FUTURE AND EMERGING TECHNOLOGIES IN AI&ML

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Review

Implementing AI and ML to Strengthen Energy Sector Competence Verification

Olawe A. Tula[1]; Olusile Babayeju[1]; Edward Aigbedion[2]

[1]*NLNG Bonny Island, Rivers State, Nigeri*

[2]*NLNG CHO Port-Harcourt, Rivers State, Nigeria*

[*]***Corresponding author***

Olawe A. Tula

NLNG Bonny Island, Rivers State, Nigeria

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ABSTRACT

Through a literature analysis, this qualitative research article employing complex adaptive systems (CAS) investigates how AI and ML have revolutionized competence assurance in Africa's energy sector. Topics covered in the article include the evolution of AI and ML methods, their use in education, building confidence and skill, obstacles and restrictions, and new developments in the field. The main results show that AI and ML improve quality control, streamline manufacturing, and speed up competence assurance. Discussion is on cutting-edge innovations like VR/AR and the combination of AI with experimental methods. Faster assurance procedures, efficient production, and a competent knowledge repository are all made possible by AI and ML, and their far-reaching effects on competence assurance are highlighted by the future implications.

Keywords

Competence assurance, Artificial intelligence, Machine learning, Virtual reality, Augmented Reality.

INTRODUCTION

A competent worker has the information, abilities, and dispositions necessary to carry out their work to the expected level of quality. Individuals who exhibit the observable personality traits that contribute to their exceptional performance are referred to be competent (Schneider, 2019; White, 1959). An individual's personality is defined by their set of interrelated qualities, values, beliefs, and experiences (Spencer & Spencer, 1993). It is a challenge for energy businesses worldwide, including their African counterparts, to generate returns on their assets via qualified and competent workers, all the while ensuring operational safety and efficiency at the highest standards (Connor et al., 2014). In order to comply with regulations and get insurance, energy (oil and gas) companies must demonstrate that their employees are competent. One of the ways to mitigate environmental hazards and ensure the safety of others is via competency management, which is about much more than just an individual's personal growth.

According to Connor et al. (2014). Assuring and proving staff competency is of the utmost importance in today's society.

In the aftermath of the Piper Alpha accident, energy producing facilities prioritized the confirmation of employee competency. Specific competencies are required, and site management must confirm their existence, according to the HSE Management System/HSE Case approach that developed into legislation as a result of the Cullen investigation into the Piper Alpha catastrophe (Clarke & Sykes, 1996). The African energy industry is only one of several that relies heavily on production processes and competency assurance. For an industry to run smoothly and safely, competence is the first and most important control (Clarke & Sykes, 1996). Clarke and Sykes (1996) and Parasuraman et al. (2000) found that when mechanical interventions are made to a system, the competency of humans is depended upon to make the final judgments and perform the ultimate actions. Automation and artificial intelligence (AI) might make complicated procedures safer (Veitch & Alsos, 2022). The creation of groundbreaking goods, technology, and solutions is essential to propel modernization and influence our world (Ninduwezuor-Ehiobu et al., 2023). Optimal production technique identification has traditionally been a laborious and complicated process, slowed down by the limits of more conventional methods.

Machine learning (ML) has only recently been used to ensure staff competency in the African energy portfolio. Machine learning (ML) is a subfield of artificial intelligence (AI) that refers to a computer or robot that is programmed to mimic the behavior of a human brain (Ughulu, 2022). New developments in artificial intelligence algorithms, cloud computing, and data availability have, however, accelerated the use of these technologies in the last several years (Akter et al., 2021; Angel et al., 2021; S. Dutta, 2018). Nkalane (2015) notes that traditional approaches including in-person training, certificates, and manual evaluations were the mainstays of personnel competence assurance in the African energy portfolio until the advent of

machine learning and AI. Although these approaches had their uses, they often failed to meet expectations for accuracy, efficiency, and scalability. African energy businesses are jumping on the bandwagon to use AI and ML to beef up their competence assurance procedures since these technologies become widely available.

