intelligence (AI) has emerged as a transformative force, revolutionizing industries and redefining business landscapes across the globe. In the context of Africa, the potential of AI to reshape commerce and services is profound, offering unprecedented opportunities for innovation, growth, and socioeconomic development. This endeavor aims to delve into the dynamic and evolving African AI ecosystem, specifically spotlighting its impact within commerce and services. By providing an in-depth exploration of the current landscape, emerging trends, challenges, and innovative applications, this seeking to disentangle the folds of AI-driven initiatives within the African continent. As we embark on the realms of AI and its implications for commerce and services in Africa, we aim to unravel the current State of Affairs that is scrutinizing the existing AI infrastructure, adoption rates, and key players in the African commercial and service sectors, this by pinpointing the use cases and success stories, with more light on the transformative potential of AI within this domain; Emerging Trends and Innovations, through an exploration of emerging technologies, trends, and developments that are catalyzing change within commerce and services across Africa (Ndour, 2022).

In commerce, AI is transforming various aspects of the industry. A striking example is the use of AI-powered chatbots and virtual assistants, which are becoming increasingly widespread to provide personalized customer support, answer consumer queries and facilitate online transactions. These AI-powered interfaces enhance user experiences, enable cost-effective customer service and contribute to higher customer satisfaction rates. More to this, AI technologies offer sophisticated data analysis capabilities that stimulate intelligent decision-making and business strategies. By analyzing customer data, AI algorithms can predict buying habits, identify emerging market trends and optimize pricing and promotional strategies. This enables companies to offer targeted products and services, increase sales and gain a competitive edge in the marketplace. In the African context, several countries have adopted initiatives to promote the development of AI in the service and commerce/trade sectors. For example, Rwanda has launched a pilot project using AI-based drones to deliver medical supplies to rural areas, overcoming infrastructure challenges. Kenya has also invested in AI solutions to improve freight logistics and parcel tracking. In the e-commerce sector, African companies have been leveraging AI to enhance customer experiences through personalized product recommendations (Rhodes, 2019). For example, Jumia, one of the largest e-commerce platforms in Africa, utilizes

AI algorithms to analyze user behavior and preferences, providing tailored product recommendations. This has led to increased customer engagement, higher conversion rates, and improved customer satisfaction. By implementing AI-powered recommendation systems, e-commerce platforms in Africa have seen notable increases in sales and customer retention. These systems have the potential to drive personalized shopping experiences, leading to greater customer loyalty and improved business performance (Ajayi, 2023). Within the hospitality industry, African companies have been integrating AI-driven chatbots and virtual assistants to streamline customer service and support. For instance, hotels and travel agencies are using AI chatbots to assist with booking inquiries, recommend travel itineraries, and provide real-time support to guests. The deployment of AI-driven customer service solutions has resulted in enhanced operational efficiency, quicker response times, and improved guest satisfaction. By leveraging AI for customer interactions, businesses in the hospitality and tourism sector have been able to provide personalized, 24/7 support, leading to a more seamless and enjoyable customer experience. Financial technology companies across Africa have been incorporating AI for fraud detection and credit scoring. Platforms like Branch and Tala use AI algorithms to assess creditworthiness based on users' mobile data and transaction histories. Additionally, AI has been instrumental in detecting and preventing fraudulent activities within financial transactions. AI-driven fraud detection and credit scoring mechanisms have expanded access to financial services for underserved populations, fostering greater financial inclusion. These initiatives have had a significant impact on lowering barriers to credit and mitigating risks within the financial sector, contributing to more responsible lending practices. Moving to the telecommunications sector, companies like MTN and Vodacom have utilized AI for voice and language processing to improve customer interactions. AI-driven virtual agents and automated call centers have been deployed to handle customer queries and provide support, contributing to more efficient and responsive customer service experiences. By harnessing AI for voice and language processing, telecommunications companies have achieved faster query resolution, reduced call wait times, and enhanced customer satisfaction. These advancements reflect a shift towards more intelligent and interactive customer interactions within the telecommunications industry.

All in all, AI offers immense opportunities in the fields of transport and commerce in Africa. Although significant progress has been made, there is still a long way to go for wider adoption of AI technologies. Despites this, these initiatives and impacts within the African AI ecosystem

in the realm of commerce and services reflect a transformative trend towards harnessing advanced technologies to address local challenges and drive substantive progress. The diverse applications of AI in areas such as e-commerce, hospitality, financial technology, telecommunications, supply chain, healthcare, and agriculture exemplify the broad-ranging potential of AI to innovate and optimize operations, improve customer experiences. These examples provide a cross-section of the innovative and impactful initiatives that are shaping the evolving landscape of commerce and services across Africa, demonstrating the potential of AI to drive positive change, enhance efficiency, and empower businesses and communities. The impact of AI initiatives within commerce and services highlights not only the potential for growth and efficiency but also the significant strides being made in leveraging technology to enhance consumer experiences and drive economic development across the continent.

1.7 AI in security

AI in security is the use of AI technologies to support, or automate various aspects of security, such as cybersecurity, physical security, border security, or national security. AI can offer various benefits for security in Africa, such as improving threat detection, prevention, and response, as well as enhancing the efficiency and effectiveness of security operations and personnel. The African Union (AU) launched the African Union Cybersecurity Expert Group (AUCSEG) in 2020, which is a network of experts and practitioners that aims to provide technical and policy advice on cybersecurity and digital transformation in Africa. The AUCSEG also supports the development and implementation of the African Union Convention on Cybersecurity and Personal Data Protection (Malabo Convention) and the African Union Cybersecurity Strategy (AU, 2019). The Nigerian Army also established the Nigerian Army Cyber Warfare Command (NACWC) in 2018, which is a specialized unit that uses AI and other technologies to conduct offensive and defensive cyber operations, as well as to counter cyber threats and misinformation. The NACWC also provides training and capacity building for Nigerian Army personnel on cyber warfare (Sheldon, 2018). More so, the South African National Defence Force (SANDF) partnered with IBM in 2019 to deploy an AI-powered command and control system, called the Intelligent Operations Center (IOC), which integrates data from various sources, such as sensors, drones, satellites, and social media, to provide real-time situational awareness and decision support for SANDF operations. The IOC also uses AI to analyze data and generate insights, such as threat assessments, risk predictions, and resource optimization (GDT, 2012).

1.8 AI in regulation

The African AI ecosystem is diverse and dynamic, with a wide range of initiatives and regulations coming from different countries and organizations across the continent. It's not a monolithic space, making it even more interesting to explore. A number of African countries have made significant strides in establishing regulatory frameworks for AI. For example, countries like South Africa, Kenya, Rwanda, and Ghana have taken steps to develop policies or draft legislation aimed at regulating AI and related technologies. One common goal among many of these efforts is to harness the potential of AI while addressing potential risks and ensuring ethical use. The impacts of these initiatives are wide-ranging. Regulatory efforts can help to boost investor confidence, stimulate innovation, and protect citizens from potential misuse of AI technologies. For example, the African Union has launched initiatives such as the African Union Commission Digital Transformation Strategy, which includes a focus on digital innovation and data governance. Additionally, local and international organizations have been actively involved in supporting the growth of AI regulation in Africa. For instance, the International Telecommunication Union (ITU) has been working with various African countries to develop policies and regulatory frameworks to guide the development and use of AI technologies. The actors involved in shaping the African AI regulatory landscape include government agencies, industry associations, international organizations, academic institutions, civil society groups, and private sector companies. For instance, the private sector, especially technology companies and startups, have been actively engaged with policymakers to ensure that regulations foster innovation while upholding ethical standards. Looking ahead, it will be crucial for African countries to continue collaborating with both regional and international partners to share best practices, learn from each other's experiences, and develop harmonized regulatory approaches that promote innovation and safeguard ethical AI use. By tapping into AI's potential while mitigating its risks, African countries can position themselves to benefit from the technology's transformative power in a manner that is inclusive, transparent, and ethical. Digging deeper into the African AI ecosystem's regulatory landscape, offers an even more nuanced understanding of some specific initiatives for instance the South African government has made strides in establishing a regulatory environment for AI. The Department of Trade, Industry, and Competition has been working on a White Paper on National Artificial Intelligence Strategy, aiming to guide the responsible and inclusive development and use of AI in South Africa. The Kenyan government, through its Ministry of ICT, Innovation and Youth Affairs, has shown interest in fostering a conducive regulatory environment for AI. The government has explored the potential of AI to drive economic growth and enhance public

service delivery while addressing ethical considerations and potential risks. With its strong focus on technology and innovation, Rwanda has shown commitment to exploiting AI for economic development. The government has been working on AI based policies and strategies as part of its broader digital transformation agenda. Ghana, too, has been active in laying the groundwork for regulating AI. The country's Ministry of Communications has initiated steps to develop policies and frameworks to govern the use of AI and data.

In conclusion, understanding these specific initiatives, collaborative efforts, and the diverse range of voices shaping Africa's AI regulatory environment is key to appreciating the richness and complexity of the ecosystem. while there is still much work to be done in harmonizing AI regulations across Africa, there are promising signs of progress and collaboration in this important area. As the African AI ecosystem continues to evolve, it will be crucial to ensure that regulations support the responsible and inclusive development of AI technologies on the continent.

2. Promises

AI technologies are an opportunity for Africa. These opportunities are truly vast and as AI continues to grow and evolve. Africa has the chance to leverage these technologies to drive positive and inclusive growth across domains. For instance, in accelerating productivity and reimagining its economic growth, which is, more than ever, vital for the welfare of the world. AI presents a wide array of opportunities for Africa, spanning various sectors and industries. Most solutions currently target the employment, food security, healthcare, and energy sectors.

2.1 Employment

On Employment, for example. Samasource has employed young people across Kenya and Uganda to train data and transmit human intelligence to AI for big-tech companies including Google, Microsoft and Yahoo (Arakpogun et al., 2021). Over 1100 young people are working on various projects across Kenya and Uganda with incomes that support, for example, the education of their siblings and overall living conditions of their families, to the extent that over 50,000 people are now benefitting from this process. The dependable income generated in the process also increases the purchasing power of people, which then helps them to gradually break the endemic cycle of poverty. For a country like Kenya with disproportionately high levels of youth unemployment of over 30%, despite a growing literacy rate, the jobs created by Samasource are critical to improving the quality of life and maintaining social cohesion in

Kenya. However, to better anticipate the impact of AI on jobs in Africa, it is important to consider the distribution of the labor force (Arakpogun et al., 2021). Approximately 54% of all workers in sub-Saharan Africa are in the agricultural sector, and in some countries this figure surpasses 70%. In the agricultural sector, AI has two primary uses that are expected to be, of significant impact and value. First, as with other sectors, AI has significant advantages in analyzing data, and it is thus useful for predicting the weather, optimizing planting and harvesting schedules, determining appropriate fertilizer needs. This use of AI has the potential to increase yields and overall land productivity or efficiency, and it is unlikely to negatively affect the African labor force in the agricultural sector. Indeed, by improving the ability to predict floods and drought, optimize land usage, and increase yields, AI may increase the need for workers in the agricultural sector. This use of AI is, therefore, not necessarily competitive with human labor, and could actually be complementary to it.

2.2 Food Security

Food insecurity is a major concern across Africa, from the Sahel region to the Horn and Southern Africa. In 2022 alone, over 656 million people in sub-Saharan Africa (SSA) suffered from food insecurity. While about 65% of global arable uncultivated land is situated in Africa, its governments collectively spend nearly billions of dollars in term of importing food. Furthermore, the locust outbreak in the Horn of Africa in 2020 destroyed over $8 billion worth of food and livestock. However, the impact of food insecurity in Africa could be mitigated with the use of AI technologies. Crop diseases and disasters could be predicted, and farmers forewarned for better preparation. It is also useful to bear in mind that agriculture in the continent is a strategic sector that needs improvement across Africa, and AI should be a critical part of the solution. Indeed, this sector, which accounts for 32% of GDP, employs over 65% of the continent's labor force. However, the sector faces numerous challenges, including the degradation of land, increased dependence on inorganic fertilizers, weak supply chains, limited markets for the produce, emerging pests and diseases, and climate change. Despite the potential of AI to improve agriculture in Africa, it is still unavailable outside governmental and research bodies. This is why Google AI lab has collaborated with farmers in rural Tanzania to create a machine-learning application called 'Nuru' (meaning light in Swahili) to diagnose early stages of cassava plant diseases for the advancement of the production of a common staple crop that provides food for over 500 million people (Arakpogun et al., 2021). Nuru works directly on farmers' cellphones, even without internet connectivity, and warns them to take early

intervention measures by quickly identifying and managing cassava plant diseases, which, in turn, helps to maintain consistent food production. In the same vein, in South Africa, several AI start-ups are solving African agricultural problems. For example, MySmartFarm, Aerobatics, Drone Clouds, and Farm Drive are AI-enabled technologies developed in South Africa to address agricultural issues including plant disease diagnosis, price prediction, marketing, expert consultation, and access to financial services (Kenneth, 2021).

2.3 Healthcare

Over the past three decades, dominated by the 'Washington Consensus', social protection issues have been relegated to the backburner. However, numerous studies show that a universal social protection system is the fundamental basis for inclusive development. Consequently, Africa should invest in artificial intelligence technologies to strengthen its social protection systems and health resilience. This effort is particularly necessary to reduce the burden of the informal economy and to increase the productivity of African workers. In the context of delays in the reporting of cancer diagnoses in South Africa as a result of the manual and unstructured pathology process, IBM Research pioneered a machine-learning system to automate the process and cut the reporting time from four to two years (Arakpogun et al., 2021). The reduction of the reporting process offers invaluable information for the government to formulate national health policy and take timely decisions that would save lives. While South Africa is among the two countries in Africa (the other being Mauritius) that meets the minimum World Health Organization's (WHO) recommendation of 23 healthcare workers per 10,000 people, the country is still struggling to provide adequate healthcare to its citizens (Arakpogun et al., 2021). Overall, access to healthcare in many African countries is acute. AI solutions like those engineered by IBM Research and other AI start-ups in Africa could be a 'game-changer', as the use of machine learning systems and mobile phones can facilitate remote diagnosis and treatment for millions across Africa, particularly those living in remote and rural areas.

2.4 Energy

Africa's energy systems face enormous challenges because of limited African capacity in electricity generation and experience. Consequently, Africa experiences the most acute forms of energy poverty in the world. It is estimated that over 630 million people across Africa live without reliable access to electricity and affordable modern cooking fuels, particularly in sub-Saharan countries, where a widening gap in electricity access remains problematic (Agusiegbe, 2022). However, the poor interconnection of national electricity grids has a massive impact on economic growth, including in countries such as Nigeria and South Africa. In this context, AI

technologies may be felt also in the areas of the traditional industries of oil, gas, and electricity. According, David G. Victor, three clusters of impacts seem most likely to affect energy and climate, particularly in the African context: two will alter the supply and demand for energy, and one will affect the abilities of societies to understand how emissions are affecting the climate and how to manage those impacts. First, most visible in the energy and climate space is the impact of AI on how energy is supplied. That's because more intelligent energy-supply systems, in effect, shift outward the supply curves. For example, machine-learning systems can improve the ability to map and understand the size and value of underground deposits of oil and gas, making it easier to tap into those resources at lower cost. The same logic also applies to renewable energy. For example, Al-assisted training for the design and operation of wind and solar farms can make these systems much more efficient in how they take financial resources and generate electricity. Second, one of the great promises of adding AI to energy markets lies with linking what customers want with the exact range of options and market conditions for supplying those energy services. Machine learning is ideally suited for making fine-grained determinations of what customers want and then adjusting energy purchasing decisions accordingly. In theory, machine learning could make a number of services that are already offered in today's market more powerful, such as: purchasing green energy credits (AI could better embed information about what customers are willing to pay for green energy and also offer different shades of green), and adjusting power purchasing decisions (as power grids shift to play a much larger role for variable renewable generators, the price of power will become more variable, creating greater social value from real-time adjustments in power purchasing). In this context, AI can allow even small consumers to automatically adjust their power consumption in real time with prevailing prices. AI can also help make electricity supplies more reliable and tailored to consumer needs (AI schemes could integrate data from hazards and then adjust grid operations accordingly, making the grid safer, more efficient, and more reliable). Third, most human-caused changes in climate are rooted in how we use energy, in particular fossil fuels that, when combusted, generate carbon dioxide (CO2). In this context, AI could help radically improve the assessment of climate change. Today's climate impact assessments rely on global scale models of the climate system that are then downscaled to regional and local assessments. The downscaling process is complex and imperfect, in part because multiple local factors affect how broad changes in the climate are manifested where people actually live, along coastlines, near wildfire zones, in cities struggling with heat stress. AI makes it possible to connect the imperfect downscaling process with real information about actual impacts, reflected in insurance claims, weather extremes, the arrival of migrants, and observed outbreaks. AI

could help automate and enrich that process, making feasible real-time adjustments to climate-impact assessments.

