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Abstract
Film also known as the 7th Art is a medium for education, information and entertainment which has over the years undergone a series of technological innovations. This paper examines the evolution of cinema from the ‘silent era’ to the ‘new age era’ characterized by a trajectory of innovations and improvements due to technological developments. The paper adapts the Diffusion of Innovations Theory (DIT) propounded by Everett Rogers in 1962 to assess the extent to which innovations in digital technology have altered the old traditional film production landscape. The paper seeks, among others, to determine and highlight the significant areas technology has impacted on the development of motion pictures globally with particular emphasis on the Nigerian film industry popularly known as Nollywood. Our major point of interest is on the roles, impacts, challenges and prospects of digital technology in the areas of production, distribution, marketing and exhibition of films. By using the assumptions of DIT which seeks to explain how, why, and at what rate new ideas and technology spread. The paper further reviews relevant literature and some empirical results from scholars to justify its claims. We are able to establish in our findings that digital technology is the driving force of film development which has contributed enormously to world cinema. Furthermore, the rapid development and emergence of Nollywood film industry as the second largest producer of films in the world next to Bollywood of India is attributable to the emergence of digital technology.

Keywords: Film, Technology, Production, Distribution, Exhibition.

Introduction
Film is believed to be one of the most exciting and challenging of the creative art forms. It gives both substance and permanent life to all that exists in reality or imagination. Over the years, the symbiotic relationship between technology and the arts has been so cordial that the motion picture industry worldwide has continued to enjoy technological innovations in the production, distribution and exhibition of films. Film historian, Gomery qtd. in Whittington has categorized technological development within cinema into three overlapping phases thus: the first is ‘invention’ which refers to the conceptualization and development phase of a technology; the second is ‘innovation’ which encompasses the manufacturing and marketing of technology and the final phases is the ‘diffusion’ of technology or the wide spread use within the industry (42).

In the early days of the development of cinema (1800), there were a lot of complementary contributions from people who experimented with the camera to create
moving images. The most notable contributors were George Eastman, Auguste and Louis Lumiere, Thomas Edison, Edward Muybridge, Georges Melies and William Horner who invented the Zoetrope, a rotating drum that created an illusion of movement. Recent technological developments resulting in the rapid acceleration of contraptions in filmmaking have rendered the old filmmaking gadgets as archival materials within the film history. Unarguably, this has not only enabled filmmakers employ their creative expressions to gain expanded access to a diverse and larger audience, but is also a paradigm shift from the way films are shot, edited and exhibited. Whittington further claims that “the development of cinema has seen the shift from silent to sound film, black and white to colour and the move from 35mm film stock to recent formats such as High Definition (HD) that capture and project images in digital form” (42). Perhaps one of the greatest contributions to film development is the invention of the camera which makes it possible for cinematographers to shoot in a higher definition which enables the viewers to take in more of the amazing work in set design and other different visual elements that embellish film narratives. Furthermore, the rapid improvement of camera technology has enabled cinematographers to move from analogue to a digital format of producing visual content for the cinema, television and social media outlets for mass consumption. This is a new creative approach that is overwhelmingly replacing the traditional ways of filmmaking. Technology is making films more exciting to watch as evidenced in the wide screen, digital imaging, Three Dimensional (3D) and Virtual Reality (VR).

The Augmented Reality (AR) is another aspect of technology that takes a real-world environment adding computer generated imagery to it which makes the audience to marvel at the superimposed images of real objects together with the voice synthesis using Audio Interface (AI). This technology makes it possible to perfectly match sound effects with silent movie footage, voices and sound in films. These are the areas that technology has broken new grounds to service the motion picture industry. Gone are the days when films were shot on celluloid (film stock), processed and a work print made for editing. The expenses incurred were enormous and by far outweigh the cost of digital film production today. Our emphasis here is on the technological developments in production, distribution and exhibition of films globally and their impacts on the success story of Nollywood, Nigeria’s nascent film industry.

Technology and Nollywood Film Industry

The involvement of the Yoruba Travelling Theatre in motion picture production may be considered as the most singular factor in the evolution of the Nigerian indigenous cinema. “The movement from stage performances to video productions was as a collaborative effort of Ola Balgun and Duro Ladipo who produced Ajani-Ogun (1975). Other films produced within the period include Amadi 1975, Ija Ominira (1977), Aiye (1979), Orun Moorun (1982), and Taxi Driver (1983)” (Afolabi 38). It is documented that the down turn of the economy of the 1980s which led to the down fall of the Nigerian currency affected the production of films on the celluloid format as it was prohibitively too expensive. Ogunleye explains that: before the use of video became wide spread in Nigeria, producers began to use 16mm reversal film
rather than the traditional 35mm negative colour film in a desperate attempt to make their films more cheaply. Online negative films, 16mm colour reversal yielded an immediate positive and hence projectable image (81).