Many new possibilities and trends have emerged as a result of machine learning and artificial intelligence's incorporation into business intelligence. According to Angra and Ahuja (2017) and Bharadiya (2023), AI algorithms are able to analyze massive amounts of data and find trends and patterns that are often associated with productive employee performance. As a result, businesses may improve their training programs and provide workers with more tailored education, leading to higher levels of competency and productivity (Bhutoria, 2022; Chen, 2023). In addition, by analyzing past data and performance indicators, AI-powered predictive analytics may provide light on where staff could make improvements (Schweyer, 2018). Additionally, ML approaches are being used to automate the examination and assessment of staff expertise. As a result, businesses may better deploy staff, maximize training resources, and proactively fill skill shortages.

In order to lessen the impact of human bias and manual review, Checco et al. (2021) proposed using artificial intelligence techniques such as natural language processing algorithms to evaluate written reports and provide immediate response. There are also training simulations that use AR and VR that are built using AI and ML technologies (Gandedkar et al., 2021). By simulating real-world situations, these tools provide workers the chance to hone their abilities. in order to get practical experience in a risk-free setting. It is the responsibility of the African energy generating businesses to guarantee, at a least, that all controls and barriers are functioning as intended to maintain activities within the specified parameters. Similar to how this guarantee applies to alarms and other forms of automated control systems, it also applies to the competency of the workforce.

There is a lot of room for improvement and expansion in the African energy portfolio's use of AI and ML for competency assurance among employees, however this practice is still in its infancy. Improved performance, decreased hazards, and higher operational efficiency in Africa's energy industry might result from a revolution in training and competence assurance processes brought about by the integration of these technologies. These state-of-the-art tools have completely altered the way companies sift through data, draw conclusions, and make choices. Predictive analytics is becoming more popular. With the help of ML algorithms, companies can accurately forecast future events by sorting through mountains of previous data in search of trends and patterns. This enables businesses to enhance operations, foresee client demands, and reduce hazards.

This paper's overarching goal is to examine how the African energy industry has made use of AI and ML to overcome the shortcomings of more conventional approaches to competence assurance. To better understand the revolutionary effects of AI and ML on the energy sector, this study will analyze case studies, provide real-world examples, and review the relevant literature in depth. This study will also examine these technologies through the lens of human competency development assurance employing complex adaptive systems, critiquing their benefits, drawbacks, and possible ethical implications.

Literature Review

Books, articles, conferences, and research papers abound on the topic of employee competence and assurance. Having said that, every single contributor has worked on projects tailored to the needs of a certain sector or company. Material, equipment, space, information, and human resources are all necessary for an organization to produce goods or provide services. According to Midhat Ali et al. (2021), the grade and quality of these resources determine which company succeeds. Companies that generate energy have the unenviable task of ensuring its safety all year round, without endangering people, assets, or the environment, all while making a profit. All aspects of facility safety, including asset integrity window, risk management, process safety, people safety, and operational integrity window, are greatly impacted by the competency of staff. Consequently, competences are defined as a set of standards for doing one's job to an adequate degree (Ufer & Neumann, 2018; Midhat Ali et al., 2021). When taken together, these factors indicate a person's level of competence, which is defined as the ability to successfully complete a task (McClelland, 1973). Legislation mandates, for audit and insurance reasons, that businesses in the energy industry prove their workers have the skills to do the jobs.

Energy generating businesses, such as those dealing with oil and gas, rely heavily on competence assurance. To guarantee that people working in the energy sector have the education, experience, and training to do their tasks well and securely, competence assurance procedures are essential. In order to understand the difficulties of ensuring competence within the technical and operational contexts, one must be familiar with its basics.

problems with the manufacturing plant's integrity and the need for new ideas to address these issues (Sparrow, 2008). To accomplish the goals of energy generating plants—ensuring safety, maintaining capacity, and making the asset reliable—AI and ML technologies are instruments toward actualizing the competence assurance process.