The adoption of AI in Africa holds great promise for addressing various socioeconomic challenges and driving innovation across industries. The potential benefits include improved healthcare delivery, enhanced agricultural productivity, more efficient infrastructure management, and expanded access to education.

CHAPTER FOUR : CHALLENGES OF AI ADOPTION IN AFRICA

Adoption and use of any innovation including AI require the necessary competence. First and foremost, AI skill is much more difficult to perfect, and there is a greater demand for AI expertise. It is important to create a conducive environment in business, health, education, and public ecosystems and encourage the employees to have interests on the use of AI to perform their operations. This will make them learn the skills. There is a need to improve the educational curriculum to integrate the teaching of AI skills from the secondary level. Improving people's learning abilities in mathematics and computer programming will help them acquire the necessary AI skills. Because the use of AI systems is permeating all aspects of life, the knowledge of AI is for all. Adding introductory programming and computer basics subjects to all fields of study may also aid in the acquisition of AI skills. All stakeholders (citizens, policymakers, and technical experts) should be involved early in the architectural design process so that societal expectations, fears and concerns are taken into account and no patchwork is necessary later as an afterthought. This will improve users' knowledge of the system, which will reduce uncertainty or fear of the unknown. A responsible data management framework that takes into account data diversity is recommended for AI developers. The framework will make it easier to collect comprehensive data for system development and will improve the accuracy of AI system operations. Ethical challenges are big concerns regarding adoption of AI systems in Africa. Many initiatives, including educational institutions, government agencies, non-governmental groups, and industry, have attempted to address the ethical and legal challenges that have arisen because of AI technology, but the impact of these efforts is still insignificant in Africa. The selection, design, deployment, and usage of AI technology have ethical implications. We therefore agree with the recommendations made that it is critical for developers to recognize that the technology they are creating is entwined with ethical dimensions, and that they have a critical role and obligation to engage with ethical considerations as developers. Making developers aware of their professional responsibilities and moral implications while developing will aid in reducing ethical issues. Also, government and other professional bodies should strengthen their ethics policies to guide the development process of AI. Creating a conducive environment encourages innovative minds. African nations are still struggling on infrastructural development. Most government policies concentrate on urban development while rural areas suffer. Government should ensure that they extend their

developments to rural locations, bringing stable and adequate network coverage across all areas. For example, most of the farming industries that need AI to boost their operations and increase productivity are in rural areas. In addition, the African Union and each respective African nation should establish AI strategies and policies that will be a foundation for the development and implementation of AI technologies

Finally, Africa has developing economies that require technological advancements to accelerate growth. As a result, it is critical that the continent encourages the use of AI in a variety of ways to perform various tasks. Establishing various agencies that can assist in dealing with citizens' doubts and fears should be encouraged as part of an awareness campaign. These agencies should improve Africa's appreciation and adoption of AI and establish efficient ways of addressing societal impacts. Technology start-ups or tech hubs should be established to train the next generation of AI experts, and local technological innovations should be supported by the government and private sector. Dr Rachel Adams in her article on the Key concerns and policy considerations for the future of the continent in AI in Africa calls on African policy-makers to "consider the best approach to AI strategies and adoptions in their countries, emphasis should lie on building sustainable local AI ecosystems that contribute AI solutions to advancing national developmental priorities and supporting inclusive and prosperous African societies. This approach requires considering the implications of AI beyond the mere economic dimensions. It necessitates critically assessing the extent to which global AI frameworks address the particular challenges AI poses in the region and building policy responses with the involvement of a broad set of stakeholders, including local tech and data entrepreneurs and social justice groups and communities that may be directly affected by AI policies" (Adams, 2022). She starts that infrastructural development, regional cooperation, advancing African value systems and principles in AI ethics, building local capacity and skills, international development assistance are important opportunities for African development, this in view of supporting the adoption of AI for the African community.

The idea of AI as a science that examines the phenomena of intelligence has been somewhat overtaken in recent years by a perception of AI as an engineering discipline in which scholars focus on producing usable programmes and tools that operate in areas that ordinarily need intelligence. AI technologies are already in use all around us, in nearly every aspect of life. It can be used in a variety of corporate roles to help employees at work by reducing their workload and in areas such as commerce, education, agriculture, and finance. In addition, Artificial Intelligence is being used in transportation, automobiles, manufacturing, and weather

forecasting. As a technology, today's AI systems have only a rudimentary understanding of human expression, tone, emotion, and the intricacies of human interaction (Smith & Shum, 2018) (Ade-Ibijola & Okonkwo, 2023). Before computers can truly act like humans, there is still a long way to go. While AI research has a long history of enthusiasm followed by extended disappointment, we are currently in the midst of an extraordinary period of technological innovation across multiple industries, which is fueling the rise of AI (Ade-Ibijola & Okonkwo, 2023). AI will have a big influence by enabling quicker and deeper advancement in practically every sector where (human) intellect plays a role. It may be used by businesses or organizations to engage customers, revolutionize product creation, optimize operations, and empower staff (Ade-Ibijola & Okonkwo, 2023). But, more crucially, AI can help society eradicate some of its flaws, difficulties and overwhelming challenges (Nishant et al., 2020). AI solutions are being put in place in some African countries and these remarkable changes are noticeable already in Kenya, Nigeria, Ghana, Ethiopia, and South Africa, Mauritius (Gadzala, 2018). Most solutions are targeted towards; the financial services, agriculture, and healthcare sectors (Okonkwo & Ade-Ibijola, 2021). South Africa leads the continent in AI adoption with a robust ecosystem that includes numerous technology hubs, research groups. Many companies in South Africa are either integrating AI solutions into their existing operations or developing new solutions using AI (Ade-Ibijola & Okonkwo, 2023)

1. Challenges

AI is a game-changing innovation with the potential to improve all sectors of the African social system. However, the adoption and use of AI applications in African society raise some issues including skills acquisition, ethics, programming, data integration, user attitude, government policy, and insufficient infrastructure and network connectivity. These challenges emerged from the review of AI-related literature and are presented and discussed in the subsequent sections.

1.1 Skill acquisition

This entails learning the theoretical and practical skills required for the development, implementation, and use of AI applications. Technological advancement necessitates the acquisition of technical skills. Business and IT leaders in Africa agree that to achieve the adoption and use of AI technologies, the stakeholders' knowledge base must be changed or improved. One of the key essential competences in the era of the Fourth Industrial Revolution (4IR) is programming skills. Furthermore, Bianco (2021) reported that one of the major barriers to the adoption of this modern technology AI is skill. Any project requires the right expertise

to succeed, and AI is no exception. Of all, AI skills are more difficult skills to master, and there is undoubtedly a demand–supply imbalance in the market. AI, as a new and growing innovation, will improve existing jobs while also creating new ones, necessitating the acquisition of new skills. According to a Gartner research circle survey, 56% of participants believe that learning new skills would be essential to execute both existing and newly developed jobs). In the development and implementation of an AI system, there is a need to incorporate expert knowledge. Despite the fact that IT professionals (software developers and engineers) design and develop AI applications, they are not the primary users of AI. In developing markets such as the African market, a scarcity of AI-ready workers is a major issue. The development of AI involves machine learning and NLP processes which consist of complex algorithms; thus, programming skills are needed.

1.2 Uncertainty

Although the adoption and use of AI applications are becoming common, it is still difficult for some business leaders to quantify the benefits associated with the technology. There are some well-known benefits of AI, such as instant response, time saving, medical advances, and revenue generation; other benefits like automation of process, enhanced learning, and customer experience are still hard for users in Africa to comprehend (Okonkwo & Ade-Ibijola, 2021). Because these technologies mimic human intelligence, that is doing human jobs in a different manner, the question is therefore: Is the adoption of AI applications beneficial or not? While some business leaders and stakeholders believe and trust in this technology, others are afraid that implementation of AI may disrupt their traditional ways of working. As a developing continent, Africa, the knowledge of AI is still at an early stage and the population is still not certain of the advantages. The fear of the unknown poses a great challenge to the adoption and use of AI in Africa.

1.3 Lack of Structured Data Ecosystem

AI initiatives rely on the quality and quantity of data contents to provide accurate information or responses to users in each situation. In many cases, an AI will fail if the data that is used to train the AI system does not reflect the demographic variables in the targeted population. A Chatbot system, for example, requires comprehensive information about its operations to provide correct responses to users; if the information requested by the user is not in the data bank, the system will fail. Data shortages in Africa are well known in the context of development, (Ade-Ibijola & Okonkwo, 2023) indicates that high-quality data are essential indicators of growth in relation to the Sustainable Development Goals (SDGs) and a key input

for the development of modern technologies. The UN Economic Commission for Africa (UNECA) stated that African data ecosystems are at "nascent stages of the African data revolution and the private sector is increasingly becoming a critical and dynamic player within African data ecosystems" (UNECA, 2016). Machine learning methods are only as good as the data they are given. AI algorithms include prejudices found in data or even in the individual who created the process, spreading social disparities. This is especially important in Africa, where users are more likely to import machine learning algorithms built and trained abroad using data that may not recognize or be biased against substantial parts of the African population. To enable researchers, developers, and users to adopt AI solutions, a deeper, larger, and more accessible pool of data is needed. In developing markets, particularly in unstable or conflict affected areas, high-quality data is not always available or accessible.

1.4 Lack of Relevant Government Policies

As AI-powered technologies are beginning to sweep over business, governance, and educational activities, there is a need for a policy on AI implementation strategies in African countries as seen in the developed countries such as Australia, China, France, and the United States. Although some African countries, such as Mauritius, Egypt, Zambia, Tunisia, and Botswana, have recognized the potential of AI to boost GDP and have developed national AI strategies, and South Africa, Nigeria, and Kenya have passed data protection laws, all are still in their infancy. The African Union (AU) proposed the Promulgation of AI laws and regulations, called structured regulation of AI to manage the benefits of the technology for Africans. Most of the African population is a late majority and laggard adopter of innovation; they take a "wait-and-see" approach to technology adoption (Okonkwo & Ade-Ibijola, 2021). AU needs to speed up to establish a well-structured adoption and implementation of AI powered technology to boost its adoption among the African population. Overall, there is a general lack of relevant policies that can prioritize the design and implementation of AI as well as address the potential impacts on society.

1.5 Ethics

In terms of technology development, ethics refers to a set of principles based on public acceptance, religious beliefs, and cultural norms on the best behaviour that can be observed and followed during the development and deployment of innovative and emerging technologies. In Africa, ethics form the basis of human activities which can promote African cultures and help to build confidence in the development and applications of technologies in Africa. While AI has enormous potential, it also poses major difficulties for businesses and governments, notably

in terms of ethics. The moral, economic, and social repercussions of the Second and Third Industrial Revolutions are still being debated in many African countries. AI has already been implicated in several examples of ethical issues. Studies have revealed some major areas of AI possible implications on the African social world including accountability, data bias, transparency, and socio-economic risks. AI technologies are systems that mimic human intelligence. AI undermines established moral and legal paradigms that place human agency solely in the hands of humans. Using biased data, AI has been noted to create socioeconomic inequality. In addition, the design of AI systems involves some complex algorithms which in turn compromise trust and transparency. Data is used to train these algorithms. It has been claimed that there is a data scarcity in Africa, and that the majority of acquired data does not correctly reflect the African experience, implying that many algorithms may not be appropriately adapted to the features of local populations. To provide an acceptable basis for AI adoption in Africa, stakeholders must have open discussions on the ethical implications of AI and take necessary steps.

1.6 User Attitudes

Another challenge facing the adoption of AI systems in Africa is the users' attitude. An adopter's attitude towards the adoption and rejection of an invention can be favorable, negative, and apprehensive. According to (Wang et al. 2008), attitudes are a primary predictive factor impacting the adoption of a new product; hence, a better knowledge of attitudes in a well-defined manner is required. Africans are very skeptical in adopting and using new technology due to culture and social influences. In a study on the adoption of AI in higher education, Chatterjee and Bhattacharjee (2020) revealed that individuals' behavioral intentions to use AI in higher education are influenced by their attitudes. Likewise, another research on the adoption of software engineering products proved that user attitude influences the adoption of software). This leads to the conclusion that higher education authorities would find it useful and beneficial to mold stakeholders' attitudes to shape their intentions and behaviour. As a result, if students have negative perceptions of Chatbot technology applications in education, they will be hesitant to adopt and use the technology. Positive perception of an innovation accelerates adoption.

1.7 Insufficient Infrastructure and Network Connectivity

Inadequate infrastructure and a dearth of network affordability are some of the major hurdles of AI adoption in Africa. The growth of infrastructural development as well as mobile technology network connectivity in Africa is slow A good percentage of Africa's population are unconnected and not having access to the internet. Adoption of AI requires adequate

availability of wireless network connectivity. In addition, African countries have the world's most expensive broadband. The Alliance for Affordable Internet (A4AI) reported that African countries inhabited nine of the ten least affordable spots in terms of internet access, with expenditures ranging from 12 to 44% of GDP.

Several challenges must be addressed to fully realize the benefits of AI to the African continent. Challenges such as the need for infrastructure development, data privacy concerns, ethical considerations, and the potential for job displacement. It is crucial for African governments, businesses, and civil society to collaborate in developing AI strategies that prioritize inclusivity, ethical use, and skill development to ensure that the adoption of AI contributes to sustainable development and prosperity across the continent.

2. Research question

Artificial intelligence, as said earlier, as being a branch of science that studies and develops intelligent machines, is a significant component of the fourth industrial revolution that will lead to fundamental changes in the way people live, work, and relate to one another. The rapid growth of the artificial intelligence is bringing in a lot of changes, and opportunities as well as challenges, as this it is being integrated in every sector of the different economies. In Africa, AI creation and implementation are transforming lives and cultures in a variety of ways including economically, socially, and politically (Ade-Ibijola & Okonkwo, 2023). AI has long been associated with economic and social development, even if its impact remains to be verified (Luan et al., 2020). In economic terms, for instance, it is said that artificial intelligence by combining available data, computing power, and algorithmic innovations could double economic growth rates by 2035. It is true that AI, like technology "has reached a point of evolution that it transforms itself and progresses without any decisive intervention on the part of man, by a kind of force that pushes it by necessity towards incessant development." (Ellul, 2018). It is because of this that there has been a fear on the place of the incoming AI and the place of Man. However, the report on anticipating the economic and social impacts of AI, points out the need of human intelligence as basic knowledge, and information practices contribute to the formation of intelligence. It is important to examine and evaluate the information practices adopted by AI actors so as to ensure responsible and ethical development and use of this technology. Increasing the adoption of AI in Africa requires the development of vibrant ecosystems based on five stakeholders who form the foundation of building AI success including policymakers, universities, large companies, start-ups, and multi-stakeholder partnerships (Ade-Ibijola & Okonkwo, 2023). Because of the widespread adoption of mobile

technologies in Africa, there is an optimism that AI technologies will be the next wave of technologies to receive wide acceptance. However, with the exception of a few nations (such as South Africa, Nigeria, Ethiopia, Kenya, and Ghana), widespread adoption of AI applications in Africa is not yet a reality. The crucial factors needed for technology adoption are sadly lacking across most of Africa, and many countries in Africa are still lacking the necessary infrastructure, governance, data ecosystem, STEM (Science, Technology, Engineering and Mathematics) Education, and other factors necessary for AI. Therefore, our area of interest here is exploring the various challenges in the adoption of AI across African regions in the area of GLAM (Galleries, Libraries, Archives and Museums).

