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Methodology Article

A High-Level Structured Methodology for Development of AI Systems in Africa

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Abstract

AI is a potential game changer for Africa to address the specific challenges she faces in sectors like healthcare, climate change and water-related issues. However, the regulation of AI is still largely underdeveloped in Africa with some existing policies and frameworks still being young. Therefore, as the adoption of AI systems spreads across Africa, so does the need for a structured methodology to guide organizations in either developing new AI systems or onboarding existing ones while maintaining the quality and ethicality of these systems. This paper aims to develop a holistic methodology that provides comprehensive guidance to companies considering to develop new AI systems or onboard existing systems. The goal is to support the development and deployment of AI systems tailored to the specific needs of Africa. The proposed methodology employs a lifecycle approach that integrates both Agile and Waterfall frameworks. By combining the adaptive flexibility of Agile with the structured progression of Waterfall, this methodology ensures adaptability and thoroughness throughout the AI system's development and implementation phases. The integration of these methodologies offers a robust, adaptable framework that can be tailored to the unique demands of AI projects in Africa, from design to implementation, deployment as well as maintenance phases, thereby maximizing the potential impact of AI technologies in the region.

Keywords

AI, AI in Africa, Ethical AI, AI Methodology, Sustainable Development, AI Policy

1. Introduction

The transformative power of AI is reshaping the global landscape, permeating every facet of society and industry [2]. Within this wave of change, Africa presents a unique opportunity to unlock unrealized potential. The continent's existing challenges, such as the health sector [1, 9, 10] and climate vulnerabilities [8, 12], serve as fertile ground for AI-powered solutions with the potential to revolutionize fields like water management, climate prediction, and healthcare delivery [10].

Meanwhile, few African countries have policies in place to guide the development and use of AI, while also considering the potential social impacts. While some countries, like Zambia, Tunisia, Mauritius, Egypt, and Botswana, have created national AI programs, and others, like South Africa, Kenya, Ghana and Nigeria, have passed data privacy laws that could be used to regulate AI, these frameworks are still in their early stages, and AI use remains largely unregulated [3].

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Culturally insensitive AI could worsen existing inequalities, while generic technologies might not address limited infrastructure or low digital literacy. Therefore, a high-level structured methodology for development of AI systems is necessary to prioritize local voices, values, and experiences, aligning with Africa's specific goals.

Africa's specific goals, as detailed in the African Union's Agenda 2063, paint a picture of a continent thriving across numerous domains. These goals encompass a high standard of living and well-being for all, alongside advancements in education, healthcare, and economic transformation. Sustainable practices in agriculture and ocean usage contribute to environmental resilience, while unity and strong institutions pave the way for a peaceful and prosperous continent. Democratic values, cultural renaissance, and gender equality further empower individuals and communities. Ultimately, Africa aims to be a major player on the global stage, self-reliant and actively shaping its own future.

Focusing on Africa's specific goals in key sectors like education, healthcare, agriculture, and infrastructure, and adopting ingenious solutions tailored to its unique challenges, such as local innovations, adapting existing technologies, and leveraging AI, has the potential to accelerate development significantly and create over 300 million new jobs [4]. Imagine intelligent systems optimizing water distribution in arid regions, delivering medical diagnoses in local languages, or predicting harvests with hyper-local accuracy [6]. Instead of replicating blueprints designed elsewhere, a laser-focused, Africa-centric approach can empower its people, bridge development gaps, and forge a distinct path towards a future shaped by African ambitions [3].

We recognize the lack of a unified structured methodology for developing AI systems in Africa. This paper proposes a high-level methodology for model-based AI development in digitized and networked African environments.

Our goal is to integrate existing Western methodologies into a seamless, tool-supported approach. We will critique both technical and non-technical aspects, adapting them to African contexts and incorporating new concepts where necessary.

1.1. Problem Statement

Africa's rapidly developing AI industry has great promise, but it also carries a significant risk: neglecting ethical considerations. We are at a crossroads at which technical advancement outweighs ethical, legal, and socio-cultural considerations. This gap opens the door to problematic AI systems that might worsen inequities, raise ethical concerns, and reinforce biases.