The first generation filmmakers like Ola Balogun, Eddie Ugboromah, Ladi Ladebo and several others had to down tools as they could no longer afford production cost of celluloid movies. The digital revolution of the early 1990s was a great breakthrough for the Nigerian Film producers as camcorders and other digital systems replaced the traditional cine film production methods. Fortune however smiled on filmmakers who took advantage of the new video technologies to practice their film craft. In a chat with Alessandro Jedlowski, a popular Nigerian video filmmaker Charles Novia confessed that “the digital video format is recognized throughout the world by film industries being equally acceptable as celluloid in terms of quality and visual definition” (242).

Okome confirms in a web article that: “the adoption of video technology by Nollywood film practitioners has been an unprecedented success...It is the spirit to defy the economic malaise of the cinema industry in Nigeria that led to the adoption of the new technology” (n. p). The new digital technologies have in no small measure opened up a new horizon for cheaper productions, better distribution and viewing environments. Today, the analogue cameras used for production are fast disappearing, making the way for high definition cameras. This paper has noted earlier that, in times past, most Nigerian movies were shot on celluloid. Film pioneers like Sanya, Dosunmu, Ola Balogun, Adamu Halilu, Eddie Ugboromah, Hubert Ogunde,ADE Afolayan and several others shot their film on celluloid. The move from celluloid to video was as a result of global economic decline of the 1980s with the Ibrahim Babangida’s introduction of economic austerity measures popularly known as Structural Adjustment Programme (SAP). The austerity measures made film production on celluloid prohibitive as the cost of film, stock, processing and editing were all done overseas. According to Mauyakufa and Pradham:

The year 1992 marked the beginning of Nollywood, Kenneth Nnebue, an electrical equipment salesman in Lagos, is attributed for taking the initiative to dispose some thousands of blank video CDS, DVD, VHS players, VHS tapes and digital cameras that were in stock in his store which he had imported from Asia. He produced a movie called Living in Bondage along with Yoruba travelling theatre artist and made thousands of copies of the film with blank DVDs that were in his stock. (816-817)

*Living in Bondage* is today heralded as the inauguration of Nollywood. The advent of the Video Home System (VHS) camera, video cassette recorders (VCR) was a game changer, a technology that was most welcome by practising filmmakers and amateurs at the time of Nigeria’s economic recession. Film productions carried out during this period using Video Home System cameras gave birth to what became popularly known as the Nigerian Home Video film. Similarly, Onuzulike qtd in Mauyakufa, and Pradham notes that: the Nigerian filmmakers are considered as the first and quicker to adopt the new technological instruments in Africa such as video
cassettes to produce multiple films at very low cost. The affordability of the new advanced technological filmmaking tools gave Nigerian filmmakers an opportunity to produce films that showcased a glimpse of Africa culture and beliefs to other continents. (814)

Jedlowski Alessandro opines that the introduction of digital technology has played a fundamental role in the video industry revolution in Nigeria: home video technologies (VHS and VCD) generated a straight – to – video distribution model that was resistant to the devastating effects of the structural adjustment programme on the Nigerian entertainment sector at the end of the 1980s. Going straight to video allowed Nigerian Cultural Entrepreneur to cut the unaffordable costs of celluloid production and bypass the problem of theatrical release in the context of collapsing cinema infrastructures (28).

From the colonial era to the late 1980s and early 1990s, almost all films made in Nigeria were on celluloid except for television broadcasting where video recording tapes such as U-Matic, VHS, and Betacam were introduced. The advances in digital technology were a digital intervention that revolutionised filmmaking in Nigeria as films were shot on video and disseminated via VHS. The production tools were just a video camcorder for shooting and a video cassette recorder/player for editing the film. Graham Kindem  and Robert Mushburger point out that, Digital software offer several advantages over the conventional means of editing film; audio tape and videotape including flexibility as well as the potential time and cost savings (1).

The introduction of new technologies has positive effects as Nigerian filmmakers are becoming more professional and conscious of film aesthetics and storytelling techniques. This movement is characterised by high production values, cinematic music scores, better visual and sound quality, more complex story structures and performance. The use of professional equipment for production has raised Nollywood to a global movie power house evidenced by the large number of films produced weekly. With this development the Nollywood film industry is now a big employer of labour. No wonder, Nollywood today is the 2nd largest film industry in the world next to Bollywood of India. According to Foster; the latest Nigerian Nollywood movies and TV shows have gained global viewers, thanks to distribution deals with Western streaming services (masterclass.com n.p.).