While AI has indeed made significant steps in various industries; we have experienced AI in healthcare, AI in banking and finance, AI in commerce and service, AI in transport just to name a few of these industries or fields of reach; its potentials within the GLAM sector remains relatively unexplored, making this quite intriguing. With a background in archives and records management, one is better positioned to drive innovation at the intersection of cultural heritage and AI technology. The GLAM sector is rich with diverse and invaluable cultural artifacts, historical documents, and artistic works that are ripe for exploration through AI applications.

By prompting the application of AI in the GLAM sector, there are open opportunities to contributing to the advancement of cultural preservation, interpretation, and audience engagement in ways that have not been explored before. This initiative can pave the way for groundbreaking innovations that harness the power of AI to enrich our understanding and appreciation of cultural heritage.

With all these happenings and changes around the area of AI and most institutions, one is tempted to ask the following questions:

What are the current informational practices employed by GLAM institutions in Africa in the context of integrating artificial intelligence technologies?

How do GLAM institutions in Africa use AI for digitization, preservation, and accessibility of cultural heritage materials, and what are the implications for information management and dissemination?

What are the challenges and opportunities associated with the adoption and implementation of AI in GLAM institutions in Africa, particularly in relation to informational practices and knowledge management?

How do GLAM institutions in Africa engage with ethical considerations and cultural sensitivities when employing AI technologies for information management and dissemination of cultural heritage materials?

What are the collaborative efforts between GLAM institutions and technology partners or AI experts in developing and implementing AI-driven solutions for information management and dissemination of cultural heritage materials?

How do GLAM institutions in Africa approach capacity building and training for their staff to effectively harness AI technologies for informational practices related to cultural heritage materials?

What role does community engagement play in shaping the informational practices of AI adoption and implementation in GLAM institutions in Africa, and how do these institutions involve local communities in decision-making processes?

What are the implications of AI-driven informational practices on the representation, accessibility, and interpretation of diverse cultural heritage materials within the African context?

How do GLAM institutions in Africa navigate issues of data privacy, bias, and inclusivity when employing AI technologies for information management and dissemination of cultural heritage materials?

What are the future prospects and potential innovations in AI-driven informational practices within GLAM institutions in Africa, and how can these advancements contribute to the preservation and accessibility of cultural heritage materials?

All these series of questions lead us to our research question which is:

“what are AI related information practices employed in GLAM (Galleries, Libraries, Archives and Museums) sector in Africa and how do these practices influence the curation, preservation, interpretation and accessibility of cultural heritage materials?”.

providing a response to this question will be a determining factor for this work.

PART THREE : METHODOLOGY

CHAPTER FIVE : AN EXPLORATORY RESEARCH

The nature of our research question, as well as the object of our study which focuses on AI applied to GLAM, is an area of research which is only just beginning in Africa. This is the reason why our study aims to be exploratory and descriptive of the first elements that emerge from the field on this question. To do this, we will rely on qualitative approaches

The research design process in qualitative research begins with philosophical assumptions that the inquirers make in deciding to undertake a qualitative study. In addition, researchers bring their own worldviews, paradigms, or sets of beliefs to the research project, and these inform the conduct and writing of the qualitative study. Further, in many approaches to qualitative research, the researchers use interpretive and theoretical frameworks to further shape the study. Good research requires making these assumptions, paradigms, and frameworks explicit in the writing of a study, and, at a minimum, to be aware that they influence the conduct of inquiry. The purpose of this chapter is to make explicit the assumptions made when one chooses to conduct qualitative research, the worldviews or paradigms available in qualitative research, and the diverse interpretive and theoretical frameworks that shape the content of a qualitative project.

1. Research Approach

The qualitative and quantitative methodologies a two main approaches in social science research.

1.1 Quantitative approach

Quantitative research refers to the type of research that is based on the methodological principles of positivism and neo-positivism and adheres to the standards of strict research design developed before the research begins.

The principle of positivism mainly emphasizes that the study should begin with the gathering of information rather than speculation. It employs quantitative measurement and the use of statistical analysis.

Quantitative research involves the collection of numerical data in order to explain, predict and control phenomena of interest, data analysis being mainly statistical. It involves collecting data

in order to test hypotheses or answer questions concerning the current status of the subject of the study. Quantitative research is applied in order to describe current conditions or to investigate relationships, including cause-and-effect relationships.

Methods of data collection employed by quantitative researchers are many, diverse, simple and straightforward. The most common methods are surveys, documentary, observations, sociometry and experimental methods.

Quantitative theories normally warrant generalizations. To achieve representativeness is one of the aims of quantitative research and several methods have been devised for this purpose. Most of these methods deal with probability sampling as well as with determining the right sample size and composition of the sample in general. Statistical techniques have been developed to assist in this process, standard errors for instance are calculated and techniques used that can assist in achieving a sample size that will allow the study to claim representativeness.

Quantitative researchers, attempt to control as many variables as possible. They therefore, prefer research strategies such as random sampling, random assignment, to treatment groups, use of standardized instruments and when appropriate, and the equalizing of conditions of groups to be compared.

Because quantitative researchers are more concerned with generalizability of their findings than with the meanings of those findings, they typically collect data from as many subjects as is feasible, using probabilistic sampling techniques.

Quantitative data collected from various sources through the use of different tools and techniques generally comprise of numerical figures, ratings, descriptive narrations, and responses to open-ended questions, quotations and field notes. Quantitative research data analysis is either parametric when the measurement level is interval and ratio or nonparametric when the scale of measurement is nominal or ordinal.

1.2 The qualitative approach

The purpose of qualitative research is to promote greater understanding of not just the way things are, but also why they are the way they are. Through intensive and extensive observation, interviews and discussions, the qualitative researcher seeks to derive and describe findings that promote greater understanding of how and why people behave the way they do. It explains and gains insight and understanding of phenomena through intensive collection of narrative data.

The qualitative research model was developed primarily in the social science and then applied to educational problems only in recent years. This model was developed by anthropologists and sociologists and is usually called "qualitative," naturalistic" "ethnographic", "subjective," or "post-positivistic" inquiry.

Qualitative inquiry employs different knowledge claims, strategies of inquiry and methods of data collection and analysis. It relies on text and image data, has unique steps in data analysis and draws on diverse strategies of inquiry. Examining the landscape of qualitative procedures shows perspectives ranging from postmodern thinking to ideological perspectives and from philosophical orientation to systematic procedural guidelines.

In qualitative research, data collected is usually subjective and the main measurement tool for collecting data is the investigator himself/herself

Therefore, before conducting effective research, the researcher needs intensive training and practice in the methods planned to be used.

A qualitative research process therefore, provides an understanding of a social setting or activity as viewed from the perspective of the research participants. To achieve this goal, a researcher is guided by the basic characteristics of qualitative studies, the strategies of inquiry, the researcher's role in the study, the purposeful sampling strategy for sites and individuals, the forms of data collection and a rationale given for their use, the procedures for recording information, the data analysis steps, organization of data for analysis, reviewing of data to obtain a sense of information, the coding of data, development of codes to form a description or to identify themes, interrelation of the themes, ways of representing data through graphs, tables, figures, the bases for interpreting the analysis (personal experiences, the literature, questions, action agenda), and indicating the multiple strategies for validating the findings.

Several definitions of research have been given. For the qualitative research it includes also direction towards the solution of a problem, emphasis on the development of generalizations, principles or theories that will be helpful in predicting future occurrences. But above all, qualitative research is based upon observable experiences or empirical evidence, demanding accurate observation and interaction with respondents in the environment.

Qualitative research is one whose data is basically descriptive in nature. This means that the data to be obtained are ordinarily expressed in nonnumerical terms. Although description is emphasized this does not mean that numerical figures are never used.

The qualitative research approach is one in which the inquirer often makes knowledge claims based primarily on constructivist perspectives (that is the multiple meanings of individual experiences, meanings socially and historically constructed with an intent of developing theory or pattern) or advocacy/participatory perspectives (that is, political issues oriented, collaborative, or change oriented) or both. It also uses strategies of inquiry such as narratives, phenomenologies, ethnographies, grounded theory studies or case studies. The researcher collects open ended, emerging data with the primary intent of developing themes from the data.

Though the quantitative method of approach deals with generalizability of findings than with the meaning of the findings, the use of hypothesis at this point is problematic:

The use of hypotheses is problematic for many reasons but especially because it determines the course of the study at the outset and restricts the options of questions and responses, forcing upon the respondent's opinions or intentions which they might otherwise have not expressed.

The research procedure employed by the quantitative researchers presupposes the presence of a research design, including hypotheses, before the research begins. Consequently, this design determines what is relevant and how it will be studied and what is meaningful and required even before the study starts. This restricts the options of the research process, blocks initiative and the motivation of the researcher, limits the effectiveness of research and produces artificial data, which do not reflect reality as a whole.

On the other hand, qualitative research is not predetermined or prestructured by hypothesis and procedures that might limit its focus, scope or operation. Its perception and approach are open in all aspects, mainly with regard to its research objects, the research situation or the research method to be employed. Reason why for our study, we will be using the qualitative mode of approach.

2. Epistemological positioning

Those undertaking qualitative studies have a baffling number of choices of approaches. One can gain a sense of this diversity by examining several classifications or typologies. One of the more popular classifications is provided by Tesch (1990), who organized 28 approaches into four branches of a flowchart, sorting out these approaches based on the central interest of the investigator; Wolcott (1992) classified approaches in a "tree" diagram with branches of the tree designating strategies for data collection; Miller and Crabtree (1992) organized 18 types according to the "domain" of human life of primary concern to the researcher, such as a focus on the individual, the social world, or the culture. In the field of education, Jacob (1987)

categorized all qualitative research into "traditions" such as ecological, psychology, symbolic interactionism, and holistic ethnography. Lancy (1993) organized qualitative inquiry into discipline perspectives such as anthropology, sociology, biology, cognitive psychology, and history. Denzin and Lincoln (2005) organized their types of qualitative strategies of inquiry into ethnography (performance and ethnographic representation), case studies, grounded theory, life and narrative approaches, participatory action research, and clinical research. John W. Creswell presents his qualitative strategies in to five approaches, Narrative, phenomenology, grounded theory, ethnography and case study. In short, there is no lack for classification systems for types of qualitative research and we'll focus much on John Creswell's qualitative strategies.

With so many possibilities, how did he decide on the five approaches presented in his work on "qualitative inquiry and research design". The choice of the five approaches resulted from following personal interests, selecting different focus, and electing to choose representative discipline orientations. The five approaches discussed in his work reflect the types of qualitative research that are most frequently seen in the social, behavioral, and health science literature. It is not unusual, too, for authors to state that certain approaches are most important in their fields (e.g., Morse & Field, 1995). Also, with preference to approaches with systematic procedures for inquiry. That is, he found books that espouse rigorous data collection and analysis methods also contributed to the selection of the five. These books were also useful in that they represented different discipline perspectives in the social, behavioral, and health sciences. For example, narrative originates from the humanities and social sciences, phenomenology from psychology and philosophy, grounded theory from sociology, ethnography from anthropology and sociology, and case studies from the human and social sciences and applied areas such as evaluation research. The primary ideas for his work came from several books that he synthesized to reflect scholarly, rigorous approaches to qualitative research. On narrative research he makes reference to the educational perspective of Clandinin and Connelly (2000) but also considers the organizational approach of Czarniawakg. (2004) and the biographical approach of Denzin (1999a). Discussing on phenomenology, he largely advanced a psychological perspective based on Moustakas. (1994) and also included the interpretive approach of van Manen (1990), In describing grounded theory, his approach relies on the systematic approach of the sociologists Strauss and Corbin (1990) but also incorporates ideas from the more recent sociological constructivist approach of Charmaz (2006). In discussing ethnography, he relies on the educational anthropology perspective of Wolcott (1999) and incorporate other perspectives from LeCompte and Schensul (1999) and the interpretive stances of Atkinson, Coffey, and Delamont (2003). In the description of case study research, he relies

on an evaluation perspective from Stake (1995) but also include the applied social science and cognitive science orientation of Yin (2003).

Five philosophical assumptions lead to an individual's choice of qualitative research: ontology, epistemology, axiology, rhetorical, and methodological assumptions. The qualitative researcher chooses a stance on each of these assumptions, and the choice has practical implications for designing and conducting research. Although the paradigms of research continually evolve, four will be mentioned that represent the beliefs of researchers that they bring to qualitative research: post positivism, constructivism, advocacy/participatory, and pragmatism. Each represents a different paradigm for making claims about knowledge, and the characteristics of each differ considerably. Again, the practice of research is informed. The three elements discussed above-assumptions, paradigms, and interpretive frameworks often overlap and reinforce each other. For the purposes of our discussion, they will be discussed separately.

2.1 Philosophical Assumptions

In the choice of qualitative research, inquirers make certain assumptions. These philosophical assumptions consist of a stance toward the nature of reality (ontology), how the researcher knows what she or he knows (epistemology), the role of values in the research (axiology), the language of research (rhetoric), and the methods used in the process (methodology) (Creswell, 2003). These assumptions, shown on the table below, are adapted from the "axiomatic" issues advanced by Guba and Lincoln (1988). However, this discussion departs from their analysis in three ways. There is no contrast qualitative or naturalistic assumptions with conventional or positive assumptions as they do, acknowledging that today qualitative research is legitimate in its own right and does not need to be compared to achieve respectability. To these issues one area of concern, the rhetorical assumption, recognizing that one needs to attend to the language and terms of qualitative inquiry. Finally, the practical implications of each assumption in an attempt to bridge philosophy and practice.

The ontological issue relates to the nature of reality and its characteristics. When researchers conduct qualitative research, they are embracing the idea of multiple realities. Different researchers embrace different realities, as do also the individuals being studied and the readers of a qualitative study. When studying individuals, qualitative researchers conduct a study with the intent of reporting these multiple realities. Evidence of multiple realities includes the use of multiple quotes based on the actual words of different individuals and presenting different perspectives from individuals. When writers compile a phenomenology, they report how individuals participating in the study view their experiences differently (Moustakas, 1994).

With the epistemological assumption, conducting a qualitative study means that researchers try to get as close as possible to the participants being studied. In practice, qualitative researchers conduct their studies in the "field," where the participants live and work. These are important contexts for understanding what the participants are saying. The longer researchers stay in the "field" or get to know the participants, the more they "know what they know" from firsthand information. A good ethnography requires prolonged stay at the research site (Wolcott, 1999). In short, the researcher tries to minimize the "distance" or "objective separateness" (Guba & Lincoln, 1988, p. 94) between himself or herself and those being researched.

All researchers bring values to a study, but qualitative researchers like to make explicit those values. This is the axiological assumption that characterizes qualitative research. How does the researcher implement this assumption in practice? In a qualitative study, the inquirers admit the value-laden nature of the study and actively report their values and biases as well as the value-laden nature of information gathered from the field. We say that they "position themselves" in a study. In an interpretive biography, for example, the researcher's presence is apparent in the text, and the author admits that the stories voiced represent an interpretation and presentation of the author as much as the subject of the study (Denzin, 1989a).