Existing AI solutions developed elsewhere fall short in Africa's unique environment. We need a tailor-made methodology that seamlessly pools technological expertise with ethical standards. Consider AI that respects local cultures, adapts to community requirements, and upholds individual rights. Conventional methodologies fail to handle the increasingly complicated ethical, legal, and sociocultural elements of AI in Africa. To navigate beyond the technological challenges that face Africa, a robust, high-level structured methodology is required.

1.2. Justification

The ever-increasing pace of deployment of AI across Africa necessitates immediate attention to its ethical, legal, and socio-cultural repercussions. Failure to address these concerns risks widening existing gaps, infringing on individual liberties, and perpetuating cultural biases. This presents a unique opportunity for interdisciplinary dialogue and research at the intersection of AI, ethics, law, and African socio-cultural realities. These collective efforts can make way for a responsible and inclusive AI ecosystem in Africa.

Ignoring the ethical, legal, and socio-cultural dimensions of AI in Africa jeopardizes its potential for positive impact. Bridging this knowledge gap through a high-level structured methodology is a critical step towards a responsible and inclusive AI ecosystem on the continent. Multidisciplinary discourse, research, and the development of innovative frameworks are vital to ensure that AI truly serves the needs and aspirations of all Africans.

2. State-of-The Art

2.1. Definition of AI

AI is the study of creating intelligent machines or systems, encompassing approaches inspired by human behavior, rational thought, and mimicking human thinking processes [11, 3, 5]. This involves adaptability and diversity in design, implementation, and systems.

As Lee (2006) aptly states in his book "Fuzzy-Neuro Approach to Agent Applications," AI strives to capture and apply human intellectual abilities, actions, and behaviors to design and build intelligent systems, software agents, and robots. This goal propels the creation of software agents, intelligent systems, and robots that engage in ever-more complex interactions with their environment.

However, the field of AI is not without problems. The absence of a recognised definition and classification scheme is one significant obstacle. This ongoing argument, sparked by authors such as Robert Wilensky in his book "Planning and Understanding: A Computing Method for Human Reasoning" [7], revolves around the basic difference between strong (hard) and weak (soft) AI.

Advocates of weak AI priorities developing programmes and systems that closely resemble human cognition and behaviour. This approach focuses on reproducing functionality rather than obtaining true human-like thinking and consciousness. Strong AI supporters, on the other hand, push for the development of systems that not only exhibit human-like intellect but also possess consciousness and self-awareness. The Turing test, which evaluates a machine's capacity to display indistinguishable human-like intellect, exemplifies this desire for strong AI.

2.2. Requirements for the High-Level Structured Methodology for Developing/Introducing AI Systems in Africa

Our proposal presents a complete set of basic requirements for an all-encompassing AI deployment approach that is specifically tailored to the African environment. These requirements are based on an in-depth assessment of contemporary difficulties and successful case studies and include:

1) A procedure for breaking down complex, interconnected systems into manageable, encapsulated phases with clear interfaces is required. This should go beyond existing approaches by allowing for deviations from standard methodologies to better fit specific project needs within the African context.
2) A robust system for capturing, documenting, and verifying project requirements has to be employed throughout the development process. Such a system can significantly facilitate clear communication and collaboration among diverse stakeholders within interdisciplinary teams. Additionally, it is crucial to ensure that requirements are aligned with the specific socio-economic and cultural context of the African project environment.
3) A system for data management infrastructure of learning and test data has to be added to the functional design, detailed design, and testing. This infrastructure will enable data reuse, allowing for the replication of test settings and consistent and reliable testing results.
4) It must be feasible to complement actual data for testing with synthetic data produced via simulation-based techniques in order to develop big datasets reflective of certain African scenarios.
5) A functional safeguarding process must be supplemented by a system that evaluates the behavior of complex functions, particularly AI, regarding safety and detects faulty learning outcomes. This system should ensure the intended functionality of the process and adhere to functional safety standards, while customizing safety evaluations to the specific risks and legal frameworks relevant to the African environment.
6) Safety by design principles, as well as human control throughout the development process, must be prioritized to assure the safety of connected systems. This enables real-time, reproducible testing under real-world conditions, minimizing risks and ensuring reliable performance.