Employee Competence

Because not everyone with the same level of credentials across disciplines may apply, employee competency is evaluated using the criteria given in the advertisement from the time of employment onwards. According to Mustapha et al. (2013), organizations start the recruitment and selection process by outlining their goals in terms of the knowledge, skills, talents, and other qualities they require. The recruiters, who are called assessors, have verified that the employee has the necessary skills and has fulfilled the job criteria, which include the minimum education level, any necessary work experience, and

any other qualities or skills shown throughout the recruiting process. When hiring new graduates and veterans, companies in the energy sector prioritize candidates with certain personality traits and other personal attributes (Velasco, 2012). Knowledge, experience, technical and soft skills, motivations, emotions, and behaviors are only a few of the many factors that contribute to an employee's competency (Midhat Ali et al., 2021). When an individual demonstrates competence, it's because they have the requisite knowledge, attitude, and skill set to carry out the duties of their position as outlined in the organization's competency framework.

task competency frameworks (JCFs) specify the components of employee competence to execute a task and provide a benchmark for the competency levels of all positions in an organization or within a department. According to Bartram (2011), JCF is the singular underlying construct framework that offers a logical, consistent, and practical foundation for understanding how people behave at work and their chances of success in specific jobs and environments within an organization. According to Bolden et al. (2003) and Campion et al. (2011), JCF are created by the energy sector to specify the necessary knowledge, abilities, and behaviors for each position inside the company. The job competence profile (JCP) is a subset of the JCF that specifies the skills and knowledge an employee needs to do their job well. Levels of competence ranging from awareness to knowledge to skill to mastery are associated with each defined capability.

The Human Resource process mandates that all employees complete a Personal or Individual Development Plan (PDP or IDP) once a year. This culminates in a Development Needs Analysis (DNA), which identifies areas of improvement for both the employee's present and future roles. In order to determine the degree of competence, the development requirements analysis method begins with a self-evaluation and is then followed by a line assessment (Wijaya & Juwono, 2021). As a responsible company, we close identified deficiencies with full seriousness and record the process for audit purposes. The accountability and assurance process is shown by the competence's auditability and the competence's attainment.

Competence Assurance.

There are usually a number of essential parts to competence assurance procedures. The provision of both one-time and continuing training to staff members is a common component of competency assurance programs. According to Singh (2023), training programs may include many learning methods such as classroom sessions, on-the-job training, online modules, and practical exercises. Making ensuring workers have access to

equipped with the requisite technical and safety-related expertise to carry out their duties. Testing and Evaluation: It is essential to test and evaluate employees' abilities on a regular basis. There are a variety of methods that may be used for this, including written examinations, practical exams, simulations, and work performance observations (Kak et al., 2001). Employees' comprehension, competence, and capacity to apply what they've learned in the classroom to actual work settings are the end goals of assessment strategies. Monitoring Performance: Ensuring competency requires constant monitoring of staff performance. Methods for doing so include keeping tabs on KPIs, comparing results to standards set in advance, and reviewing and evaluating employees on a frequent basis. Documentation of Competence: The energy sector keeps meticulous records of employee competency, such as records of certification, records of training completion, and assessments of performance. Clients or regulatory agencies may demand these documents as proof of an employee's competence. Planned measures for improvement and remediation are implemented in the event that any weaknesses or gaps in competence are detected. Until the necessary competency is reached, this may need more training, mentorship, or work redistribution. Compliance with Regulations: Many rules and regulations pertaining to the skill level of workers are imposed on the energy sector. Competence assurance methods should conform to these legislative requirements in order to ensure conformity and lessen the dangers connected with inadequate employee competency (Marchetti, 2011). Iterative and continually improving competence assurance methods are essential. In order to find ways to improve and incorporate industry best practices, it is helpful to get feedback from stakeholders, workers, and supervisors. All things considered, the energy sector's competence assurance procedures center on making sure workers have the knowledge, abilities, and experience to do their jobs well and safely (Durbin & Melber, 2004). To guarantee that workers are competent enough to fulfill operational demands and industry standards, training, evaluation, performance monitoring, and regulatory compliance are crucial.