Researchers are notorious for providing labels and names for aspects of qualitative methods (Koro-Ljungberg & Greckhamer, 2005). There is a rhetoric for the discourse of qualitative research that has evolved over time. Qualitative researchers tend to embrace the rhetorical assumption that the writing needs to be personal and literary in form. For example, they use metaphors, they refer to themselves using the first-person pronoun, "I," and they tell stories with a beginning, middle, and end, sometimes crafted chronologically, as in narrative research (Clandinin & Connelly, 2000). Instead of using quantitative terms such as "internal validity," "external validity," "generalizability," and "objectivity," the qualitative researcher writing a case study may employ terms such as "credibility," "transferability," "dependability," and "confirmability" (Lincoln & Guba, 1985) or "validation" (Angen, 2000), as well as naturalistic generalizations (Stake,1995). Words such as "understanding," "discover," and "meaning" form the glossary of emerging qualitative terms (see Schwandt, 2001) and are important rhetorical markers in writing purpose statements and research questions (as discussed later). The language of the qualitative researcher becomes personal, literary, and based on definitions that evolve during a study rather than being defined by the researcher. Seldom does one see an extensive "Definition of Terms" section in a qualitative study, because the terms as defined by participants are of primary importance.

The procedures of qualitative research, or its methodology, are characterized as inductive, emerging, and shaped by the researcher's experience in collecting and analyzing the data. The logic that the qualitative researcher follows is inductive, from the ground up, rather than handed down entirely from a theory or from the perspectives of the inquirer. Sometimes the research questions change in the middle of the study to reflect better the types of questions needed to understand the research problem. In response, 'the data collection strategy, planned before the study, needs to be modified to accompany the new questions. During the data analysis, the researcher follows a path of analyzing the data to develop an increasingly detailed knowledge of the topic being studied.

Table 4: Philosophical assumptions with implications for practice

Table: philosophical assumptions with implications for practice

Assumption	Question	Characteristics	Implications for Practice (Examples)
Ontological	What is the nature of reality?	Reality is subjective and multiple, as seen by participants in the study	Researcher uses quotes and themes in words of participants and provides evidence of different perspectives
Epistemological	What is the relationship between the researcher and that being researched?	Researcher attempts to lessen distance between himself or herself and that being researched	Researcher collaborates, spends time in field with participants, and becomes an "insider"
Axiological	What is the role of values?	Researcher acknowledges that research is value-laden and that biases are present	Researcher openly discusses values that shape the narrative and includes his or her own interpretation in conjunction with the

			interpretations of participants
Rhetorical	What is the language of research?	Researcher writes in a literary, informal style using the personal voice and uses qualitative terms and limited definitions	Researcher uses an engaging style of narrative, may use first-person pronoun, and employs the language of qualitative research
Methodological	What is the process of research?	Researcher uses inductive logic, studies the topic within its context, and uses an emerging design	Researcher works with particulars (details) before generalizations, describes in detail the context of the study, and continually revises questions from experiences in the field

Source: John Creswell's qualitative strategies

2.2 Paradigms or Worldviews

The assumptions reflect a particular stance that researchers make when they choose qualitative research. After researchers make this choice, they then further shape their research by bringing to the inquiry paradigms or worldviews. A paradigm or worldview is "a basic set of beliefs that guide action" (Guba, 1990, p. 17). These beliefs have been called paradigms (Lincoln & Guba, 2000; Mertens, 1998); philosophical assumptions, epistemologies, and ontologies (Crotty, 1998); broadly conceived research methodologies (Neuman, 2000); and alternative knowledge claims (Creswell, 2003). Paradigms used by qualitative researchers vary with the set of beliefs they bring to research, and the types have continually evolved over time (contrast the paradigms of Denzin and Lincoln, 1994, with the paradigms of Denzin and Lincoln, 2005). Individuals may also use multiple paradigms in their qualitative research that are compatible, such as constructionist and participatory worldviews (see Denzin & Lincoln, 2005). In this discussion,

Cresswell focus on four worldviews that inform qualitative research and identify how these worldviews shape the practice of research. The four are post-positivism, constructivism, advocacy/participatory, and pragmatism (Creswell, 2003). It is helpful to see the major elements of each paradigm, and how they inform the practice of research differently.

2.3 Post-positivism

Those who engage in qualitative research using a belief system grounded in post-positivism will take a scientific approach to research. The approach has the elements of being reductionistic, logical, an emphasis on empirical data collection, cause-and-effect oriented, and deterministic based on a priori theories. We can see this approach at work among individuals with prior quantitative research training, and in fields such as the health sciences in which qualitative research is a new approach to research and must be couched in terms acceptable to quantitative researchers and funding agents (e.g., the a priori use of theory; see Barbour, 2000). A good overview of post-positivist approaches is available in Phillips and Burbules (2000).

In terms of practice, postpositivist researchers will likely view inquiry as a series of logically related steps, believe in multiple perspectives from participants rather than a single reality, and espouse rigorous methods of qualitative data collection and analysis. They will use multiple levels of data analysis for rigor, employ computer programs to assist in their analysis, encourage the use of validity approaches, and write their qualitative studies in the form of scientific reports, with a structure resembling quantitative approaches (e.g., problem, questions, data collection, results, conclusions).

This approach to qualitative research has been identified as belonging to post-positivism (Denzin & Lincoln, 2005), as have the approaches of others (e.g., Taylor & Bogdan, 1998). Cresswell does not tend to use this belief system, although he'll not characterize all of his research as framed within a postpositivist qualitative orientation (e.g., see the constructivist approach in McVea, Harter, McEntarffer, and Creswell, 1999, and the social justice perspective in Miller and Creswell, 1998). In their discussion here of the five approaches, for example, he emphasizes the systematic procedures of grounded theory found in Strauss and Corbin (1990), the analytic steps in phenomenology (Moustakas, 1994), and the alternative analysis strategies of Yin (2003).

2.4 Social Constructivism

Social constructivism (which is often combined with interpretivism; see Mertens, 1998) is another worldview. In this worldview, individuals seek understanding of the world in which they live and work. They develop subjective meanings of their experiences-meanings directed toward certain objects or things. These meanings are varied and multiple, leading the researcher to look for the complexity of views rather than narrow the meanings into a few categories or ideas. The goal of research, then, is to rely as much as possible on the participants' views of the situation. Often these subjective meanings are negotiated socially and historically. In other words, they are not simply imprinted on individuals but are formed through interaction with others (hence social constructivism) and through historical and cultural norms that operate in individuals' lives. Rather than starting with a theory (as in post positivism), inquirers generate or inductively develop a theory or pattern of meaning. Examples of recent writers who have summarized this position are Crotty (1998), Lincoln and Guba (2000), Schwandt (2001), and Neuman (2000).

In terms of practice, the questions become broad and general so that the participants can construct the meaning of a situation, a meaning typically forged in discussions or interactions with other persons. The more open-ended the questioning, the better, as the researcher listens carefully to what people say or do in their life setting. Thus, constructivist researchers often address the "processes" of interaction among individuals. They also focus on the specific contexts in which people live and work in order to understand the historical and cultural settings of the participants. Researchers recognize that their own background shapes their interpretation, and they "position themselves" in the research to acknowledge how their interpretation flows from their own personal, cultural, and historical experiences. Thus, the researchers make an interpretation of what they find, an interpretation shaped by their own experiences and background. The researcher's intent, then, is to make sense (or interpret) the meanings others have about the world. This is why qualitative research is often called "interpretive" research.

2.5 Advocacy/Participatory

Researchers might use an alternative worldview, advocacy/participatory, because the postpositivist imposes structural laws and theories that do not fit marginalized individuals or groups and the constructivists do not go far enough in advocating for action to help individuals. The basic tenet of this worldview is that research should contain an action agenda for reform that may change the lives of participants, the institutions in which they live and work, or even the researchers' lives. The issues facing these marginalized groups are of paramount importance

to study, issues such as oppression, domination, suppression, alienation, and hegemony. As these issues are studied and exposed, the researchers provide a voice for these participants, raising their consciousness and improving their lives. Kemmis and Wilkinson (1998) summarize the key features of advocacy/participatory practice:

Participatory action is recursive or dialectical and is focused on bringing about change in practices. Thus, at the end of advocacy/participatory studies, researchers advance an action agenda for change.

It is focused on helping individuals free themselves from constraints found in the media, in language, in work procedures, and in the relationships of power in educational settings. Advocacy/participatory studies often begin with an important issue or stance about the problems in society, such as the need for empowerment.

It is emancipatory in that it helps unshackle people from the constraints of irrational and unjust structures that limit self-development and self-determination. The aim of advocacy/participatory studies is to create a political debate and discussion so that change will occur.

It is practical and collaborative because it is inquiry completed "with" others rather than "on" or "to" others. In this spirit, advocacy/participatory authors engage the participants as active collaborators in their inquiries. Other researchers that embrace this worldview are Fay (1987) and Heron and Reason (1997).

In practice, this worldview has shaped several approaches to inquiry. Specific social issues (e.g., domination, oppression, inequity) help frame the research questions. Not wanting to further marginalize the individuals' participating in the research, advocacy/participatory inquirers collaborate with research participants. They may ask participants to help with designing the questions, collecting the data, analyzing it, and shaping the final report of the research. In this way, the "voice" of the participants becomes heard throughout the research process. The research also contains an action agenda for reform, a specific plan for addressing the injustices of the marginalized group. These practices will be seen in the ethnographic approaches to research found in Denzin and Lincoln (2005) and in the advocacy tone of some forms of narrative research (Angrosino, 1994).

2.6 Pragmatism

There are many forms of pragmatism. Individuals holding this worldview focus on the outcomes of the research-the actions, situations, and consequences of inquiry-rather than antecedent conditions (as in post positivism). There is a concern with applications-"what works"-and solutions to problems (Patton, 1990). Thus, instead of a focus on methods, the important aspect of research is the problem being studied and the questions asked about this problem (see Rossman & Wilson, 1985). Cherry Holmes (1992) and Murphy (1990) provide direction for the basic ideas:

Pragmatism is not committed to any one system of philosophy and reality. Individual researchers have a freedom of choice. They are "free" to choose the methods, techniques, and procedures of research that best meet their needs and purposes.

Pragmatists do not see the world as an absolute unity. In a similar way, mixed methods researchers look to many approaches to collecting and analyzing data rather than subscribing to only one way (e.g., quantitative or qualitative).

Truth is what works at the time; it is not based in a dualism between reality independent of the mind or within the mind.

Pragmatist researchers look to the "what" and "how" to research based on its intended consequences-where they want to go with it.

Pragmatists agree that research always occurs in social, historical, political, and other contexts.

Pragmatists have believed in an external world independent of the mind as well as those lodged in the mind. But they believe (Cherry Holmes, 1992) that we need to stop asking questions about reality and the laws of nature. "They would simply like to change the subject" (Rorty, 1983, p. xiv.)

Recent writers embracing this worldview include Rorty (1990), Murphy (1990), Patton (1990), Cherry Holmes (1992), and Tashakkori and Teddlie (2003).

In practice, the individual using this worldview will use multiple methods of data collection to best answer the research question, will employ both quantitative and qualitative sources of data collection, will focus on the practical implications of the research, and will emphasize the importance of conducting research that best addresses the research problem. In the discussion here of the five approaches to research, you will see this worldview at work when ethnographers employ both quantitative (e.g., surveys) and qualitative data collection (LeCompte & Schensul,

1999) and when case study researchers use both quantitative and qualitative data (Luck, Jackson, & Usher, 2006; Yin, 2003).

3. Positioning myself in favor of social constructivism

Social constructivism is an approach which considers that reality and knowledge are the result of social construction, that is to say of a process of interaction and negotiation between actors. This approach is opposed to other currents which postulate the existence of an objective reality, independent of human observation and interpretation, or which reduce reality to a sum of empirical facts.

Social constructivism is emerging as a worldview that moves away from more traditional approaches, such as post-positivism. At the heart of this vision is the recognition that individuals are not simply passive recipients of meanings, but active actors in constructing their understanding of the world. Constructivist researchers take an inductive approach, generating theories or models of meaning from the subjective experiences of participants, rather than starting from a pre-established theory.

In practice, social constructivism manifests itself through broad and general research questions, allowing participants to actively construct the meaning of a situation. This openness in questioning is essential, because it encourages the diversity of perspectives and the richness of meanings. Researchers listen attentively to participants, encouraging discussions and interactions to explore social processes. This approach is interested not only in what individuals say or do, but also in how these meanings are negotiated socially and historically.

The emphasis on the specific contexts in which individuals live and work distinguishes social constructivism. Researchers seek to understand the influences of historical and cultural norms on the construction of meanings. Recognizing that each researcher brings their own background, the positioning of the researcher becomes crucial. Researchers position themselves in the research, recognizing how their personal, cultural, and historical experiences shape their interpretation. This transparency strengthens the validity of the research and contributes to a more contextualized interpretation.

The constructivist approach is reflected in methodologies such as phenomenological studies, where individuals describe their subjective experiences, and in the grounded theory perspective of Charmaz, which bases its theories on individuals' perspectives. These concrete examples

demonstrate how social constructivism finds concrete applications in qualitative research, highlighting the dynamic aspects of human interactions and allowing in-depth exploration of the phenomena studied.

It is clear that social constructivism offers a compelling and profound approach to approaching qualitative research. By emphasizing the diversity of meanings, social interactions and recognition of contexts, this worldview enriches our understanding of the subjective realities of individuals. Constructivist researchers, by positioning themselves transparently, contribute to more authentic and contextually grounded interpretive research. It is in this approach that the power of social constructivism lies in contemporary qualitative research and that we position ourselves.

In comparison with other epistemological positions, social constructivism is distinguished by its rejection of the idea of an objective and universal reality. Unlike post-positivism which adopts a scientific, reductionist and cause-and-effect oriented approach, social constructivism favors complexity and the multiplicity of meanings.

Compared to advocacy/participation which emphasizes participatory action and emancipatory inquiry, social constructivism focuses more on understanding subjective meanings without necessarily immediately committing to action programs. Similarly, compared to pragmatism which focuses on research findings, social constructivism emphasizes meaning and interpretation as fundamental goals.

Social constructivism is not a unified theory, but rather a set of perspectives that share certain common characteristics, such as an emphasis on language, communication, culture, history, context, and situation.

The choice of social constructivism as an epistemological positioning arises from its unique capacity to explore the richness of meanings attributed by individuals to their reality. By opting for this approach, you recognize the value of diversity of points of view and the need to deconstruct preconceived notions. Social constructivism offers a flexible methodological platform, allowing deep immersion in participants' experiences while encouraging ongoing reflection on the researcher's role in knowledge construction.

Of course, social constructivism is not without limits or criticism. Some criticize it for neglecting the material, biological or structural aspects of reality, or for putting the truth and validity of knowledge into extreme perspective. Others oppose it with more realistic, positivist, rationalist or pragmatist approaches, which claim greater objectivity, rigor or efficiency in the

production and dissemination of knowledge. There are therefore debates and controversies between the proponents of social constructivism and those of other epistemological positions, which enrich the field of research and knowledge.

But it is clear that social constructivism offers a compelling and profound approach to qualitative research. By emphasizing the diversity of meanings, social interactions and recognition of contexts, this worldview enriches our understanding of the subjective realities of individuals. Constructivist researchers, by positioning themselves transparently, contribute to more authentic and contextually grounded interpretive research. It is therefore in this approach that the power of social constructivism lies in contemporary qualitative research and that for which we position ourselves.

CHAPTER SIX : RESEARCH STRATEGY

This qualitative study aims to explore the impact of artificial intelligence (AI) on Galleries, Libraries, Archives, and Museums (GLAM) institutions in Africa. Through in-depth interviews and thematic analysis, this research seeks to understand the experiences, challenges, and opportunities that AI presents for GLAM professionals in the African context. By focusing solely on qualitative methods, this study aims to provide rich, nuanced insights into the complex interactions between AI technologies and cultural heritage institutions in Africa.

Galleries, Libraries, Archives, and Museums (GLAM) play a crucial role in preserving and promoting cultural heritage in Africa. With the increasing integration of artificial intelligence (AI) technologies in GLAM institutions worldwide, it is essential to understand how these innovations are shaping the practices and experiences of professionals working in these sectors. This qualitative study seeks to explore the impact of AI on GLAM institutions in Africa, with a specific focus on the perspectives and experiences of professionals involved in the implementation and utilization of AI technologies.