3. Conception of the High-Level Structured Methodology

The core of our holistic methodology is building systems that effectively perform their tasks and support the organization, users, businesses, and other stakeholders, without negatively impacting their cultural values, beliefs, and traditions. These systems should not significantly reduce, displace, or replace jobs, and ultimately, should not pose any threat to humanity. To fulfill the requirements outlined in section 2.2, the following elements are added to the methodology presented in section 4:

1) XAI techniques: These entail using techniques that improve the interpretability and understandability of AI models, enabling stakeholders to gain a better understanding of the system's operation and the rationale behind its decisions. This is especially crucial in the African setting, where issues with accountability and transparency could arise.
2) Fairness and bias detection mechanism integration: This would entail proactively detecting and reducing potential biases in AI systems, such as those based on racial, gender, or ethnic background. This is critical for ensuring that AI systems be utilised properly and ethically in Africa, which has a long history of prejudice and marginalisation.
3) Human-in-the-loop decision-making: This entails creating systems that let people alter or interfere with decisions made by AI, particularly when they are important. This is essential to ensuring that AI systems are utilised responsibly and that humans are eventually held accountable for their activities.
4) Data governance framework: A solid framework for data governance, which should include defining precise policies and processes for gathering, storing, and using data in AI systems, is introduced. This is critical to protecting people's privacy and security, as well as ensuring ethical and responsible data use.

4. High-Level Structured Methodology

The High-level structured methodology is a holistic approach to software development that covers all aspects of the process, from requirements gathering to deployment and maintenance. It is an iterative and systematic process designed to generate software that is dependable and of excellent quality.

The proposed high-level methodology is a hybrid of the Waterfall and Agile software development methods. Waterfall is a sequential method, requiring each stage to be completed before moving on. In contrast, Agile is iterative, gathering requirements and developing and testing software in short cycles. This hybrid approach harnesses the qualities of both methodologies and allows for developers to take advantage of

Waterfall's clarity of scope and Agile's adaptiveness to market demands [13].

Therefore, Figure 1 shows a proposed high-level structured methodology for the development and introduction of AI systems. Developing and deploying effective and ethical AI systems can be a complex challenge. The proposed methodology offers a comprehensive and well-structured approach that guides organizations through every crucial stage, from initial requirements analysis to ongoing maintenance. This structure is crucial to ensure that AI systems are not only effective but also ethically sound [8]. By following this framework, organizations can significantly increase their chances of success in building AI systems that deliver real value.