History of AI and Machine learning.

The foundations of AI can be traced back to the 20th century when pioneers as Alan Turing and John McCarthy laid the footing for the topic (Delipetrev et al., 2020; Penn, 2021; WhatsApp, 1974). Turing's paper "Computing Machinery and Intelligence", ideas about computing machines and the potential for them to simulate human thinking which later became AI (Zhao et al., 2023). The term "artificial intelligence" was coined by in 1955 during the Dartmouth Workshop, which marked the official birth of AI as a research discipline (Delipetrev et al., 2020). The advent of machine learning (ML) was facilitated by academics' investigation into how computers might learn from data as computational capabilities increased. (Moubayed et al., 2018; Zhou et al., 2017). To categorize patterns, early machine learning algorithms—like Frank Rosenblatt's perceptron—tried to emulate human neural networks (Thakur & Konde, 2021). Conceptually, ML algorithms can be viewed as searching through a large space of candidate programs, guided by training experience, to find a program that optimizes the performance metric (Jordan & Mitchell, 2015). ML sits at the crossroads of computer science, statistics and a variety of other disciplines concerned with automatic improvement over time, and inference and decision-making under uncertainty. AI and ML have had significant milestones in historical evolution that have reshaped various industries. These technologies have advanced their capabilities and applicability, from early symbolic reasoning to the resurgence of neural networks and the advent of deep learning (Ninduwezuor-Ehiobu et al., 2023). In competence assurance, AI

and ML have emerged as powerful tools to accelerate human assessment, prediction, and optimize production performance.

Artificial Intelligence AI And Machine learning ML in Competence Assurance Processes

The incorporation of AI and ML in competence assurance processes represents a pivotal advancement in contemporary workforce development. By harnessing the capabilities of AI and ML, organizations can implement more nuanced and personalized competence assessments. Johnson et al. (2020) supported this transformative approach by their studies, which highlight the enhanced objectivity and accuracy achieved through algorithmic evaluation. Furthermore, the adaptive nature of AI and ML technologies, ensures that competence assurance processes evolve in tandem with evolving job requirements, contributing to a more dynamic and responsive workforce (Brown & Williams, 2021). In summary, the synergy between AI, ML, and competence assurance not only refines assessment methodologies but also aligns workforce competencies with the demands of a rapidly changing professional landscape.

Virtual reality and Augmented reality

The history of virtual reality (VR) and augmented reality (AR) can be traced back several decades, with significant developments in recent years. Both technologies have gained widespread popularity and are being increasingly integrated into various industries due to their numerous benefits. The concept of VR emerged in the 1960s, but it wasn't until the 1990s that significant advancements in hardware and software made VR more accessible (Chesher, 1994). The release of consumer VR headsets, such as the Oculus Rift, HTC Vive, and PlayStation VR, in the 2010s propelled VR into the mainstream (Slater & Sanchez-Vives, 2016). These headsets provided immersive experiences by blocking out the real world and placing users in a digitally generated environment. On the other hand, AR has its roots in the 1960s as well, but it gained more attention in the 1990s with the invention of the Head-Mounted Display (HMD) by Tom Caudell (Tanaka Montoya, 2019). However, it was the launch of AR applications such as Pokémon Go in 2016 that brought AR to the forefront of popular culture.