In his contribution to the various ways technology has impacted on the motion picture industry, Saurabh Sharma, a Digital Marketing Executive at Arka Software confirms thus: it is captivating to see how technology is influencing the filmmaking industry. Right from the film shooting to the projection on the silver screen, it is technology that is driving the user experience. The use of advanced visualization techniques innovative gadgets, filmmaking software and other tools will help the filmmakers to keep experimenting with this art and offer enthralling and immersive experience to movie goers. (raindance.org, n.p). From the above, it can be stated that technology has opened up diverse possibilities for filmmaking as well as expanded the scope /process from production to post production.
**Diffusion of Innovation Theory (DIT)**

The overwhelming effect and use of modern technologies in filmmaking today may be ascribable to Everett Rogers. In 1962, the communication scholar, propounded a theory that aims to explain how, why and for how long new technologies, products and/or ideas spread. In the Diffusion of Innovation Theory (DIT), he identifies four elements that impact the diffusion of new technologies: The innovation, the communication channels, time and the social system in which the new technology operates in. For an emerging idea/technology to be accepted and sustained by a wider audience, it needs to be adopted by the people it is exposed to. The categories of actors that he identified that are crucial in the process of an idea/technology to catch on are the innovators themselves, the early adopters, the early majority, the late majority and laggards (Rogers, 1962 qtd. in Alexander M. Atzberger, n.p). The DIT has prevailed over time and has proven to be a useful tool to understand the underlying mechanisms for an innovation to catch on, regardless of its cultural or societal system (Atkin, Hunt and Lin 623).

Rogers’ Diffusion of Innovations Theory (DIT) explains how, why and the rate at which a product, service gains momentum and diffuses or spreads through a population or social system. This theory postulates that people as a part of the social system easily adopt a new idea, behaviour or product. The DIT still holds when explaining emerging trends in today’s time as foundational for explaining both macro and micro level processes, with a distinct set of limitations. Overall, the theory needs an overhaul to bring in a nuanced understanding across multiple areas in order to explain today’s complex media world. The adoption process of people exposed to emerging innovations suggested in the theory is applicable and generalizable across a wide field of different disciplines (Alecia 644; Sundstrom 95).

The theory identifies the key steps that are necessary to explain the process that adopters need to go through in order for an innovation to catch on (Atkin et al. 623), but is not a suitable application when trying to explain the processes of complex technologies. Scholars have continued to utilize the DIT as a vantage point to develop extensions and additional elaborate concepts that help explain the increasingly technological landscape and diffusion process (Atkin et al. 624).

Without doubt, DIT has positively affected the growth of the motion picture industry today. When applicable to filmmaking, we look at adoption as a means whereby filmmakers have turned over to the new production technology and are working and achieving results in the areas of production, distribution and exhibition of films quite different from what was obtainable in the past. This is a paradigm shift to a more vibrant, cost effective, result oriented operation. According to Woods, this technology applies to many industries but with very special and innovative applications in the film industry. Current challenges encountered by filmmakers push them to test and exceed boundaries, or even break the rules to create and release stunning videos and films. And Australian film production companies are highly equipped and supportive of filmmakers when it comes to the integration of innovations and technologies (1).
These digital technologies have greatly enabled the growth of vibrant film industries across the globe and have assisted raw talents to use the latest trends and technologies to engage in the practice and art of making movies for domestic and international consumption. One can therefore logically say that this digital world is now the new stage for all professionals and novices to engage themselves as they take advantage of these technologies so as to get international recognition at film festivals. Like any industry, the motion picture industry relies on technology to facilitate production, distribution and exhibition of film products. Digital technology today is literally changing films themselves, as well as the circumstances of their consumption. Chapain, and Stachowiak believe that the film industry can be highly innovative through adaptation of innovations. In their exact words,

The very birth of film was a consequence of the invention of the cinematograph as a motion picture film camera in the late 19th century. Since then, the film industry has created and adapted many innovations of different kinds. They embrace new equipment and tools and the related new ways of using them, but also novel ways of organizing the film production process. All that led to vast aesthetic innovations, the emergence of film styles and genres of the mastering of new filming techniques. (72)

From the foregoing, we can see that the history of cinematography itself is filled with product innovations which are totally based on improved technologies. The coming of sound at the end of the 1920s and the mid-1930s may also be considered as great technological feat in the development of the movies. Sound has indeed transformed many dimensions of the cinema as it has tremendous impact on the way filmmakers tell their stories and communicate with an audience (Villarejo 64).

New Camera Technology

Making a film is not an easy task. Film technology today has penetrated almost all levels of production with an array of cameras for shooting. Better cameras provide more versatility and image quality. Frank Eleanya, Author at Businessday NG reports that: Kunle Afolayan. Producer and director of the 2020 hit movie Citation is also one of the modern Nollywood practitioners that prioritises high level production. The movie Citation was shot with Canon EOS C500 Mark, one of the latest cameras produced by Canon (n.p).

