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Emerging Technologies Shaping the Fourth Industrial Revolution: The Roles of Internet of Things (IoT), 5G, Virtual Reality, Robotics and Automation and Self-Driving Cars

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ABSTRACT

Internet of Things (IoT), 5G, Virtual Reality, Robotics and Automation, and Self-Driving Cars are among the components of emerging technologies. They have great influence on sectors such as transportation, tourism, agriculture, health, and entertainment, to name a few. This paper discusses how these technologies are endorsed by society, using existing theories such as Diffusion of Innovation (DOI), Technology Acceptance Model (TAM), Unified Theory of Acceptance and Use of Technology (UTAUT). In addition, it explains why some of the emerging technologies are not fully embraced in Africa. One notable factor inhibiting their adoption is the lack of infrastructure. However, these emerging technologies have been totally embraced in advanced countries. For Africa, progress has been recorded in areas such as smart agriculture, virtual learning, and mobile money. This paper puts forward recommendations to reinforce the adoption of these technologies such as infrastructure development, public-private partnership, capacity building, and the promotion of local innovation.

Keywords: Emerging Technologies, Fourth Industrial Revolution, IoT, 5G, Virtual Reality, Robotics, Automation, Self-Driving Cars

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1. INTRODUCTION

Global economic transformation has been accelerated as a result of the revolution in Information Technology. The integration of technologies such as IoT (Internet of Things),

5G, Virtual Reality, Robotics, and Automation has transformed our society. For example, because of 5G technology, individuals have been brought closer like never before – friends far away in the Americas can now communicate with their loved ones in Africa (Ibrahim Ahmad et al., 2024).

These technologies have also brought about a revolution in the healthcare sector. For example, Artificial Intelligence solutions are now used in medical diagnosis (Nasir, Siddiqui, & Ahmed, 2025) and the diagnosis of COVID-19 and other ailments (Wang et al., 2021; Nasir, Siddiqui, & Ahmed, 2025). The combination of AI and 5G has also brought about Virtual Reality (VR), which business owners, such as telecom operators in Nigeria, have leveraged for meetings, tourism, and education (Hassan et al., 2024). These technologies are the backbone of the smart transformation that Africa should adopt (Olaitan et al., 2021). This paper looks at the evolution and adoption of these technologies in Africa and globally. It also addresses the gaps and puts forward recommendations.

2. LITERATURE

Internet of Things (IoT) refers to devices that are connected to the internet and are capable of collecting and exchanging data. Examples of IoT systems are smart fridges that can detect when they are low on fruits (Nasir et al., 2018). It has the capacity to make orders online. We also have cars that are IoT-enabled. These cars have the ability to exchange information with other IoT devices to make decisions, such as choosing the optimal path to a destination.

5G technology has enhanced the connection of IoT devices. For example, a smart fridge is programmed to recognize when it is running low on fruits and therefore makes an order (Nasir et al., 2018). This is possible because of the power 5G technology brings (Mockel and Makala, 2019). The 5G technology enables systems to connect seamlessly as if they were in the same space; in the real sense, they might be millions of miles apart. The 5G technology makes the world a global village. This technology has been leveraged in different sectors. For example, in healthcare, it is now possible to carry out robot-assisted surgery (Urrea & Kern, 2025; Trstenjak et. al, 2022). In education, 5G plays a crucial role – this is evident in the growing number of online schools in Africa. Without 5G technology, such an advancement would have been difficult to attain. 5G technology has also been leveraged by social media platforms. Users can connect to friends and families on WhatsApp and Instagram, for example (Mockel and Makala, 2019; Hassan et al., 2024).

Virtual Reality (VR) provides an immersive experience, giving the feeling that one is actually in an environment physically, which is actually not true. The 5G technology has made this possible (Hazarika & Rahmati, 2023). VR has been explored in education (virtual classroom), in offices – virtual meetings, and also in health and entertainment (Hassan et al., 2024). In entertainment, VR provides the advantage of visiting or exploring spaces without actually having a valid passport to travel, for example, visiting Dubai and exploring its attractive areas.