The benefits of VR and AR technologies are diverse and have the potential to revolutionize various fields. Some of the significant benefits are as follows. Enhanced Training and Education: VR and AR offer immersive learning experiences, allowing users to practice real-world scenarios in a safe and controlled environment (Enyedy & Yoon, 2021). This is particularly beneficial in industries like healthcare, engineering, and aviation, where hands-on training is crucial. Improved Visualization: Both VR and AR enable users to visualize complex data, designs, and models in a more comprehensive and interactive manner. This can aid in better decision-making, design iterations, and understanding of complex concepts. Increased Efficiency and Productivity: Overlaying digital information onto the physical world, AR can provide real-time guidance and instructions to users (Poupyrev et al., 2002). This can help streamline workflows, reduce errors, and increase efficiency in areas like manufacturing, logistics, and maintenance. Visualization of Architecture and Design: VR and AR have transformed the way architecture and design are presented and experienced. Clients and stakeholders can now visualize and interact with 3D models, making the design process more immersive, collaborative, and accurate. Remote Collaboration: VR and AR technologies enable remote teams to collaborate and communicate effectively by creating shared virtual spaces (Yu et al., 2022). This can be particularly beneficial for global teams, reducing the need for travel and enabling real-time collaboration. As VR and AR technologies continue to evolve, their benefits are expected to expand further. Industries such as healthcare, education, manufacturing, energy, tourism, and retail are increasingly adopting these technologies to improve their processes, enhance experiences, and unlock new opportunities.

Virtual Realities and Competence Assurance.

As a result of digital transformation, the physical and digital worlds of work are increasingly merging. The same logic applies to services as it does to goods. The potential educational benefits of virtual reality (VR) are many. The possibility exists for it to improve procedures and promote openness across many departments and organizations. Avoiding unsafe working situations requires open communication (Weigel et al., 2022). Part of the hybrid value chain is finding the weak points in the knowledge and skill transfer between service workers and computer-aided designers. An empirical approach to better competency transfer using virtual reality was suggested by Weigel et al. (2022), who were motivated by design science. To find out how virtual and augmented reality may improve training, Kaplan et al. (2021) looked into it. Training in VR/AR often yields results on par with training in a more traditional setting, according to the results. In conclusion, service workers are better protected from harm on the job because to virtual reality (VR) improvements to the work process that enable early investigation of safety-related design problems.

Research Strategy

Literature reviews, conceptual analysis, and expert opinion went into creating this framework. Using the paradigm of complex adaptive systems, the research synthesises data from several domains. Systems as diverse as the nervous system, ecosystems, galaxies, and social networks have all benefited from the insights provided by complex adaptive systems (CAS) theory (Wang et al., 2015). "Exchange matter, energy, or information across its boundaries and use that exchange of energy to maintain its structure" (Cleveland, 1994) is the definition given to complex adaptive systems, which are open, living systems. When it comes to improving competence assurance in Africa's energy industries via the use of AI and ML, complex adaptive systems are the way to go.

Benefits of Technology

Some see AI as a harbinger of the Fourth Industrial Revolution and a hope for humanity's survival. Organizational strategy ecosystems and talent management execution procedures both benefit from AI's increased capabilities. A growing number of HRM tasks are using AI, with learning and development being one such area (D. Dutta & Kannan Poyil, 2023). There is a vast array of intellectual, social, and industrial uses for AI that can either supplement or completely replace human workers. Companies are using AI and other AI-driven technology into their HRM strategies to manage employees in

both local and global organizations. The usage of artificial intelligence (AI) in human resource management has skyrocketed in the last decade. Because of this, there has been a proliferation of studies examining topics including how AI and robots will affect society, how businesses and individuals will benefit from AI adoption, and how HRM practices that use AI will fare (Budhwar et al., 2022).

Artificial intelligence (AI) is bringing about rapid innovation in many sectors, including human resource management (HRM), talent management (TM), finance, healthcare, retail, supply chain, logistics, and utilities (Dwivedi et al., 2021). Leading professional commentators have pointed out that the fast rise of AI in fields like as business and management, government, the public sector, and science and technology brings with it a plethora of possibilities, realistic evaluations of effect, problems, and possible research objectives. The research of Dwivedi et al. (2021) offers fresh and important information on artificial intelligence (AI), its social and economic impacts, and the ways in which both sectors shape AI research and development.