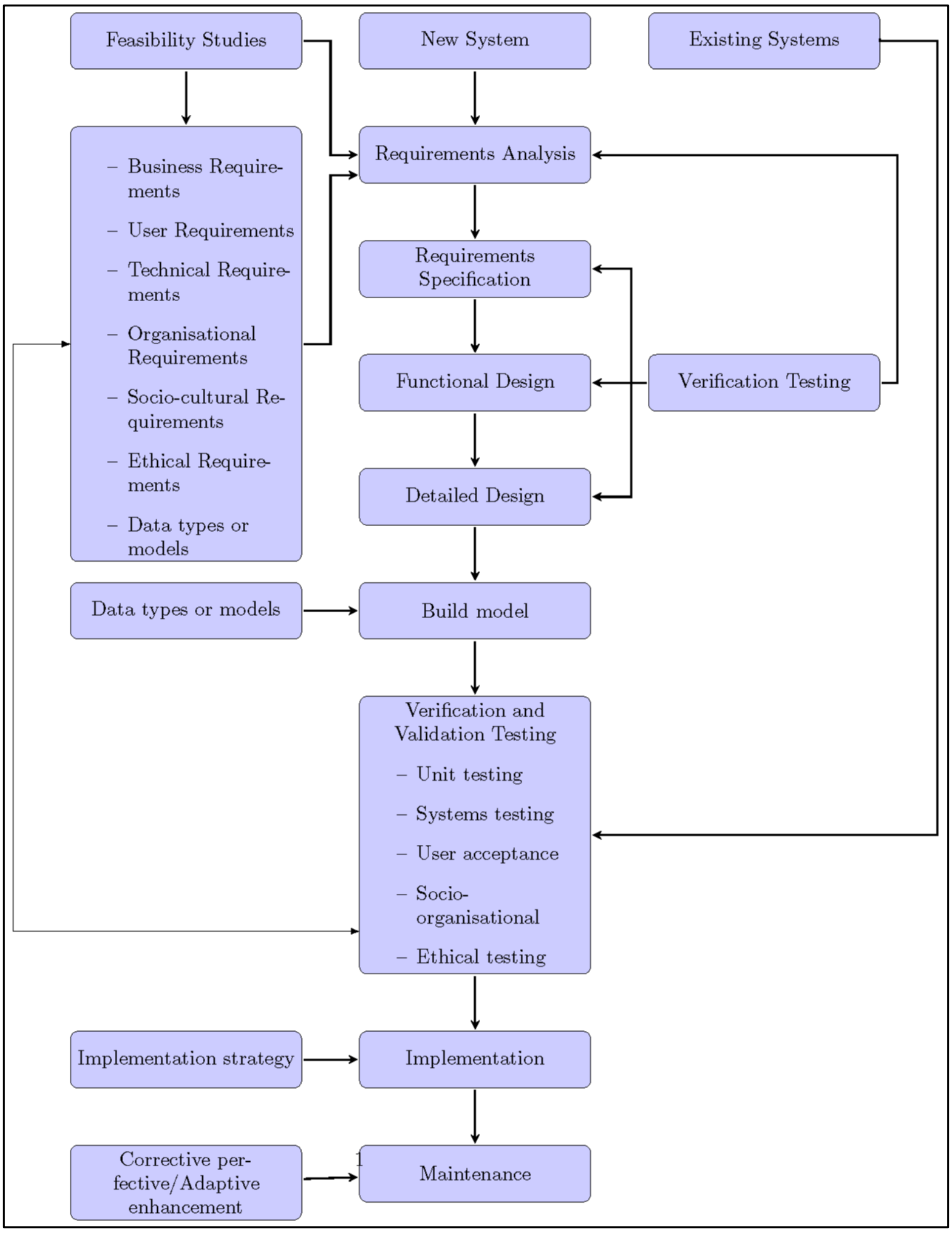

Figure 1. *A High-level Structured Methodology for Development/Introduction of AI Systems.*

4.1. The Planning Phase

The planning phase is the initial stage of AI system development, encompassing critical steps to ensure the project's feasibility and alignment with organizational objectives. This phase comprises feasibility studies, new system development, existing system integration, business requirements analysis, user requirements elicitation, technical requirements definition, organizational requirements assessment, socio-cultural considerations, and data type or model selection.

Feasibility studies assess the project's viability while taking into consideration financial, technical, and resource restrictions. The 'New System' box represents the AI system being developed, while the 'Existing Systems' box highlights the introduction of existing AI systems into an organization, and the possible integration of the same with existing IT infrastructure and operational processes. This decision point determines whether to develop a new AI system from scratch or to adapt an existing system to meet the organization's specific needs.

The requirements analysis involves gathering and analyzing the requirements for the AI system. This entails determining the business and user requirements besides the functional and non-functional requirements. Business requirements define the high-level business-oriented objectives the AI system aims to achieve, while user requirements articulate the specific needs and expectations of the system's users. Technical requirements outline the hardware, software, and data specifications, while organizational requirements address governance structures, risk management, and security considerations. Socio-cultural or non-functional criteria include fairness, bias mitigation, and ethical concerns to make sure the AI system is in line with society values and does not inflict harm that is not intended. Data types or models represent the data types or models that will be used by the AI system. Besides machine learning models like neural networks or decision trees, this may also involve other data types, like text, photos, or videos. Refer to Figure 1 for the arrows illustrating the information flow between these stages.

Algorithmic Representation of the Planning Phase with Integrated AI Considerations

With XAI concerns, fairness, human-in-the-loop decision-making, and data governance in mind, this algorithm illustrates the essential processes in the design phase of AI system development. The specific implementation details and control flow statements may vary depending on the platform or programming language used.