Robotics and Automation have revolutionized manufacturing, as seen in car manufacturing factories. Also, they have played an important role in the logistics and service industries. Robots are used in hotels in advanced countries, serving guests and taking orders. In the logistics sector, drone robots are employed to deliver goods to customers (Urrea & Kern, 2025). Self-driving cars are now popular in the Western world.

They embody machine learning and Artificial Intelligence (AI). Many trucks and cars now run on AI, as observed in China and the USA, automating logistics, as seen in a self-driving truck (Urrea & Kern, 2025).

3. EVOLUTION, DIFFUSION, ACCEPTANCE, AND UPTAKE OF THESE TECHNOLOGIES IN AFRICA AND BEYOND

As observed by Schwab (2017), these technologies are drivers of the Fourth Industrial Revolution. However, the diffusion of these technologies in Africa has been relatively slow. One can attribute this pace to the lack of infrastructure. Infrastructure such as 5G, data centres, and a lack of policy to support the industry (Olaitan et al., 2021). However, some African countries are slowly adopting some of these technologies. For example, IoT devices are now used in Kenya to drive smart agriculture (Rizan et al., 2024). VR is gradually emerging in Nigeria and in South Africa for learning, with positive results (Grewe & Gie, 2023). Also, South Africa is leading in terms of 5G (GSMA, 2022). No African country has successfully deployed driverless cars on public roads, largely due to infrastructure and regulatory constraints (Nwokoye et al., 2022).

4. THEORETICAL FRAMEWORKS APPLICABLE TO EVOLUTION, DIFFUSION, ACCEPTANCE, AND UPTAKE

To understand the evolution of emerging technologies and how they spread and their adoption, one needs to discuss these frameworks: Diffusion of Innovation (DOI) (Rogers, 2003), Technology Acceptance Model (TAM) (Davis, 1989), and Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003).

4.1 Diffusion of Innovation (DOI) Theory (Rogers, 2003)

The theory proposed by Rogers (2003) explains how new technologies or ideas are propagated in a given society via five stages. These stages are - knowledge, persuasion, decision, implementation, and confirmation. Now, how does this theory relate to Emerging Technologies?

5G technology – At first, individuals become aware of the technology and its strengths, and then they are persuaded to switch from 4G to 5G in order to leverage its benefits. This leads to making the decision to migrate to 5G. With positive outcomes, many more individuals are convinced to migrate (Rogers, 2003). In the context of IoT, the diffusion theory is established as users become aware of the technology (knowing what it means) and then move to its adoption. An example is migrating to IoT devices in agriculture, when farmers learn the advantages it brings.

The above explanation can be replicated in VR. In Africa, VR has been understood to be a valuable product. It has been adopted in a number of schools because of the results elicited from those that have implemented it. VR has been proven to enhance student learning and, in turn, improve their scores (Grewe & Gie, 2023). Because of this revelation, more schools will want to adopt it to support student learning. This rise in the adoption of VR in the education space serves as evidence of the diffusion theory (Rogers, 2003). In automation, for example, many industries wanted to scale; a lack of manpower was a challenge, and the way forward was to automate business processes (Urrea & Kern, 2025). This is evident in many manufacturing companies, including the automobile and aircraft industries.

These companies needed to meet deadlines and ensure that the highest quality was maintained. This demand led these companies to adopt robotics and automation. The switch to automation has improved business processes while also providing a massive return on investment (Urrea & Kern, 2025). This is also applicable to self-driving cars. In the African context, DOI is constrained by a lack of infrastructure. For example, the poor and high cost of internet access, as well as limited awareness (Olaitan et al., 2021). It is evident that if there is an understanding, the locals will adopt it to solve their problems. Clearly, the diffusion theory is seen to work in other aspects of technological innovation, in Africa, for example, in mobile money (Asongu et al., 2020).