Difficulties and restrictions

There are several restrictions and difficulties specific to the African energy sector when attempting to include AI and ML into competence assurance procedures. Adebayo et al. (2018) and Okonkwo et al. (2020) found that infrastructure restrictions in Africa make it harder for AI and ML technologies to be seamlessly adopted. A major obstacle to training reliable models for competency evaluation in the African energy industry, as highlighted by Ogunleye and Ahmed (2019), is the lack of locally appropriate datasets. According to the study (Adewole & Afolabi, 2021), algorithmic standardization is already complicated due to cultural subtleties and variety in work methods. In order to create contextually appropriate strategies that successfully use AI and ML and meet the special issues of the African energy business, it is necessary to acknowledge these problems.

UPCOMING OPPORTUNITIES AND MODERN FASHION

For long-term growth in Africa's energy sector, it is critical to foresee how AI and ML may change competence assurance procedures. The combination of AI and ML has the potential to completely transform competency evaluation. This is because it will allow for better predictive analytics for workforce planning and will also make it easier to respond to changing industry demands (Osei-Bryson et al., 2020; Kamau et al., 2021). More people will be able to use AI since edge computing solutions are becoming more common, which will help with infrastructure issues (Adewumi et al., 2019). In order to address data scarcity, it is anticipated that the creation of locally relevant datasets via collaboration would play a crucial role (Abiodun et al., 2022). Looking forward, it seems that the African energy sector will be able to build strong competence assurance frameworks that are tailored to their unique situation by taking use of these innovations. has to be assessed via testing in order to gauge individuals' competence, as well as their job skills and the unique collective competencies that teams need to reduce operational risks.

Possible Moral Consequences of Technology

A small elite group of engineers, scientists, programmers, and architects has historically controlled AI development, and this exclusive group has failed to represent the rich diversity of human society in terms of race, gender, age, geography, and socioeconomic status. There is a risk that people may become too dependent on more autonomous technology. The initial goal of artificial intelligence was to help humans, but when bias is deliberately programmed into it, people stop being autonomous and start acting more like robots (Ashok et al., 2022). Computer programs and algorithms that analyze faces may be biased against certain racial, ethnic, gender, etc. groups (Khan et al., 2019). In 2018, the World Economic Forum (WEF) brought attention to the fact that people's work experiences would be affected by the increasing use of artificial intelligence (AI) technology by organizations. Among these factors is how individuals evaluate the significance of their job (Bankins & Formosa, 2023). According to Bankins and Formosa (2023), when people believe that their job has worth, relevance, or a broader purpose, they are more likely to engage in meaningful work. This kind of work often requires strategically using various and complicated talents to contribute to the well-being of others. There are many obstacles to the widespread use of AI, such as prejudice, discrimination, inequality, and the marginalization of some groups of people; sensitive ethical concerns, such as privacy; and bias in the gathering and processing of data. Careful handling of this data, respect for people' privacy rights, and protection against data breaches provide an ethical problem (Ninduwezuor-Ehiobu et al., 2023). In order to keep sensitive information private, including proprietary data, researchers and organizations should have strong data privacy safeguards in place (Goroff et al., 2018). This necessitates adhering to data protection standards, implementing access restrictions, storing data securely, and using encryption.

Conclusion

The purpose of this research study is to investigate how ML and AI may improve competence assurance in Africa's energy sector. It covers topics such as the development and use of AI and ML approaches throughout history, how they might be used to learning, the difficulties and limits of this field, new technology that is coming out, and ethical implications. The core results show how ML and AI may improve quality control, streamline manufacturing, and speed up competence assurance. Things to think about from an ethical standpoint include things like data privacy, IP protection, employment loss, bias reduction, openness, and the possibility of human-AI cooperation. Algorithms powered by AI can spot trends and patterns linked to high-performing employees, paving the way for more personalized training programs. By automating review and assessment using machine learning approaches, human bias is reduced. Training simulations using virtual reality (VR) and augmented reality (AR) are also helping to build a sustainable future by simulating real-life situations so that workers may hone their abilities in a risk-free setting.

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