Algorithm: AI System Planning Phase

Start:

Inputs:

1) Project goals and objectives
2) Data sources and types

Outputs:

1) Non-functional requirements (including XAI considerations)
2) Data governance policies and procedures
3) Business, user, technical, and organizational requirements

Steps:

1) Define project goals and objectives: Identify the overall purpose and desired outcomes of the AI system.
2) Establish data governance policies and procedures: Define how data will be collected, stored, used, and shared throughout the system development lifecycle.
3) Choose data sources and types: Select the data sources and types that will be used to train and operate the AI system.
4) Apply bias detection techniques: Analyze the selected data for potential biases using appropriate tools and techniques.
5) Identify business, user, technical, and organizational requirements:
   a. Business requirements: Define the high-level objectives the AI system aims to achieve.
   b. User requirements: Specify the needs and expectations of the system's users.
   c. Technical requirements: Outline the hardware, software, and data specifications needed for the system.
   d. Organizational requirements: Address governance structures, risk management, and security considerations.
6) Incorporate XAI considerations into non-functional requirements: Specify the desired level of explainability, transparency, and interpretability for the AI model.
7) Consider human-in-the-loop decision-making scenarios: Identify potential points in the system where human intervention might be necessary or desirable.

End:

4.2. The Design Phase

The design phase translates the defined requirements into a detailed blueprint for the AI system. This phase encompasses three crucial stages: Requirements Specification, Functional Design, and Verification Testing. The 'Requirements Specification' stage documents the system's architecture, components, and interfaces, forming a comprehensive guide to the AI system's development. Functional Design involves crafting a visual representation of the AI system's functionalities and interactions, providing a clear roadmap for its implementation. Verification Testing takes the nonfunctional requirements of design into account. It serves as a rigorous quality control measure, ensuring that the design aligns with the established requirements and functions as intended. Some of these constraints are to ensure attributes such as fairness, transparency, privacy, security, or safety and are vital for maintaining the relevance and effectiveness of AI systems over time [8, 2]. The arrows in Figure 1 illustrate the flow of information between these levels.

Algorithmic Representation of the Design Phase with Integrated AI Considerations

This algorithm explains the key elements in the AI design phase, considering XAI, fairness, human-in-the-loop decision-making, and data governance to ensure the system's ethical and responsible development.

Algorithm: AI System Design Phase

Inputs:

1) System requirements (functional, non-functional, including XAI considerations)
2) Data governance policies and procedures

Outputs:

Detailed design document (including XAI, fairness, human-in-the-loop, and data governance considerations)

Steps:

1) Review system requirements: Analyze the provided functional, non-functional requirements, and XAI considerations for the AI system.
2) Define the system architecture: Design the overall structure of the AI system, including its components and their interactions.
3) Incorporate XAI techniques:
   a. Identify specific XAI techniques: Select appropriate XAI techniques to achieve the desired level of interpretability and understandability of the AI model based on the defined requirements.
   b. Integrate XAI techniques into design: Design how the chosen XAI techniques will be implemented within the system, including how explanations will be generated and presented to users or integrated into decision-making.
4) Implement fairness checks:
   a. Define a fairness metrics: Based on data governance policies and the identified risks, define specific metrics to be used for evaluating potential bias in the model.
   b. Design fairness checks: Design mechanisms within the system to monitor model predictions for bias using the defined metrics. Integrate procedures for mitigating any identified biases based on fairness considerations.
5) Design for human-in-the-loop decision-making:
   a. Identify scenarios for human intervention: Based on the requirements and potential risks, identify specific scenarios where human involvement in the decision-making process might be necessary or desirable.
   b. Design for human interaction: Design interfaces and functionalities that enable human review of AI decisions and incorporate human input into the decision-making process as needed.
6) Ensure data governance compliance:
   a. Review data governance policies: Analyze the specified data governance policies and procedures relevant to the design phase.
   b. Design for compliance: Integrate mechanisms into the design to ensure the system adheres to data governance requirements, such as data access control, data security measures, and data anonymization techniques.
7) Document the design: Create a comprehensive design document that captures the system architecture, functionalities, XAI integration details, fairness checks, human-in-the-loop considerations, and data governance compliance measures.
8) Prepare for verification testing: Prepare the design document and any relevant information for the verification and testing phase.