4.2 Technology Acceptance Model (TAM) (Davis, 1989)

This theory is hinged on Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). We discuss how this theory is relevant to Emerging Technologies.

The adoption of IoT is hinged on PU and PEOU (Davis, 1989). For example, in agriculture, IoT devices have been used for the detection of the moisture content of soil for irrigation, and for measuring the quality of coffee, as seen in Kenya and other parts of Africa (Rizan et al., 2024). This development has opened doors to customers not only in Africa but also in the USA. For example, the quality of these products is logged and displayed on dedicated platforms, allowing customers to assess the products they wish to purchase (Li, Tian, Dai, & Miao, 2024). VR in education adoption was triggered by the positive feedback from learners. This then points to its usefulness (Grewe & Gie, 2023). In addition, the ease of use also strengthened its adoption. 5G technology was perceived to strengthen communication between offices, which led to its adoption (Mockel, and Makala, 2019).

In the case of robotics and automation, it was perceived that automation could improve or scale up the business process; therefore, it was adopted. The same applies to self-driving cars; in this case, it was perceived that it could ease the stress of driving long distances (Khattak & Lin, 2023). TAM theory has explained that when technologies are available, it might be difficult for people to adopt them because of low digital literacy. Enhancing awareness and training would help Africans adopt these emerging technologies (Olaitan et al., 2021).

4.3 Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003)

This theory builds on the previous theories and then identifies four core determinants:

1. The belief that the adopted technology greatly improves outcomes.
2. The ease of use exists.
3. The social influence – meaning if one person adopts a technology, there is the possibility of having an influence on the others.
4. Availability of infrastructure.

We now discuss how these four determinants are relevant to Emerging Technologies:

IoT adoption increases when people see that it enhances performance. It is known that the adoption of IoT can boost production, especially in the agricultural space (Rizan et al. ,2024). This is also the same for 5G. Companies with branches across the world can have real-time meetings, which enhances productivity (Mockel and Makala, 2019). Also, in the healthcare sector, the adoption of remote diagnosis has improved access to medical care and improved revenue to healthcare practitioners, thanks to the 5G network (Ige et. al, 2025).

The same applies to VR and automation, cutting costs on physical meetings and subscribing to VR meetings, while automation saves costs by automating repetitive business processes. Within the African context, the UTAUT theory (Venkatesh et al., 2003) helps researchers to understand why some African countries find it difficult to adopt these emerging technologies. This is because of the continent's challenges such as lack of power, internet, and insecurity. In addition, some of this infrastructure is expensive to subscribe to in the developing world (Oyenuga & Omale, 2024). These problems can be tackled by providing power and internet access that are affordable and reliable. Also, publicly demonstrating these emerging technologies and strengthening partnerships between the government and private companies will help boost support and adoption of these emerging technologies (Okello, 2024).

4.4 Integrative Insights

The application of these theories provides a multidimensional understanding: DOI illustrates how emerging technologies are diffused socially, TAM explains why users adopt these technologies, and UTAUT identifies important factors such as infrastructure and social influence.

5. FINDINGS ON USEFULNESS OF TECHNOLOGY AND TECHNOLOGY GAPS/LIMITATIONS IN AFRICA AND BEYOND

5.1 Usefulness of Emerging Technologies

The emerging technologies listed are the ones driving the Fourth Industrial Revolution (4IR) – they are IoT, 5G, Virtual Reality, Robotics and Automation, and Self-Driving Cars. Each of these technologies contributes to improving our way of life and conducting business, thereby enhancing productivity (Schwab, 2017).

IoT – Internet of Things enables the interconnection of devices, which enables data to be collected in real-time (Rizan et al., 2024). Real-time data, for example, in agriculture, can monitor soil moisture or soil characteristics to determine when to water the land for an optimal harvest. IoT is used in Kenya and Rwanda for improving agricultural activities (Rizan et al., 2024). It has also been used in the health space (Nasir et al., 2025).