Given the nature of this study, which relies on publicly available and consultable literature, and social media content, ethical considerations primarily revolve around ensuring the responsible use of information, respecting intellectual property rights and upholding privacy standards when referencing user generated content from social media platforms. All data sources will be appropriately cited and attributed to uphold academic integrity and acknowledge the contributions of authors and participants in online discussions. More to that, efforts will be made to ensure that the representation of social media content is done in a manner that respects privacy and anonymity of individuals contributing to online discussions.

Our study employs a multifaceted approach to investigate the integration of artificial intelligence in Galleries, Libraries, Archives and Museums (GLAM) institutions in Africa. The methodological approach encompasses a comprehensive review of existing documentation, a method which involves delivering information by carefully studying written documents, or visual information from sources called documents. These could be textbooks, newspapers, articles, speeches, advertisements, pictures and many others (martin E. Amin, 2005) an analysis of insights derived from platforms and lastly the analysis of data extracted or gotten from these platforms. Below is an elaboration on the research approaches used.

1. RESEARCH DESIGN

1.1 Research objectives:

- Identify the applications and uses of AI in GLAM, and the actors involved.
- Assess the impacts and benefits of AI for GLAM,
- Analyze the issues and challenges of AI for GLAM, such as data quality, reliability, ethics and participation.
- Propose recommendations and best practices for the development and integration of AI in GLAM

1.2 Type of research:

A social constructivist qualitative case study.

1.3 Context:

Presentation of the rapid increase in AI use in the globe, elaboration on the state of AI in Africa, with the various challenges faced and proposed recommendations for future adoption into the GLAM structures.

1.4 Case presentation: An overview of GLAM

GLAM is an acronym that stands for Galleries, Libraries, Archives, and Museums. These are institutions that collect, preserve, and share cultural heritage and knowledge with the public. Each of these spaces plays a vital role in preserving, showcasing and providing access to cultural and historical materials to create innovative projects and services.

The activity of every space in GLAM can vary depending on the type, size, and mission of the institution. Some examples of activities are:

1.4.1 Galleries:

Galleries are dedicated to the exhibition and promotion of visual art. They provide a platform for artists to showcase their work to the public, fostering creativity and cultural exchange. Galleries often curate temporary exhibitions that highlight specific artists, movements, or themes, as well as maintaining permanent collections. By presenting a diverse range of artistic expressions, galleries contribute to public discourse and appreciation of visual arts.

1.4.2 Libraries:

Libraries are repositories of knowledge and information, housing vast collections of books, periodicals, manuscripts, and digital resources. They serve as centers for research, education,

and community engagement, offering access to a wide range of materials for learning and exploration. Libraries also provide important services such as lending books and other materials, providing access to digital resources, offering information and reference services, organizing literacy and learning programs,

literacy programs, public lectures, and access to special collections and archives, making them vital community resources.

1.4.3 Archives:

Archives are dedicated to the preservation and management of historical records and documents. They collect and safeguard primary source materials such as letters, photographs, maps, official documents, and audiovisual recordings. Archives play a crucial role in providing access and consultation services, facilitating research and discovery, promoting public awareness and engagement, preserving the documentary heritage of societies, providing valuable resources for historical research, genealogy, and understanding the evolution of cultures and institutions over time.

1.4.4 Museums:

Museums are institutions that collect, preserve, and interpret objects of cultural, historical, or scientific significance. They encompass a wide range of disciplines including art, history, natural history, science, and technology. Museums often curate exhibitions that explore specific themes or narratives, offering educational programs and public events to engage visitors with their collections. By presenting tangible artifacts and immersive experiences, museums contribute to public understanding and appreciation of diverse aspects of human culture and the natural world.

Collectively, GLAM institutions serve as vital resources for education, research, and cultural enrichment. They contribute to the preservation of heritage, the promotion of creativity and innovation, and the fostering of understanding and appreciation of diverse cultures and knowledge. Additionally, GLAM institutions often collaborate with each other to share resources and expertise, further enhancing their collective impact on society. With all these rules pertaining to GLAM institutions, with the integration of AI, various areas of activities and sectors will be boasted.

1.5 Methodology

1.5.1 Online Document analysis or consultation:

The online document consultation for this research was conducted through comprehensive searches of scholarly databases, including but not limited to PubMed, JSTOR, and Google Scholar; academic journals; conference proceedings and relevant publications pertaining to AI technologies, cultural heritage preservations, ethical frameworks, community engagement and inclusive practices. This review served as a foundational component for synthesizing existing knowledge, key term identification and contextualization of ethical and inclusive considerations related to AI in the African GLAM sector. The search strategy involved the use of relevant keywords such as "artificial intelligence," "GLAM institutions," "cultural heritage," and "Africa.". also, consultation encompasses a comparative analysis of AI adoption in GLAM institutions on a global plan so as to provide insight on best practices and to be able to bring out best lessons and apply to the African context.

1.5.2 Social media analysis/consultation

In addition to literature review, we incorporated the analysis of discussions, opinions and insights shared on social media platforms related to GLAM structures, cultural heritage and AI technologies. Social media provides a rich source of real-time discourse, diverse perspectives and community driven narratives that contribute to understanding public perceptions, emerging trends and local experiences regarding the integration of AI in GLAM. Platforms such as twitter, Facebook groups, professional forums and online communities dedicated to AI and GLAM and discussions on cultural heritage were analyzed in order to discover prevalent themes, concerns and innovative approaches in the area of AI.

1.5.3 Website analysis/consultation:

We also incorporated websites into our research methodology so as to be open to diverse perspectives in order to discover prevalent themes and innovative approaches.

1.6 Analysis plan

Thematic Analysis: Identification of recurring themes from documents.

Comparison of Results with Literature: Putting the case study results into perspective with existing knowledge about AI in GLAM

1.7 Critical analysis

Lessons learned: discussion on what is already being done as far as AI is concerned in the area of Galleries, Libraries, archives and museums are concerned.

Challenges: Identification and discussion of the main challenges faced these structures for instance ethical considerations, data quality and availability and other factors.

Opportunities: Identification and discussion of opportunities offered by AI to improve AI practices in GLAM. This may include opportunities to improve access and quality of care, to innovate and create new solutions, and to integrate and collaborate with regional and global initiatives.

AI has the potential to revolutionize how GLAM institutions engage with their audiences, manage their collections, and preserve cultural heritage. By using AI technologies responsibly and ethically, GLAM institutions can use these opportunities to enrich public access to knowledge and foster a deeper appreciation of our shared cultural heritage. All this is not without regarding the challenges such as integrating AI into existing systems and workflows, developing and maintaining AI skills and competences among GLAM staff and stakeholders, as well as fostering a culture of innovation and experimentation.

PART FOUR : ANANLYSIS AND RESULTS

CHAPTER SEVEN : ANALYSIS AND INTERPRETATION

Galleries, Libraries, Archives, and Museums (GLAM) institutions play a crucial role in preserving cultural heritage, providing access to information, and engaging the public with diverse collections. Each of this type of institution has a distinct focus or area of reach but they are all cultural institutions, playing an important role in the preservation and dissemination of human knowledge and culture. Galleries focus primarily on visual arts such as paintings, sculptures, photography; offering the possibility to the audience not only to view the various arts works but equally purchase these arts works. Libraries, are places where literary, musical or artistic and reference materials such as books, monographs, manuscripts, recordings are kept. These spaces are there for collecting, preserving, organizing and providing access to books and other written materials. Archives, on the other hand, are there for preservation and conservation of historical records generated as a result of human activities to serve for future references. Museums, display and conserve objects of historical and/or cultural value. The integration of artificial intelligence (AI) presents numerous opportunities to enhance the functions and services of GLAM institutions, revolutionizing how they manage, interpret, and share cultural resources. This section gives and overview of these institutions, then globally presents key potentials for using AI to transform the operations and services of GLAM institutions.

1. Mapping the African AI Ecosystem

In the heart of a continent known for its rich tapestry of cultures, landscapes, and untapped potential, a remarkable narrative is unfolding one driven by innovation, collaboration, and the exponential growth of artificial intelligence. The African AI ecosystem, a vibrant and dynamic domain, stands as a testament to the continent's pursuit of technological advancement and its commitment to using AI for sustainable development and positive societal impact. Within this ecosystem, a myriad of forces and actors converge, each contributing to the rich and diverse fabric of African AI innovation. From leading research institutions and enterprising startups to visionary government initiatives and impactful use cases, the spectrum of AI-related activities on the continent is as multifaceted as the diverse communities it serves (Olanipekun, 2023). At the forefront of this expanding ecosystem are the academic and research initiatives that serve as the cradle of AI expertise and knowledge transfer. Academic institutions and research centers across Africa are actively nurturing a new generation of AI talent, fostering groundbreaking

research, and propelling the continent to the forefront of AI innovation. Here, the spirit of collaboration across global research networks intertwines with locally relevant challenges, giving rise to solutions that are not only innovative but also deeply rooted in the unique contexts of African societies. Complementing these academic endeavors are the enterprising startups and innovation hubs that act as the driving engines of AI-driven solutions across diverse sectors. From healthcare and agriculture to finance and transportation, these startups are harnessing the power of AI to address local challenges, foster economic growth, and unlock new opportunities for prosperity. Supported by a network of incubators, accelerators, and mentorship programs, these startups represent the frontline of innovation, propelling Africa into the leading unit of AI-driven entrepreneurship (Olanipekun, 2023).

Furthermore, the unfolding narrative of the African AI ecosystem is marked by the strategic engagement of governments and corporate entities, each recognizing AI as a catalyst for economic development, social progress, and enhanced public services. Initiatives such as the establishment of specialized AI research centers, public-private partnerships, and the integration of AI in corporate operations exemplify the commitment to harnessing AI for the betterment of African societies (Wairegi et al., 2021). Crucially, the African AI landscape is underpinned by a resounding commitment to ethical and inclusive AI development. Though leaders, policymakers, and advocacy groups are actively shaping the discourse around responsible AI deployment, ensuring that AI technologies respect and reflect the diverse social, cultural, and economic contexts of African communities. From impactful use cases addressing healthcare challenges and agricultural productivity to fostering financial inclusion and preserving cultural heritage, the African AI ecosystem embodies a narrative of progress, collaboration, and inclusivity. It is a story of talent, perseverance, and cross-continental collaboration, a story that positions Africa as a pivotal participant in the global AI landscape. In the bold strokes of this narrative, the African AI ecosystem encapsulates the promise of innovation and transformation, heralding a future where technology enriches lives, empowers communities, and charts a course toward a brighter tomorrow for all (Wairegi et al., 2021).

Hence, Mapping the African AI ecosystem involves understanding the diverse network of stakeholders, initiatives, and technological advancements that collectively contribute to the development, application, and impact of artificial intelligence across the continent. This comprehensive view encompasses academic research, industry collaborations, policy initiatives, community-driven innovation, and ethical considerations, reflecting the vibrant landscape of AI development in Africa. For more specificity on the initiatives of AI in the

African continent, we'll be delving into the GLAM (Galleries, Libraries, Archives, Museums) sector. In mapping the African AI ecosystem in GLAM, we'll analyze what has been done so far as GLAMs are concerned (this with the use of case studies for better understanding and illustration). Analysing the different opportunities these sectors of activity is exposed to with its challenges, will give room for better recommendations hence an innovative perspective.

- **Use of AI in GLAM**

Artificial intelligence has transformed the way things are now done in today's society. Every institution is gradually implementing these AI procedures into their day to day activities and Libraries, Museums, archives and Galleries are not left out. Several Galleries, Libraries, Archives, and Museums (GLAM) institutions have started to explore the use of artificial intelligence (AI) in their activities, though at varying levels of adoption and implementation, With several innovative applications already in effect in the world. The African continent on its part is still gradually coming alive when AI is concerned and for this reason, not much is said on the various AI applications and initiatives in GLAM in Africa.

The African continent has also developed some strategic frameworks and policies to guide the development and adoption of AI in GLAM and other sectors. For instance, the African Union Artificial Intelligence Continental Strategy for Africa aims to create a common vision and roadmap for harnessing AI for Africa's socio-economic development (AUDA-NEPAD, 2022). This strategy covers aspects such as infrastructure, skills, governance, ethics, and innovation, and identifies GLAM as one of the priority areas for AI intervention. Another example is the Developing an Artificial Intelligence for Africa Strategy, a proposal by the Boston Consulting Group and the BCG Henderson Institute, which suggests that African companies should take the lead in developing and deploying AI applications that are tailored to local needs and contexts, and that can improve their competitiveness and create social impact (Matters, 2021). The proposal also recommends that African governments, academia, and civil society should support the creation of an AI ecosystem that fosters collaboration, capacity building, and regulation.

As it is noticeable, the African continent has done a lot in the area of implementing AI into the various GLAM activities, and has a lot of potential to do more, it presents a set of opportunities which can bring future ameliorations into the different structures. From enhancing collection management, to user satisfaction, AI overs several opportunities to the GLAM sector.

2. Opportunities of AI in GLAM

- **Enhanced Collection Management**

AI technologies offer the potential to revolutionize collection management processes within GLAM institutions. Through advanced image recognition, natural language processing, and data analysis, AI can automate cataloging, metadata tagging, and classification of artifacts, enabling more efficient organization and retrieval of cultural assets. For instance, in galleries, Ai can be used in the creation of new artworks or in Analysing and interpreting already existing ones.

- **Personalized Visitor Experiences**

AI-powered recommendation systems and personalized content delivery can enhance visitor experiences within GLAM institutions. By analyzing visitor preferences, behavior, and historical data, AI can curate personalized tours, suggest relevant exhibits, and provide interactive experiences tailored to individual interests.

- **Preservation and Conservation**

AI technologies can significantly contribute to the preservation and conservation of cultural artifacts and archival materials. Machine learning algorithms can assist in identifying degradation patterns, recommending conservation treatments, and automating the monitoring of environmental conditions to ensure the long-term preservation of valuable collections.

- **Enhanced Access to Information**

AI-driven natural language processing and chatbot technologies can improve access to information within GLAM institutions. By enabling conversational interfaces and intelligent search capabilities, visitors can easily access relevant information about collections, exhibitions, and historical resources, enhancing their engagement and learning experiences.

- **Data Analysis and Insights**

AI-powered analytics can unlock valuable insights from vast amounts of data held by GLAM institutions. By applying machine learning algorithms to analyze visitor trends, engagement patterns, and collection usage, institutions can gain actionable insights to inform decision-making, exhibition curation, and strategic planning.

- **Cultural Heritage Research**

AI technologies can facilitate advanced research and analysis of cultural heritage materials. From deciphering ancient scripts to identifying historical patterns in art or music, AI algorithms can aid researchers in uncovering new knowledge and understanding the significance of cultural artifacts.

- **Enhanced Curation and Recommendation Systems**

AI can help GLAM institutions develop more sophisticated curation and recommendation systems for their collections. By analyzing user preferences, browsing behavior, and historical data, AI algorithms can provide personalized recommendations for artworks, books, archival materials, or museum exhibits, improving the visitor experience and increasing engagement.

- **Digitization and Preservation**

AI technologies, such as optical character recognition (OCR) and computer vision, can aid in the digitization and preservation of cultural materials. AI-powered tools can automate the process of digitizing and cataloging archival documents, photographs, and artworks, making these resources more accessible to researchers and the public.

- **Content Analysis and Metadata Tagging**

AI can be used to analyze and tag large volumes of content, such as digitized texts, images, and audiovisual materials. Natural language processing (NLP) and image recognition algorithms can automatically generate descriptive metadata, improving searchability and accessibility of digital collections within libraries, archives, and museums.

- **Visitor Analytics and Personalized Experiences**

AI-powered analytics can help GLAM institutions gain insights into visitor behavior, preferences, and engagement patterns. This data can be used to create personalized experiences for visitors, such as tailored exhibition tours, interactive digital guides, or customized educational content based on individual interests.