End:

4.3. The Implementation Phase

The implementation phase brings the design to life, transforming it into a functional AI system. This phase encompasses four key steps: Detailed Design, Data Types or Models, Build Model, and Verification and Validation Testing. Detailed Design meticulously outlines the algorithms, data structures, and code that will orchestrate the system's operation. Data Types or Models encapsulate the input data and the learning models that the AI system will use. The Build Model process meticulously constructs the AI model, employing the selected algorithms and data. Verification and Validation Testing rigorously assesses the implemented system, ensuring that it adheres to the specified requirements, functions as intended, and delivers accurate results. Refer to Figure 1 for the arrows illustrating the information flow between these stages.

Algorithmic Representation of the Implementation Phase with Integrated AI Considerations

The essential phases in the implementation phase of AI development are outlined in this algorithm, which also considers data governance, fairness, human-in-the-loop decision-making, XAI, and other factors to guarantee the responsible creation and use of the AI system.

Algorithm: AI System Implementation Phase

Inputs:

1) Detailed design document (including XAI, fairness, human-in-the-loop, and data governance considerations)
2) Training data
3) Data governance policies and procedures

Outputs:

1) Trained and tested AI model
2) Documentation of implementation details

Steps:

1) Review the detailed design document: Analyze the detailed design document, paying particular attention to the sections outlining XAI integration, fairness checks, human-in-the-loop functionalities, and data governance compliance measures.
2) Prepare a development environment: Set up the necessary development environment, including tools, libraries, and frameworks required for implementing the chosen algorithms and data structures.
3) Implement system logic:

Develop the core functionalities of the AI system based on the detailed design document.

Integrate XAI techniques: Implement the chosen XAI techniques as specified in the design document, ensuring they generate explanations or insights as intended.

4) Pre-process data: Clean, pre-process, and prepare the training data according to the chosen model requirements.

Optionally, apply bias detection techniques: If not already done in the planning phase, apply bias detection techniques to identify potential biases in the training data and consider appropriate mitigation strategies.

5) Build and train the model: Train the AI model using the prepared data, adhering to data governance policies and procedures regarding data access, security, and privacy.

Implement fairness checks: Incorporate the designed fairness checks into the training process to monitor for bias and implement mitigation strategies if necessary.

6) Implement human-in-the-loop functionalities: Develop and integrate the user interface or other mechanisms for human intervention as designed, including functionalities for human review, input, and decision-making integration.

7) Perform verification and validation testing:
   a. Conduct rigorous testing to ensure the system functions as planned, meets the specified requirements, and delivers accurate results.
   b. Evaluate the effectiveness of the implemented XAI techniques in providing interpretability and understandability.
   c. Test for potential biases using appropriate metrics and assess the effectiveness of the implemented fairness checks.

8) Document implementation details: Document the specific implementation details, including decisions made, challenges encountered, and solutions implemented throughout the process. This documentation should also capture the details of XAI integration, fairness mitigation strategies, and human-in-the-loop functionalities.

End:

4.4. The Deployment Phase

The deployment phase entails the seamless integration of the AI system into the organization's existing IT infrastructure and operational processes. This phase comprises two key steps: Implementation Strategy and implementation. Refer to Figure 1 for the arrows illustrating the information flow between these stages.

Implementation Strategy involves developing a comprehensive plan for deploying the AI system into production. This includes:

1) Identifying the necessary resources
2) Anticipating potential risks and challenges
3) Establishing clear deployment objectives

Implementation involves the practical deployment of the AI system into production. This includes:

1) Preparing the deployment environment
2) Installing the AI system
3) Configuring the AI system to interact seamlessly with other systems and data sources

To ensure a smooth adoption and effective utilization of the AI system, comprehensive training and support are provided to users. This may involve:

1) Providing detailed documentation
2) Conducting hands-on workshops
3) Offering online training modules

Ongoing support is provided to users after the system has been deployed to:

1) Address any issues
2) Resolve bugs
3) Provide additional training as needed

Algorithmic Representation of the Deployment Phase with Integrated AI Considerations

The deployment phase of AI development is outlined in this algorithm, which also includes data governance, human-in-the-loop decision-making, fairness monitoring, and XAI concerns to guarantee the responsible and moral operation of the deployed AI system.