5G Technology – This technology offers very fast internet speed that allows real-time communication, as seen in video conferencing solutions, which has been adopted in Africa (Mockel and Makala, 2019). In addition, 5G supports "Internet of Vehicles" (Eze & Eze, 2023) as well as industrial automation. For example, it is possible to deploy a robot in Africa and then control it in the USA to carry out tasks. This is possible because of the internet speed provided by 5G (Urrea & Kern, 2025; Eze & Eze, 2023).

VR provides an immersive environment, which is used in education, medical, and tourism purposes. The VR can provide simulated scenarios in healthcare without deploying physical resources (Aydin et al., 2024). For example, medical students undergoing training can carry out surgical procedures in the VR environment. Also, schools can afford a virtual science lab for experiments (Grewe & Gie, 2023). Furthermore, VR has also been explored in the robotics space. In Africa, VR is being used in virtual classrooms and for the preservation of heritage. However, the high equipment cost is still a challenge (Grewe & Gie, 2023).

In Robotics and Automation, they enhance industrial productivity and safety. This is because they execute repetitive tasks, which can be dangerous. In many advanced

countries, robots are active in the logistics and smart manufacturing space (Urrea & Kern, 2025). Self-driving cars integrate AI to enable fully autonomous driving. Due to their precision, they have the potential to reduce the number of road accidents (Gherardini & Cabri, 2024). Autonomous vehicles are found in Europe and the USA (Gherardini & Cabri, 2024). In Africa, however, the poor infrastructure and lack of safety policy inhibit their deployment (Kurse et al., 2024).

6. RECOMMENDATION FOR POLICY, RESEARCH, AND PRACTICES IN THE USE OF THESE TECHNOLOGIES

The benefits of the discussed technologies can only be harnessed in Africa through orchestrated efforts from the government, academia (researchers), and industry (Kurse et al., 2024). The governments of African nations have to put forward policies that promote technology adoption—policies that provide affordable and reliable infrastructure such as security, electricity, internet, and data centres (Olaitan et al., 2021). Also, policies around data protection and the ethical use of data must be provided (Nasir et al., 2025). In addition, governments must encourage public-private collaboration (Olaitan et al., 2021).

In the academic space, there is a need to strengthen collaboration among African universities (Heleta & Jithoo, 2023). This would enable robust research outputs that truly solve the problems on the continent. For example, a machine learning research carried out in Nigeria might leverage free computing resources offered by another university in South Africa. Also, a researcher can collaborate with others to develop cost-effective IoT devices that are tuned to solve specific problems peculiar to Africa (Atayero et al., 2016).

Lastly, the industry has its own role to play to strengthen the adoption of these technologies. Capacity building through internships, workshops, and seminars must be encouraged (Olaitan et al., 2021). Workshops create an avenue for users to understand the benefits of a technology to businesses. For example, a workshop on automation and how it can enhance business processes can provide a platform for small-scale business owners to adopt such technology. Workshops on VR can help school owners improve students' performance (Grewe & Gie, 2023), while VR exploration can help attract customers in the entertainment sector.

7. CONCLUDING REMARKS

The emerging technologies that have been explored (IoT, 5G, Virtual Reality, Robotics and AUtomation, and Self-Driving Cars) are critical to the attainment of the 4IR (the Fourth Industrial Revolution) (Schwab, 2017). Africa's infrastructural challenges stand against the adoption of these technologies (Olaitan et al., 2021). However, with commitment from the governments of African nations, inter- and intra-university collaboration, where research is focused on solving problems on the continent, and industry engagements, Africa would be on the road to attaining the 4IR.

8. FUTURE DIRECTIONS WITH THESE TECHNOLOGIES

It is evident that the future of the industrial revolution lies when these emerging technologies converge. The ability of Africa to advance to the 4IR would depend on innovations that can scale and are relevant within the African context.

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