- **Conservation and Restoration**

AI technologies, including machine learning and image analysis, can assist in the conservation and restoration of artworks and historical artifacts. AI algorithms can help conservators identify damage, assess deterioration, and recommend appropriate conservation techniques, contributing to the long-term preservation of cultural heritage.

- **Natural Language Processing for Archives and Libraries**

AI-powered natural language processing tools can facilitate advanced search capabilities within archival documents and library catalogs. This can enable users to extract insights from historical texts, manuscripts, and rare books more efficiently, supporting scholarly research and historical inquiry.

- **Virtual and Augmented Reality Experiences**

AI-driven virtual and augmented reality applications can create immersive experiences for museum visitors. By leveraging AI for object recognition and spatial mapping, museums can develop interactive exhibits that provide contextual information, storytelling elements, and engaging visualizations of historical or artistic content.

- **Predictive Analytics for Collection Management**

AI-based predictive analytics can assist GLAM institutions in making informed decisions about collection management, acquisitions, and deaccessioning. By analyzing trends in cultural heritage markets, audience interests, and conservation needs, AI can help optimize collection development strategies.

- **Language Translation and Multilingual Access**

AI-powered language translation tools can facilitate multilingual access to GLAM collections and resources. By automatically translating descriptive information, exhibition labels, or archival finding aids into multiple languages, AI can broaden the reach of cultural institutions to diverse global audiences.

The integration of AI technologies presents a wealth of opportunities to enhance the functions and services of GLAM institutions. By leveraging AI for collection management, personalized visitor experiences, preservation efforts, improved access to information, data analysis, and cultural heritage research, GLAM institutions can embrace innovation and enrich their contributions to education, research, and cultural preservation.

3. Risks and challenges related to the use of ai in glam institutions

The integration of artificial intelligence (AI) in Galleries, Libraries, Archives, and Museums (GLAM) institutions holds tremendous potential to revolutionize operations and services. However, the adoption of AI also raises significant challenges that must be carefully considered. This write-up explores these challenges related to the use of AI in GLAM institutions and emphasizes the importance of addressing these concerns to ensure responsible and equitable deployment of AI technologies.

- **Ethical Implications:**
  - **Bias and Representation**

AI algorithms are susceptible to biases present in training data, which can perpetuate existing inequalities and underrepresentation of certain cultural groups. GLAM institutions must ensure that AI applications do not reinforce biased narratives or perpetuate stereotypes in the representation of cultural artifacts, historical materials, and diverse voices.

  - **Privacy and Data Security**

The use of AI in GLAM institutions may involve the collection and processing of visitor data, raising concerns about privacy and data security. Institutions must uphold strict ethical standards for data collection, consent, and protection to safeguard the privacy rights of visitors and prevent unauthorized use or exploitation of personal information.

- **Transparency and Accountability**

The opaque nature of AI algorithms poses challenges for transparency and accountability in decision-making processes. GLAM institutions must strive to provide clear explanations of how AI technologies are used, ensure accountability for algorithmic outcomes, and establish mechanisms for addressing potential biases or errors in AI-driven operations.

- **Cultural Sensitivity and Respect**

AI applications in GLAM institutions should uphold cultural sensitivity and respect for diverse perspectives. Institutions must carefully consider the ethical implications of using AI to interpret, classify, or present cultural materials, ensuring that these technologies do not inadvertently diminish the richness and complexity of cultural heritage or perpetuate cultural insensitivity.

- **Access and Inclusivity**

The deployment of AI should not exacerbate existing barriers to access or exclude marginalized communities from engaging with cultural resources. GLAM institutions must prioritize inclusivity in the design and implementation of AI-driven services, ensuring that all visitors have equitable opportunities to benefit from these technological advancements.

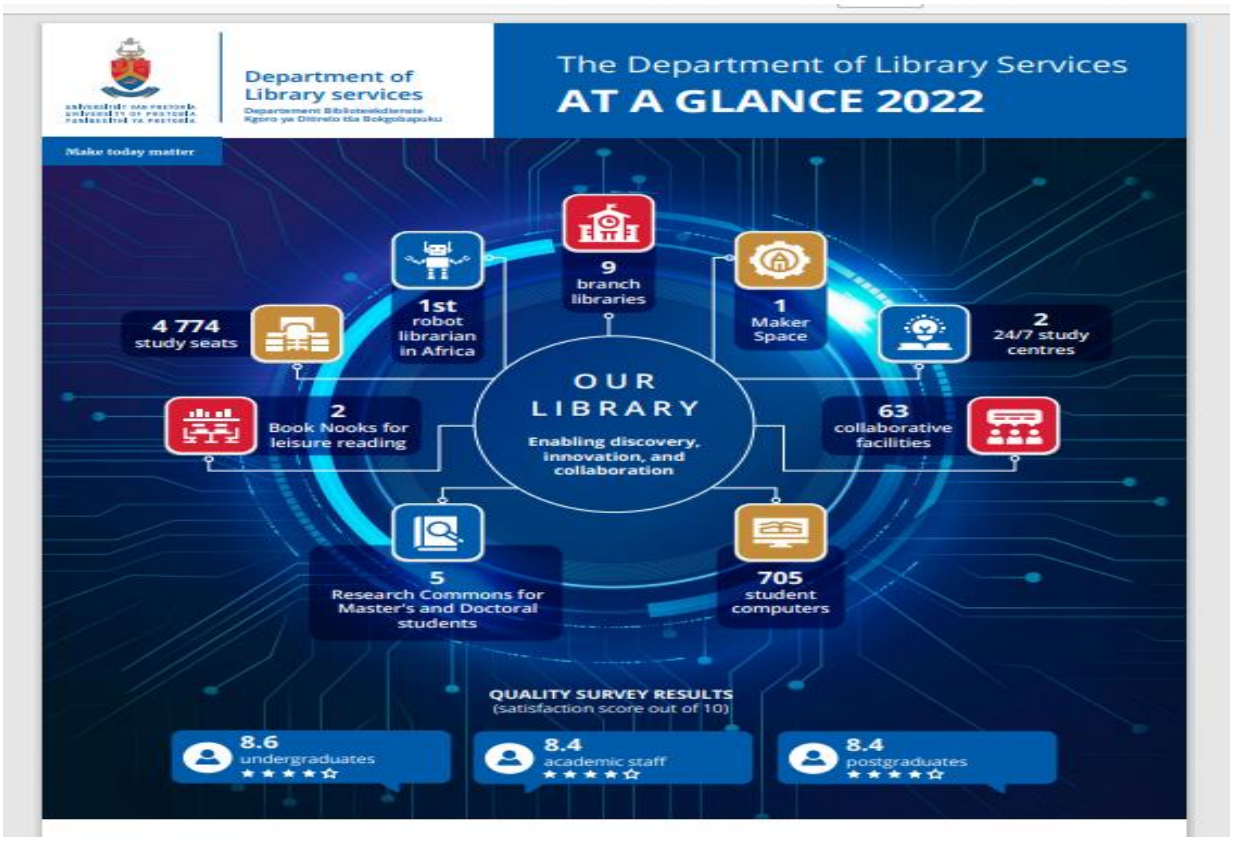
- **Human-Machine Collaboration**

As AI technologies automate certain tasks within GLAM institutions, ethical considerations arise regarding the impact on human labor, expertise, and decision-making. Institutions must

navigate the ethical implications of human-machine collaboration, striving to leverage AI as a tool that augments human capabilities while preserving the essential role of human expertise and judgment in cultural stewardship.

The ethical implications related to the use of AI in GLAM institutions underscore the critical need for responsible, ethical, and inclusive deployment of these technologies. By addressing concerns related to bias and representation, privacy and data security, transparency and accountability, cultural sensitivity, access and inclusivity, and human-machine collaboration, GLAM institutions can ensure that AI integration aligns with ethical principles and supports their mission to preserve, interpret, and share cultural heritage responsibly.

CHAPTER EIGHT : AI INITIATIVES IN GLAMS



Source https://www.up.ac.za

In recent years, the integration of artificial intelligence technologies has been revolutionising the way Galleries, libraries, archives and museums structures operate in Africa. These institutions are gradually using AI to improve on their activities such as improved accessibility, and engage with audience in innovative ways. This section presents us few of these structures which have begun using AI technologies.

1. University of Pretoria : Department of library services

The Department of Library Services has nine faculty libraries spread over all the University of Pretoria (UP) campuses. These provide access to a range of print and digital publications, and specialised services. Each department at the University has a dedicated information specialist (trained librarian) who specialises in that department's resources. The information specialists can help with:

literature searches, relevant information and referencing

information literacy training and research data management

bibliometric analysis for funding and NRF applications

appropriate accredited journals to publish in information on predatory journals

The University of Pretoria Library Services being one of the leading academic libraries in Africa, with a vision to be a dynamic partner in knowledge creation, here are some of the initiatives or innovations at the University of Pretoria library services as far as AI or technological advancement is concerned.

- **Libby**

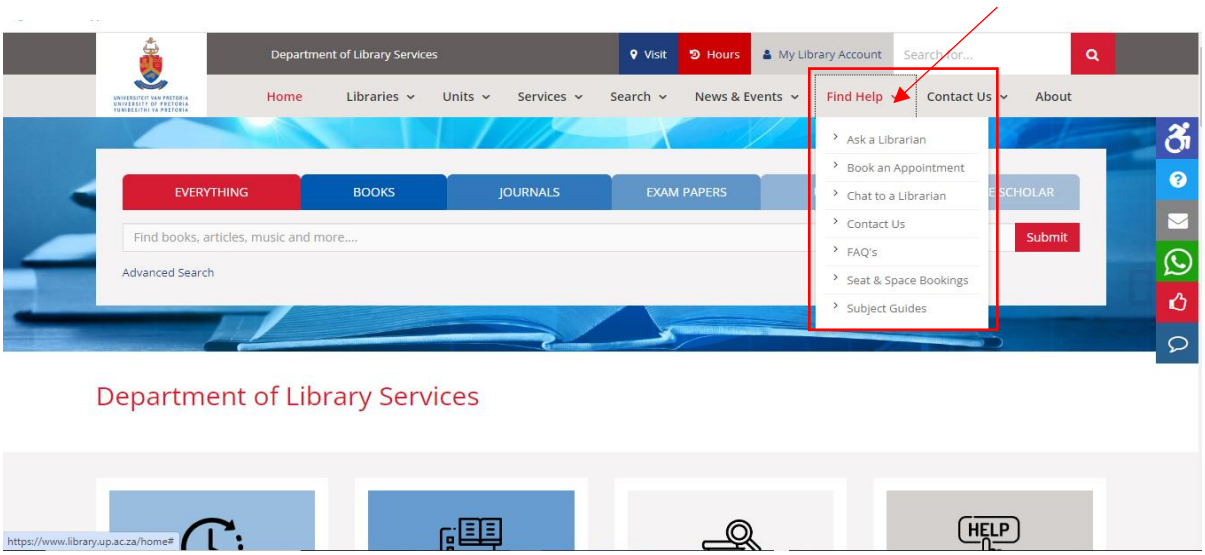
a service robot librarian that can greet visitors, provide directions, answer FAQs, and assist with library resources.

The department of library services is at the forefront of the universities 4IR focus with a rather interesting staff member Libby, a resident library robot. It weighs just about 19kg, stands 90cm tall, tall enough to interact with visitors in wheelchairs. She has an array of more than 60 sensors, cameras, and software integration that enables her to receive and process various commands and requests. A tablet integrated on her chest is for manual input and her brain is connected to Watson, IBM's question answering computer system, which processes queries directed at it. Libby runs off Android based software which opens up opportunities for the department of library services to develop new and exciting client facing applications. Libby is not only for work, but she has other features which give her the ability to dance, play music and enjoy a light pat on the head. these features are important for this library. For the presence of this robot frees staffs from repetitive work hence creating more time to focus on other library issues.

Source https://www.up.ac.za

- **Ask-a-Librarian and Chat to a Librarian**

An online reference services that enable users to get help from librarians via email or live chat.

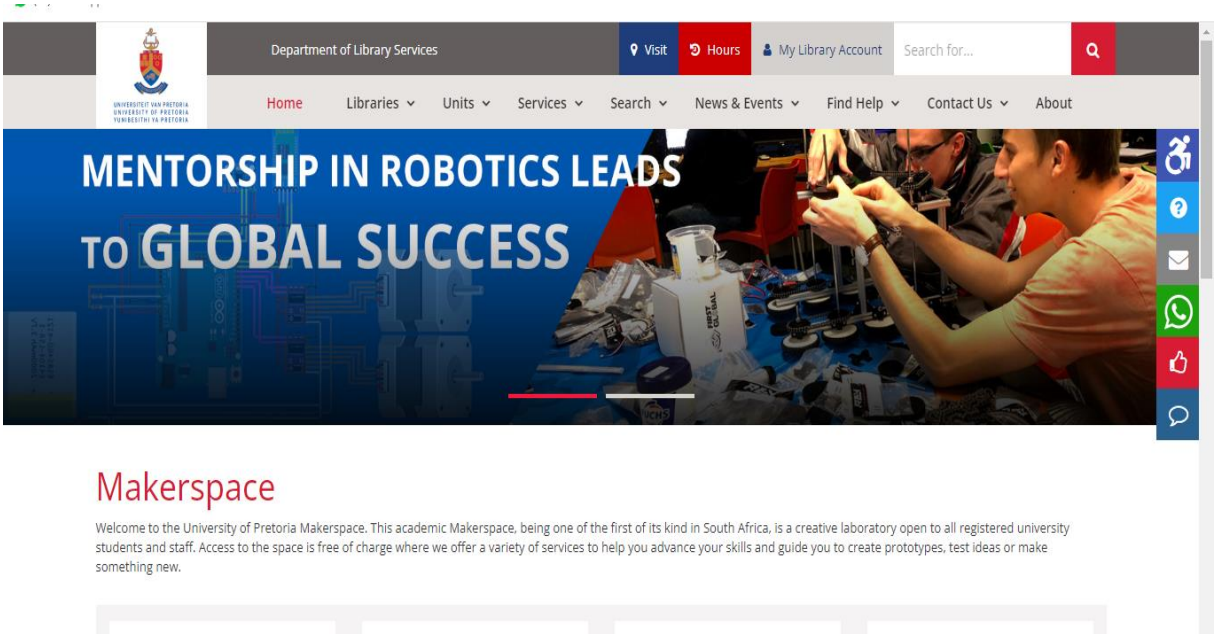


Source https://www.up.ac.za

- **MakerSpace**

a creative space that offers 3D printing and scanning, guidance on 3D design and modelling, training on 3D principles for rapid prototyping, circuity and robotics, and more.