Algorithm: AI System Deployment Phase

Inputs:

1) Trained and tested AI model
2) Deployment environment details
3) User training materials
4) Data governance policies and procedures

Outputs:

1) Deployed AI system
2) User training materials (including XAI explanations)
3) Monitoring plan for fairness and bias
4) Procedures for human-in-the-loop decision-making

Steps:

1) Develop deployment strategy:
   a. Define the resources required for deployment (hardware, software, personnel).
   b. Establish clear objectives for the deployment, including performance metrics and expected outcomes.
   c. Identify and analyze deployment-related risks.
2) Integrate XAI into training materials:
   a. Review user training materials and incorporate explanations or insights generated by the chosen XAI techniques.
   b. Develop specific training modules on interpreting XAI outputs and using them effectively in decision-making.
3) Define fairness monitoring plan:
   a. Identify metrics to track fairness indicators relevant to the deployed system.
   b. Establish procedures for investigating and addressing any identified biases during operation.
4) Define human-in-the-loop procedures:
   a. Specify the scenarios and criteria for human intervention in the decision-making process.
   b. Outline escalation procedures for complex or critical decisions requiring human review and approval.
5) Adapt and implement data governance:
   a. Review data governance policies and procedures, adapting them to the specific requirements of the deployed system.
   b. In the deployment environment, specify and put into

place technological controls for data security and access.

6) Prepare deployment environment:
   a. Configure the target environment (hardware, software, infrastructure) to meet the system's requirements.
   b. Ensure compatibility and secure communication between the AI system and other relevant systems and data sources.
7) Deploy the AI system:
   a. Install the trained AI model and associated components in the prepared environment.
   b. Configure the system parameters to ensure proper interaction with other systems and data sources.
8) Implement fairness monitoring:
   a. Integrate tools or mechanisms to monitor the deployed system for potential biases using the defined metrics.
   b. Establish trigger points for raising alerts or triggering automated corrective actions based on fairness indicators.
9) Train users:
   a. Conduct training sessions for users on the functionality of the AI system, including proper utilization of XAI explanations.
   b. Provide training on the established procedures for human-in-the-loop decision-making and escalation protocols.
10) Enforce data governance:
   a. Continuously monitor adherence to adapted data governance policies and procedures during operation.
   b. Provide users with ongoing training and awareness programs on data governance principles and responsible data practices.

End:

4.5. The Maintenance Phase

The maintenance phase plays a crucial role in keeping AI systems operational, reliable, and aligned with evolving organizational needs. It encompasses a range of activities aimed at addressing potential issues, enhancing performance, and adapting the system to changing requirements. These activities are categorized into four main types: corrective, perfective, adaptive, and enhancement maintenance.

1) Corrective maintenance is finding and resolving problems or flaws that might impair the system's operation. This type of maintenance ensures that the AI system remains stable and meets its intended purpose.
2) Perfective maintenance focuses on improving the system's performance, efficiency, or effectiveness. It may involve optimizing algorithms, refining data analysis techniques, or enhancing user interfaces. Perfective maintenance aims to elevate the overall quality of the AI system.
3) Adaptive maintenance adapts the AI system to meet changing requirements or environmental conditions. This may involve incorporating new data sources, integrating with third-party applications, or adjusting the system's behavior in response to evolving user needs. Adaptive maintenance keeps the AI system relevant and sensitive to the changing environment.
4) Enhancement maintenance introduces new features or capabilities to the AI system. This type of maintenance expands the system's scope and potential, enabling it to address new challenges or provide additional value to users. Enhancement maintenance adds to the system's overall capabilities and versatility.

The maintenance phase necessitates a collaboration among data scientists, software developers, and domain specialists. These individuals work together to identify and address maintenance needs, ensuring that the AI system remains aligned with the organization's goals and objectives. This collaboration fosters a sustainable AI ecosystem that adapts and evolves over time.

Algorithmic Representation of the Maintenance Phase with Integrated AI Considerations

The integration of XAI techniques ensures that AI systems remain interpretable and understandable to human stakeholders to foster trust and ease human-in-the-loop decision-making [5]. This algorithm outlines the main steps involved in the maintenance phase of AI development, considering XAI, fairness, human-in-the-loop decision-making, and data governance to ensure the AI system's responsible and sustainable operation throughout its lifecycle.