Source https://www.up.ac.za

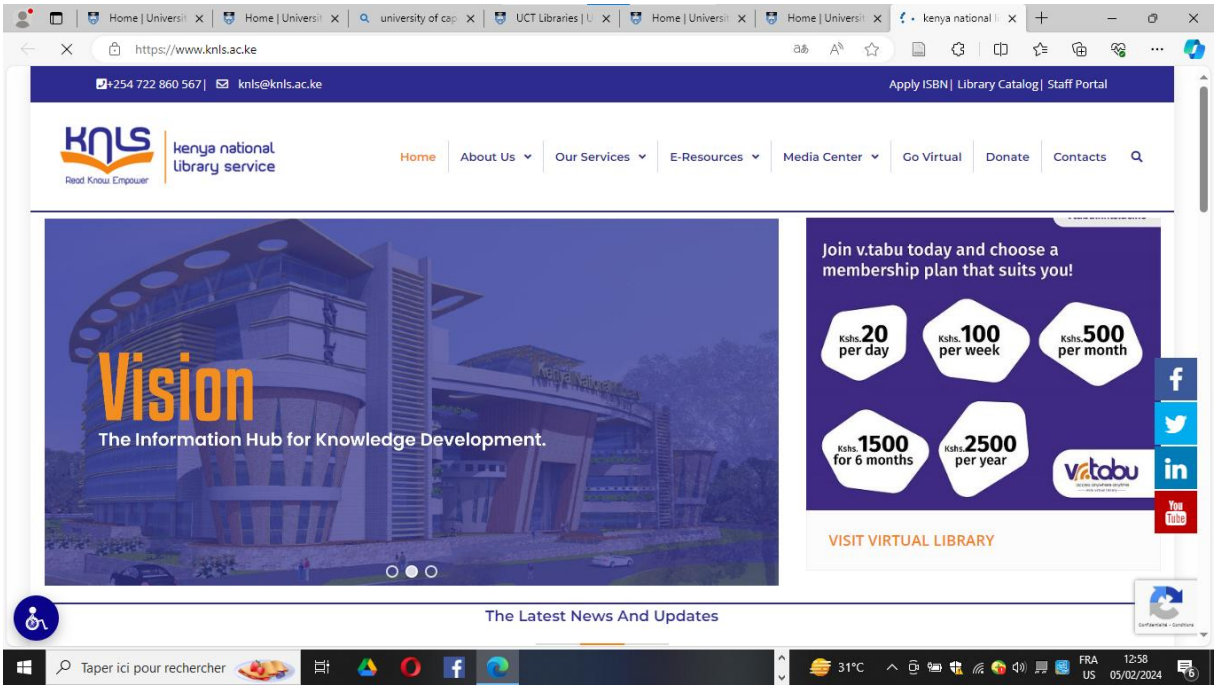


Source https://www.up.ac.za

These are some of the examples of how the University of Pretoria library services are using innovative technologies and practices to enhance their services and user experience.

2. Kenya national library service

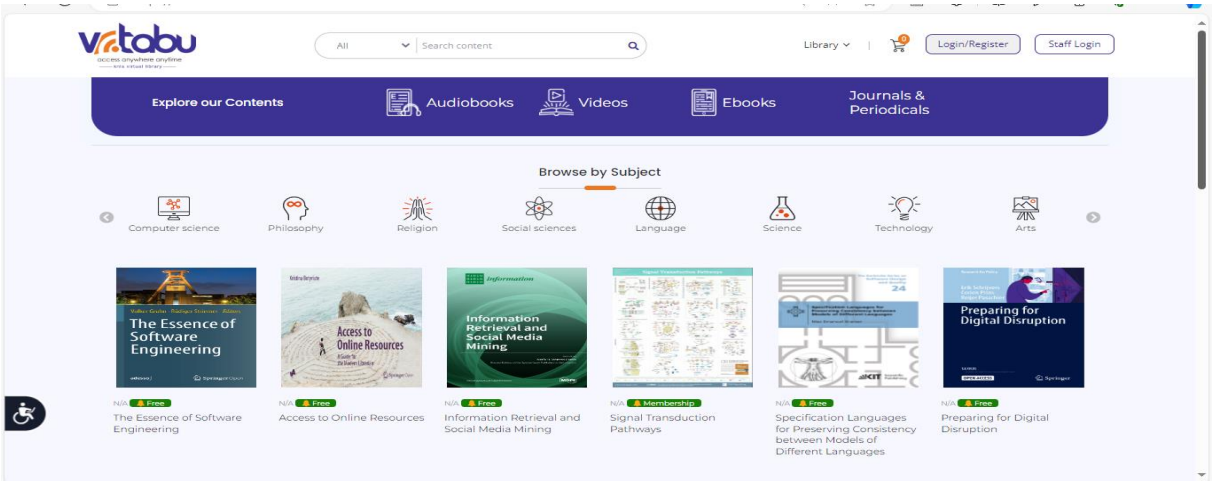
The Kenya National Library Service (KNLS) has embraced technology, including artificial intelligence (AI)



Source https://www.knls.ac.ke

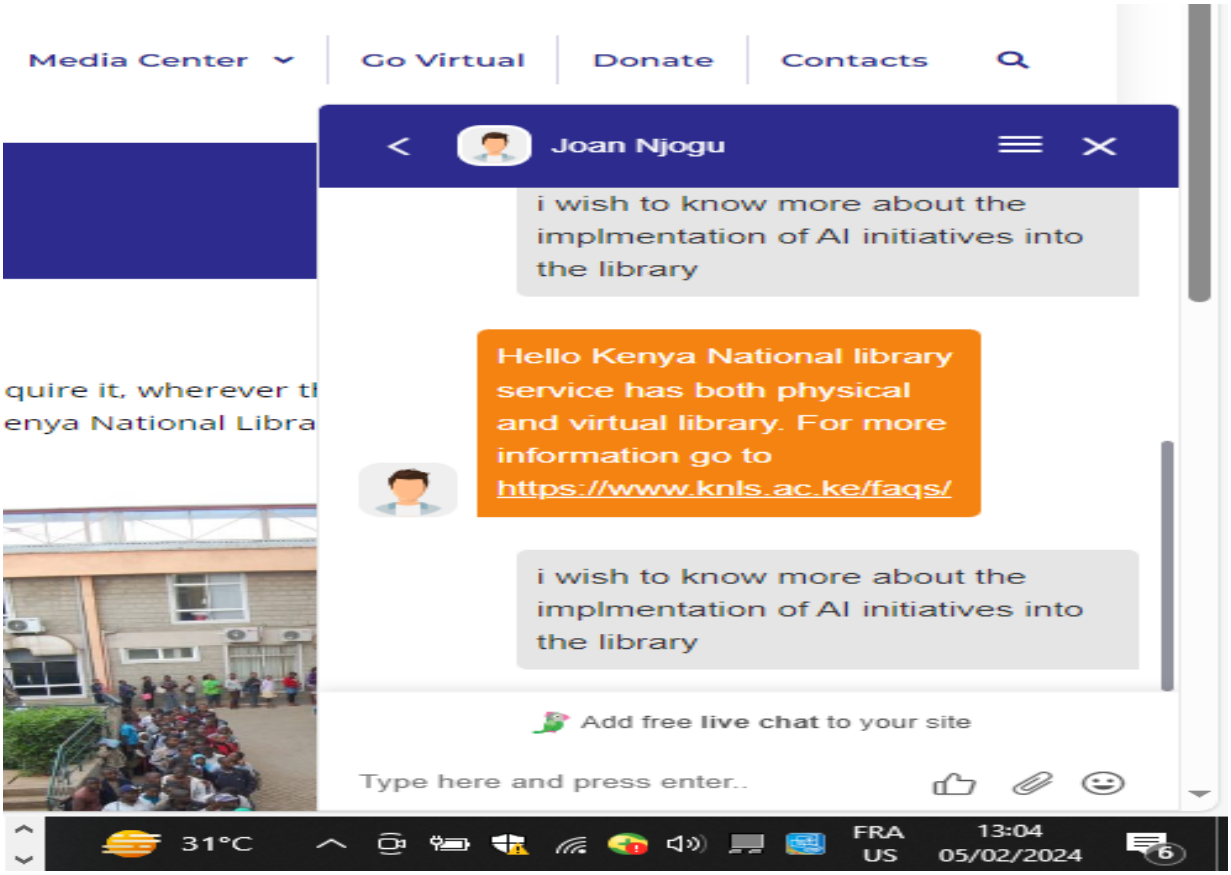
To enhance its services and make them more accessible, here are notable initiatives:

Virtual Library (Vtabu): In September 2022, KNLS launched the country's first virtual library, known as Vtabu. Vtabu aims to encourage a reading culture and provides an avenue for individuals to grow and hone their skills in various fields, anytime and anywhere. Accessible from any internet-enabled device globally, Vtabu hosts over 200,000 digitized books, periodicals, research papers, and government publications



Source https://www.knls.ac.ke

Chatbots: the library as built a chatbot system for preprogram services like book renewals, study reservations, recommendations of study materials, library information.



Source https://www.knls.ac.ke

All in all, institutions managing cultural heritage, are bound to integrate AI practices into their activities; for AI remains a fast growing field, with the purpose of simplifying human activities for better productivity and results.

GENERAL CONCLUSION

As Galleries, Libraries, Archives, and Museums (GLAM) institutions in Africa embark on the journey of integrating artificial intelligence (AI) technologies into their informational practices, it is imperative to chart a path that upholds ethical principles, fosters inclusivity, and leverages AI to address the unique challenges and opportunities within the African cultural heritage landscape. Drawing from insights gained through scholarly research and practical experiences, this write-up offers a set of recommendations for guiding future AI integration in GLAM institutions across Africa.

- **Ethical Frameworks and Community Engagement:**

Prioritize the development and adoption of ethical frameworks that guide the responsible use of AI technologies within GLAM institutions. These frameworks should encompass principles of transparency, accountability, fairness, and privacy to ensure that AI-driven practices align with ethical standards.

Foster meaningful community engagement to co-create AI solutions that are culturally sensitive, respectful of diverse knowledge systems, and responsive to the needs and aspirations of local communities. This entails involving community stakeholders in the design, implementation, and evaluation of AI applications within GLAM institutions.

- **Capacity Building and Knowledge Sharing:**

Invest in capacity building initiatives that empower GLAM professionals in Africa with the requisite skills and knowledge to effectively harness AI technologies for digitization, preservation, and dissemination of cultural heritage materials.

Facilitate knowledge sharing and collaboration among GLAM institutions, technology experts, and cultural practitioners to exchange best practices, innovative approaches, and lessons learned in AI integration. This can be achieved through regional networks, workshops, and collaborative projects.

- **Inclusive Representation and Multilingual Access:**

Emphasize the importance of inclusive representation in AI-driven initiatives by ensuring that cultural heritage materials from diverse communities and traditions are adequately represented and preserved within digital collections.

Leverage AI technologies to enable multilingual access to cultural heritage materials, thereby facilitating broader engagement with linguistic diversity and ensuring that marginalized languages are not overlooked in the digital realm.

- **User-Centered Design and Personalized Experiences:**

Adopt a user-centered design approach to AI integration, focusing on creating personalized experiences that cater to the diverse needs and preferences of audiences accessing cultural heritage materials. This involves using AI for personalized recommendations, interactive interfaces, and immersive storytelling experiences.

- **Data Governance and Privacy Protection:**

Establish robust data governance mechanisms to safeguard the privacy, confidentiality, and integrity of cultural heritage data when employing AI technologies. This includes implementing data protection protocols, encryption standards, and secure storage practices to mitigate potential risks associated with data misuse or unauthorized access.

- **Collaboration with Indigenous Knowledge Holders:**

Foster collaborative partnershs with indigenous knowledge holders, traditional custodians, and local communities to ensure that AI integration respects and amplifies indigenous perspectives, knowledge systems, and cultural protocols and not changes them entirely.

Recognize the importance of indigenous intellectual property rights and traditional knowledge protection in the context of AI-driven initiatives, thereby promoting equitable partnerships and mutual respect for cultural sovereignty.

- **Continuous Evaluation and Adaptation:**

Emphasize the need for ongoing evaluation and adaptation of AI integration strategies within GLAM institutions, informed by feedback from diverse stakeholders, impact assessments, and iterative refinements to ensure alignment with evolving ethical standards and community needs.

By embracing these recommendations, GLAM institutions across Africa can navigate the complexities of AI integration while upholding ethical considerations, promoting inclusivity, and harnessing the transformative potential of AI technologies to advance the preservation and accessibility of the continent's rich cultural heritage. It is our collective responsibility to ensure that AI integration in GLAM institutions reflects a commitment to ethical practice, cultural

diversity, and community empowerment, thereby fostering a future where technology serves as a catalyst for preserving and celebrating Africa's diverse cultural legacy.

Artificial intelligence (AI) in the GLAM (Galleries, Libraries, Archives, and Museums) sector is crucial for the responsible and ethical use of AI technologies. It is evident that AI has the potential to significantly impact the way cultural heritage institutions manage, preserve, and provide access to their collections. However, this also brings about important considerations regarding data privacy, transparency, and accountability. Throughout this study, we have observed that for AI to be implemented in the GLAM sector it must prioritize the ethical collection, use, and dissemination of data. This includes ensuring that data is obtained and utilized in a manner that respects the rights and privacy of individuals, particularly when dealing with sensitive cultural and historical information. Transparency in the use of AI algorithms and decision-making processes is essential to build trust with stakeholders and users.

Added to this, it is but of very great importance for AI actors in the GLAM sector to establish clear governance structures and mechanisms for accountability. This involves developing policies and guidelines that address the responsible use of AI technologies, as well as mechanisms for addressing potential biases and ensuring fairness in AI-driven processes. Added to this, it is crucial to consider the potential impact of AI on the labour forces within cultural heritage institutions and to ensure that AI is used in ways that augment human expertise rather than replacing it.

Moreover, the ethical use of AI in the GLAM sector should be guided by principles of inclusivity, diversity, and equity. It is essential to recognize that AI technologies have the potential to perpetuate biases and inequalities if not carefully managed. Therefore, AI actors in the GLAM sector should actively work to mitigate bias and discrimination, ensuring that AI applications are designed to be fair and inclusive in usage.

As the use of AI continues to evolve in the GLAM sector, it is essential for AI actors to remain vigilant in their commitment to ethical information practices. This requires ongoing engagement with users and researchers, including community members, scholars, and experts in AI ethics, to address emerging challenges and opportunities. By fostering a culture of continuous improvement and learning. AI actors can ensure that their practices align with evolving ethical standards and best practices.

All in all, the responsible use of AI in the GLAM sector has the potential to enhance access to cultural heritage while safeguarding the rights and interests of all individuals involved. By

upholding ethical information practices, AI actors can contribute to a more inclusive and equitable cultural heritage landscape.

BIBLIOGRAPHY

11 | 2022 Intelligence artificielle et innovation sociale. (n.d.). Retrieved September 28, 2023, from https://journals.openedition.org/ctd/6294

6 ways Google is working with AI in Africa. (2023, June 1). Google. https://blog.google/intl/en-africa/company-news/6-ways-google-is-working-with-ai-in-africa/

7 Types of Artificial Intelligence. (2019, June 19). https://www.forbes.com/sites/cognitiveworld/2019/06/19/7-types-of-artificial-intelligence/?sh=309d5057233e

Abardazzou, N. (2017, September 16). *The rise of artificial intelligence in Africa*. How We Made It in Africa. https://www.howwemadeitinafrica.com/rise-artificial-intelligence-africa/59770/

Adams, D. R. (2022). *KEY CONCERNS AND POLICY CONSIDERATIONS FOR THE FUTURE OF THE CONTINENT*.

Ade-Ibijola, A., & Okonkwo, C. (2023). Artificial Intelligence in Africa: Emerging Challenges. In D. O. Eke, K. Wakunuma, & S. Akintoye (Eds.), *Responsible AI in Africa* (pp. 101–117). Springer International Publishing. https://doi.org/10.1007/978-3-031-08215-3_5

Africa in Motion Film Festival. (n.d.). Retrieved January 27, 2024, from https://www.africa-in-motion.org.uk/

Africa's AI-Based Businesses and Innovations. (2023, September 15). https://www.forbesafrica.com/technology/2023/09/15/africas-ai-based-businesses-and-innovations/

Agusiegbe, O. (2022, March 15). *Access to Energy in Sub-Saharan Africa | EnvironBuzz™ Magazine*. https://environbuzz.com/access-to-energy-in-sub-saharan-africa/, https://environbuzz.com/access-to-energy-in-sub-saharan-africa/

AI in relation to GLAMs. (n.d.). Europeana PRO. Retrieved January 27, 2024, from https://pro.europeana.eu/project/ai-in-relation-to-glams

Aimée-Danielle LEZOU KOFFI. (2023). *(DOC) Projet de recherche « Les pratiques informationnelles des décideurs et des acteurs du développement en Afrique ». Service IRS/VAL/PUB de l'Agence Française de Développement et Le laboratoire Médiation, Information, Communication et Arts (MICA) de l'Université Bordeaux-Montaigne (France) |*

Aimée-Danielle LEZOU KOFFI - Academia.edu. https://www.academia.edu/46929141/Projet_de_recherche_Les_pratiques_informationnelles_des_d%C3%A9cideurs_et_des_acteurs_du_d%C3%A9veloppement_en_Afrique_Service_IRS_VAL_PUB_de_l_Agence_Fran%C3%A7aise_de_D%C3%A9veloppement_et_Le_laboratoire_M%C3%A9diation_Information_Communication_et_Arts_MICA_de_l_Universit%C3%A9_Bordeaux_Montaigne_France_

Aimée-Danielle LEZOU KOFFI. (n.d.). *(DOC) Projet de recherche « Les pratiques informationnelles des décideurs et des acteurs du développement en Afrique ». Service IRS/VAL/PUB de l'Agence Française de Développement et Le laboratoire Médiation, Information, Communication et Arts (MICA) de l'Université Bordeaux-Montaigne (France) | Aimée-Danielle LEZOU KOFFI - Academia.edu*. Retrieved September 26, 2023, from https://www.academia.edu/46929141/Projet_de_recherche_Les_pratiques_informationnelles_des_d%C3%A9cideurs_et_des_acteurs_du_d%C3%A9veloppement_en_Afrique_Service_IRS_VAL_PUB_de_l_Agence_Fran%C3%A7aise_de_D%C3%A9veloppement_et_Le_laboratoire_M%C3%A9diation_Information_Communication_et_Arts_MICA_de_l_Universit%C3%A9_Bordeaux_Montaigne_France_

Anticiper les impacts économiques et sociaux de l'intelligence artificielle | France Stratégie. (2023, September 26). https://www.strategie.gouv.fr/publications/anticiper-impacts-economiques-sociaux-de-lintelligence-artificielle

Arakpogun, E. O., Elsahn, Z., Olan, F., & Elsahn, F. (2021). Artificial Intelligence in Africa: Challenges and Opportunities. In A. Hamdan, A. E. Hassanien, A. Razzaque, & B. Alareeni (Eds.), *The Fourth Industrial Revolution: Implementation of Artificial Intelligence for Growing Business Success* (Vol. 935, pp. 375–388). Springer International Publishing. https://doi.org/10.1007/978-3-030-62796-6_22

Artificial Intelligence: Definition, history and risks. (2023, January 9). *Data Science Courses | DataScientest*. https://datascientest.com/en/artificial-intelligence-definition

AUF - Caraïbe. (2023, September 26). *Pratiques informationnelles des acteurs de l'intelligence artificielle en Afrique (PIAIA)—AUF*. https://www.auf.org/caraibe/nos-actions/toutes-nos-actions/pratiques-informationnelles-acteurs-de-lintelligence-artificielle-afrique-piaia/

Buchanan, B. G., & Smith, R. G. (1988). Fundamentals of Expert Systems. *Annual Review of Computer Science*, *3*(1), 23–58. https://doi.org/10.1146/annurev.cs.03.060188.000323

Bulinge, F. (2022). Introduction. In *Maîtriser l'information stratégique* (pp. 23–31). De Boeck Supérieur; Cairn.info. https://www.cairn.info/maitriser-l-information-strategique--9782807337763-p-23.htm

Chaudiron, S., & Ihadjadene, M. (2010). De la recherche de l'information aux pratiques informationnelles. *Études de Communication, 35*, 13–30.

Chen, Y., Stanley, K., & Att, W. (2020). Artificial intelligence in dentistry: Current applications and future perspectives. *Quintessence International*, *51*(3), 248–257. https://doi.org/10.3290/j.qi.a43952

datascientist. (n.d.). *Intelligence Artificielle: Tout ce qu'il faut savoir*. Retrieved November 16, 2023, from https://datascientest.com/intelligence-artificielle-definition

Deng, L., & Liu, Y. (2018). A joint introduction to natural language processing and to deep learning. *Deep Learning in Natural Language Processing*, 1–22.

Developing an Artificial Intelligence for Africa strategy—Development Matters. (n.d.). Retrieved January 27, 2024, from https://oecd-development-matters.org/2021/02/09/developing-an-artificial-intelligence-for-africa-strategy/

Doua, E. (2022). Enjeux et pratiques de l'intelligence artificielle dans le secteur bancaire en Côte d'ivoire. *Communication, technologies et développement*, *11*, Article 11. https://doi.org/10.4000/ctd.6669

Ellul, J. (2018). *The technological system*. Wipf and Stock Publishers.

Ertel, W. (2018). *Introduction to artificial intelligence*. Springer.

Evolution of AI in Africa—Article—The Yuan. (n.d.). Retrieved November 18, 2023, from https://www.the-yuan.com/159/Evolution-of-AI-in-Africa.html

Flowers, J. C. (2019). *Strong and Weak AI: Deweyan Considerations*.

Gadzala, A. (2018). *Coming to Life: Artificial Intelligence in Africa*.

Gardiès, C., Fabre, I., & Couzinet, V. (2010). Re-questionner les pratiques informationnelles. *Études de communication, 35*(2), 121–132. Cairn.info. https://doi.org/10.4000/edc.2241

Gonçalves, B. (2023). The Turing Test is a Thought Experiment. *Minds and Machines, 33*(1), 1–31. https://doi.org/10.1007/s11023-022-09616-8

Gray, P. S., Williamson, J. B., Karp, D. A., & Dalphin, J. R. (2007). *The research imagination: An introduction to qualitative and quantitative methods*. Cambridge University Press.

Groundbreaking Report Highlights Artificial Intelligence in Africa—AI for Good. (n.d.). Retrieved December 5, 2023, from https://aiforgood.itu.int/groundbreaking-report-highlights-artificial-intelligence-in-africa/

Hindi, R., Janin, L., Berthet, C., Charrié, J., Cornut, A.-C., & Levin, F. (2017). Anticiper les impacts économiques et sociaux de l'intelligence artificielle. *Mars*.

Intelligence artificielle: Chercheurs et professionnels croisent les regards—Togo Breaking News. (2023, September 26). https://togobreakingnews.info/intelligence-artificielle-chercheurs-et-professionnels-croisent-les-regards/?print=print

Is Africa AI ready? These are the countries that made the world's AI readiness ranking for 2020—Face2Face Africa. (n.d.). Retrieved December 5, 2023, from https://face2faceafrica.com/article/is-africa-ai-ready-these-are-the-countries-that-made-the-worlds-ai-readiness-ranking-for-2020

Jackson, P. (1986). *Introduction to expert systems*. https://www.osti.gov/biblio/5675197

Janiesch, C., Zschech, P., & Heinrich, K. (2021). Machine learning and deep learning. *Electronic Markets*, *31*(3), 685–695. https://doi.org/10.1007/s12525-021-00475-2

Kenneth, G. (2021). *Evolution of AI in Africa*. https://www.the-yuan.com/159/Evolution-of-AI-in-Africa.html

Kiyindou, A., Damome, E., & Akam, N. (2020). Introduction. *Communication, technologies et développement*, *8*, Article 8. https://doi.org/10.4000/ctd.3332

Lambert, E., & Deyganto, K. O. (2023). Innovative Financial Services and Commercial Banks' Profitability in Africa. *Qeios*. https://doi.org/10.32388/GCU9AR

Latzko-Toth, G., Pastinelli, M., & Gallant, N. (2017). Usages des médias sociaux et pratiques informationnelles des jeunes Québécois: Le cas de Facebook pendant la grève étudiante de 2012. *Recherches Sociographiques*, *58*(1), 43–64.

Lionel Janin, Rand Hindi. (2023, September 26). *Anticiper les impacts économiques et sociaux de l'intelligence artificielle | France Stratégie*. https://www.strategie.gouv.fr/publications/anticiper-impacts-economiques-sociaux-de-lintelligence-artificielle

Luan, H., Geczy, P., Lai, H., Gobert, J., Yang, S. J. H., Ogata, H., Baltes, J., Guerra, R., Li, P., & Tsai, C.-C. (2020). Challenges and Future Directions of Big Data and Artificial Intelligence in Education. *Frontiers in Psychology*, *11*, 580820. https://doi.org/10.3389/fpsyg.2020.580820

Lucas, P. J. F. (n.d.). *Principles of Expert Systems*.

Mabe, K., & Potgieter, A. (2021). Collaboration between libraries, archives and museums in South Africa. *South African Journal of Information Management*, *23*(1), 1–8. https://doi.org/10.4102/sajim.v23i1.1269

Matters, D. (2021, February 9). *Developing an Artificial Intelligence for Africa strategy*. Development Matters. https://oecd-development-matters.org/2021/02/09/developing-an-artificial-intelligence-for-africa-strategy/

McCombes, S. (2019). How to write a literature review. *Retrieved*, *24*, 2020.

Mullane, M. A. (2023, March 24). *The multiple applications of AI in transport*. IEC E-Tech. https://etech.iec.ch/issue/2023-02/the-multiple-applications-of-ai-in-transport

Ndour, P. A. (2022, May 12). Benefits and risks of introducing artificial intelligence in commerce: The case of manufacturing companies in West Africa, Zhuo, Z., et al, 2020. *WATHI*. https://www.wathi.org/benefits-and-risks-of-introducing-artificial-intelligence-in-commerce-the-case-of-manufacturing-companies-in-west-africa-zhuo-z-et-al-2020/

Neelam, M. (2022). *Neelam MahaLakshmi (2021) Aspects of Artificial Intelligence In Karthikeyan.J, Su-Hie Ting and Yu-Jin Ng (eds), "Learning Outcomes of Classroom Research" p:250-256, L' Ordine Nuovo Publication, India. 978-93-92995-15-6*.

Nishant, R., Kennedy, M., & Corbett, J. (2020). Artificial intelligence for sustainability: Challenges, opportunities, and a research agenda. *International Journal of Information Management*, *53*, 102104. https://doi.org/10.1016/j.ijinfomgt.2020.102104

Okonkwo, C. W., & Ade-Ibijola, A. (2021). Chatbots applications in education: A systematic review. *Computers and Education: Artificial Intelligence*, *2*, 100033. https://doi.org/10.1016/j.caeai.2021.100033

Olanipekun, V. (2023). *Nurturing Africa's AI ecosystem for global impact | TechCabal*. https://techcabal.com/2023/07/03/nurturing-africas-ai-ecosystem-for-global-impact/

Oriji, O., Shonibare, M., Daraojimba, R., Abitoye, O., & Daraojimba, C. (2023). FINANCIAL TECHNOLOGY EVOLUTION IN AFRICA: A COMPREHENSIVE REVIEW OF LEGAL

FRAMEWORKS AND IMPLICATIONS FOR AI-DRIVEN FINANCIAL SERVICES. *International Journal of Management & Entrepreneurship Research*, *5*, 929–951. https://doi.org/10.51594/ijmer.v5i12.627

Piccinini, G. (2004). The First Computational Theory of Mind and Brain: A Close Look at Mcculloch and Pitts's "Logical Calculus of Ideas Immanent in Nervous Activity." *Synthese*, *141*(2), 175–215. https://doi.org/10.1023/B:SYNT.0000043018.52445.3e

Rajaraman, V. (2014). JohnMcCarthy—Father of artificial intelligence. *Resonance*, *19*(3), 198–207. https://doi.org/10.1007/s12045-014-0027-9

Recommendation of the Council on Artificial Intelligence (OECD) | International Legal Materials | Cambridge Core. (n.d.). Retrieved September 27, 2023, from https://www.cambridge.org/core/journals/international-legal-materials/article/abs/recommendation-of-the-council-on-artificial-intelligence-oecd/EC74B60333EEB276393DB53307519B19

Revolutionizing E-commerce in Africa: How AI Can Drive Online Retail and Customer Satisfaction. (n.d.). Retrieved December 6, 2023, from https://www.linkedin.com/pulse/revolutionizing-e-commerce-africa-how-ai-can-drive-online-ajayi

Rhodes, D. (2019, November 13). Jumia: Challenges and Solutions for E-commerce in Africa. *The Green Light*. https://medium.com/the-green-light/jumia-challenges-and-solutions-for-e-commerce-in-africa-b3c634252818

Sarker, I. H. (2022). AI-Based Modeling: Techniques, Applications and Research Issues Towards Automation, Intelligent and Smart Systems. *SN Computer Science*, *3*(2), 158. https://doi.org/10.1007/s42979-022-01043-x

Simonnot, B. (2009). Culture informationnelle, culture numérique: Au-delà de l'utilitaire. *Les Cahiers Du Numérique*, *5*(3), 25–37.

Smith, B., & Shum, H. (2018). *The Future of Artificial Intelligence, According to Microsoft*. https://www.businessinsider.com/future-of-artificial-intelligence-microsoft-brad-smith-harry-shum-2018-1

Tabassi, E. (2023). *AI Risk Management Framework: AI RMF (1.0)* (error: NIST AI 100-1; p. error: NIST AI 100-1). National Institute of Standards and Technology. https://doi.org/10.6028/NIST.AI.100-1

Takyar, A. (2023, February 14). *Use cases and applications of AI in banking and finance*. LeewayHertz - AI Development Company. https://www.leewayhertz.com/ai-use-cases-in-banking-and-finance/

The African Union Artificial Intelligence Continental Strategy For Africa | AUDA-NEPAD. (n.d.). Retrieved January 27, 2024, from https://www.nepad.org/news/african-union-artificial-intelligence-continental-strategy-africa

The AI In African Innovation Explained. (2023, September 14). https://www.forbesafrica.com/technology/2023/09/14/the-ai-in-african-innovation-explained/

The AI In African Innovation Explained—Forbes Africa. (n.d.). Retrieved December 6, 2023, from https://www.forbesafrica.com/technology/2023/09/14/the-ai-in-african-innovation-explained/

The Digital Bleek and Lloyd. (n.d.). Retrieved January 27, 2024, from http://lloydbleekcollection.cs.uct.ac.za/

The Future of AI in Statistics in Africa: Is the Continent Ready? | ISI. (n.d.). Retrieved January 28, 2024, from https://www.isi-web.org/article/future-ai-statistics-africa-continent-ready

The multiple applications of AI in transport | IEC e-tech. (n.d.). Retrieved December 5, 2023, from https://etech.iec.ch/issue/2023-02/the-multiple-applications-of-ai-in-transport

The rise of artificial intelligence in Africa. (n.d.). Retrieved November 18, 2023, from https://www.howwemadeitinafrica.com/rise-artificial-intelligence-africa/59770/

Trivedi, K. S. (2023). Fundamentals of Artificial Intelligence. In K. S. Trivedi (Ed.), *Microsoft Azure AI Fundamentals Certification Companion: Guide to Prepare for the AI-900 Exam* (pp. 11–31). Apress. https://doi.org/10.1007/978-1-4842-9221-1_2

Vernon, D. (2019). Robotics and artificial intelligence in africa [regional]. *IEEE Robotics & Automation Magazine*, *26*(4), 131–135.

Wairegi, A., Omino, M., & Rutenberg, I. (2021). AI in Africa: Framing AI through an African Lens. *Communication, Technologies et Développement*, *10*, Article 10. https://doi.org/10.4000/ctd.4775

What is Artificial Intelligence? Types, History, and Future [2023 Edition] | Simplilearn. (n.d.). Retrieved September 27, 2023, from https://www.simplilearn.com/tutorials/artificial-intelligence-tutorial/what-is-artificial-intelligence

Whitby, B. (2009). *Artificial intelligence*. The Rosen Publishing Group, Inc.

Winfield, A. F., & Jirotka, M. (2018). Ethical governance is essential to building trust in robotics and artificial intelligence systems. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *376*(2133), 20180085.

Xu, Y., Liu, X., Cao, X., Huang, C., Liu, E., Qian, S., Liu, X., Wu, Y., Dong, F., & Qiu, C.-W. (2021). Artificial intelligence: A powerful paradigm for scientific research. *The Innovation*, *2*(4).

Zhang, C., & Lu, Y. (2021). Study on artificial intelligence: The state of the art and future prospects. *Journal of Industrial Information Integration*, *23*, 100224.