Algorithm: AI System Maintenance Phase

Inputs:

1) Deployed AI system
2) User feedback and reported issues
3) Performance monitoring data
4) Evolving requirements and environmental conditions

Outputs:

1) Updated AI system (improved performance, new features, adapted functionalities)
2) Documentation of maintenance activities and decisions

Steps:

1) Monitor system performance:

Continuously monitor the AI system's performance using established metrics and data logging practices.

Leverage user input, crash reports, and system activity records to pinpoint problems and opportunities for enhancement.

2) Identify maintenance needs:

Analyze the collected data to identify needs for corrective, perfective, adaptive, or enhancement maintenance based on:

Corrective: Identified bugs, errors, or performance disruptions.

Perfective: Opportunities to improve efficiency, effectiveness, or user experience.

Adaptive: Evolving requirements, new data sources, or changes in the operational environment.

Enhancement: Opportunities to add new features, functionalities, or capabilities.

3) Integrate AI considerations:

i. Throughout all maintenance activities:

a. Utilize XAI techniques: Leverage explanations generated by XAI to understand the root causes of issues, guide improvements, and assess the potential impact of changes on the system's behavior.

b. Adhere to data governance: Ensure all maintenance activities comply with established data governance policies and procedures regarding data access, security, and privacy.

ii. For corrective and adaptive maintenance:

Re-evaluate for bias: Assess the potential for emerging biases after bug fixes, data source changes, or other significant modifications. Mitigate any identified biases if necessary.

iii. For corrective, perfective, and adaptive maintenance:

Ensure appropriate human oversight: Assess the effectiveness of human-in-the-loop procedures and make adjustments as needed. Maintain appropriate levels of human oversight throughout the maintenance process, especially when addressing complex issues or introducing significant changes.

iv. For enhancement maintenance:

a. Consider XAI for potential impact: Evaluate the potential impact of introducing new features or functionalities on the system's interpretability and explainability using XAI techniques.

b. Evaluate for bias in new functionalities: Assess potential biases in newly introduced functionalities and implement mitigation strategies if necessary.

4) Perform maintenance:

Based on the identified needs and considerations, perform the required maintenance activities. This may involve:

a. Corrective: Fixing bugs, addressing errors, or implementing workarounds.

b. Perfective: Optimizing algorithms, refining data analysis techniques, or enhancing user interfaces.

c. Adaptive: Integrating new data sources, modifying system behavior, or adapting to changing environments.

d. Enhancement: Adding new features, functionalities, or capabilities to the system.

5) Validate and test changes:

Thoroughly test and validate any changes made during maintenance to ensure they function as intended, maintain system stability, and address the identified issues or requirements.

6) Document and deploy updates:

a. Document the maintenance activities undertaken, decisions made, and changes implemented.

b. After testing and validation have been completed satisfactorily, begin releasing the improved AI system into the operational environment.

7) Monitor and iterate:

a. Continue to monitor the system's performance and user feedback after deployment.

b. Use the collected data and insights to inform future maintenance cycles, fostering a continuous improvement process for the AI system.

End:

By implementing comprehensive maintenance practices, organizations can maximize the value of their AI systems, ensuring their long-term effectiveness, reliability, and adaptability.

5. Conclusion

The deployment of AI in Africa presents a double-edged sword: immense promise for addressing pressing challenges and significant ethical, legal, and socio-cultural risks. Navigating this complex landscape necessitates a framework that prioritizes responsible AI development and implementation. To address this need, this paper proposes a high-level structured methodology tailored to the unique context of Africa.

This methodology combines existing practices with Africa's specific socio-economic and cultural realities. It emphasizes phased project management, clear requirements gathering, robust data management, safety evaluations, and human oversight. Additionally, it incorporates XAI techniques, fairness checks, human-in-the-loop decision-making, and data governance principles to ensure responsible AI implementation.

By implementing this methodology, African nations may minimize dangers and optimize the advantages of AI. Furthermore, fostering interdisciplinary dialogue and collaborative research is crucial to refine and implement this framework, ultimately positioning Africa as a leader in responsible AI development.

Abbreviations

AI	Artificial Intelligence
XAI	Explainable Artificial Intelligence

Conflicts of Interest

The authors declare no conflicts of interest.

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