The basic camera mounts are handheld, shoulder, tripod, steadicam and monopod. Today, the director of photography may wear a steadicam mount which absorbs the wobbles and jitters even if he walks or runs about with the camera while keeping the picture perfectly steady. Camera movements today are most fascinating especially when autonomous drone cameras are used for aerial shots to give a bird’s eye view of a scene. With advancements in camera technology, these shots which were hitherto obtained using only helicopters are easily obtained by using a drone camera. The autonomous drone camera technology is designed with the capability to take shots from different camera angles, while avoiding obstacles in flight. Nowadays the drone camera can shoot 4k or 5k resolution footage of digital quality pictures.
Smartphone Technology

The emerging digital film technology and data compression have introduced a myriad of digital Smartphones that come with an in-built digital camera. Some of these quality smartphone cameras have mega pixels with an aperture opening of f/1.4 which allows more light into the camera lens with greater potential for visual detail. The following are among the top quality digital smartphone cameras of comparable high quality picture resolution: Google Pixel 7 Pro, Samsung Galaxy S22 Ultra, Apple iPhone 14 Pro (equipped with telephoto), and wide angle lenses. The digital smartphone is a technological feat that is comparable to images generated by some professional film cameras like the ARRI-ALEX 35, Black Magic and some others.

The Galaxy S22 Ultra continues to raise the bar of what to expect in terms of smartphone photography. Not only does it continue to be the only smartphone to support 8k resolution video recording (with remarkable results) but the Galaxy S22 Ultra’s zoom capabilities are second to none. (expertreviews.co n.p.)

With today’s technology, some video films shot with an IPhone or a smartphone have incredible, unbelievable picture quality. Depending on the user’s skill and creativity, one can use these gadgets to produce visuals that are almost close to the quality of DSLR cameras.

Film Editing

Post production editing is another integral aspect of the digital revolution in filmmaking. The old school celluloid film editing is carried out by manually cutting two sections of film which are spliced together in a film splicer using film cement. This approach to film editing is a lot of risk taking as editing errors may result to dropping scenes all together from the movie. There is also the likelihood of the film getting scratched, squeezed or jammed on its movement on the rollers. With the digital approach, the non-linear editing uses tools to drag and drop sequences for editing and application of transitional effects. It is a seamless approach that does not need any laboratory services for printing and application of effects. The use of montage is effected with ease while the audio is enhanced with a high definition digital file to enrich the sound.

Distribution/Exhibition

As pointed out by Silverman, “distribution has long been the catching point for filmmakers. A print can cost between two hundred and three hundred thousand dollars but because of the expense of producing prints and the infrastructure to make and deliver them, distribution remained exclusively the activity of the studios.” He goes further to argue that the cost of shipping and destroying 35mm film prints cost distributors $1.5 billion a year (65). What this implies is that the process of distributing films for theatrical exhibition in the past was cumbersome and involved making multiple copies of the film, transportation-shipping, and a lot of time consumption. Digital technologies are breaking up this distribution oligopoly in the following ways
as the digital copy makes reproduction and delivery costs cheap to free, thus distribution
stops being a model of scarcity

- Distribution on DVD
- Download movies with bandwidth
- Theatrical
- Video on Demand (VOD)
- Netflix, Hulu, Amazon prime etc.
- Social Media
- Internet
- YouTube

Technology has had the most profound impact on the development of the film industry as witnessed during the COVID-19 outbreak. With its attendant restrictions on social gathering and safe distancing, YouTube, Netflix were very popular channels where people could assess content. Below is a chart showing some technological innovations in the film industry in the areas of production, post production, distribution and exhibition.

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Production, Post production, Distribution/Exhibition

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The Nollywood Film industry today relies on the new digital tools and innovations which have become an acceptable norm for producing films. Ugo Ben Ebelebe acknowledges that substantial discussions about the film industry have been concerned with technological innovation and the opportunities that emanate from it. He states that:

Whilst these technological advances seem to stimulate a number of radical transformations in film practices worldwide, within the emergent Nigerian film industry, the use of new digital technologies has impacted almost every aspect of the moviemaking practice. Emerging innovative filmic practices are immensely changing the landscape of the aesthetics of both form and content creation for filmmakers. In the area of content distribution, internet-based platforms are not only eroding the traditional systems, they are fostering new connections between the content producers and consumers. (1)

Today, high end quality cameras like the Red One, Red Epic, and Scarlet, Red Weapon, Arri Alexa, Black Magic and several models of Sony cameras are used in Nollywood productions. Madichie et al. give an anecdotal evidence of the impact of technology in camera operation during production as follows: by improved video technologies like high - end digital cameras Red One, Red Epic, and Scarlet, Red weapon cameras... Panasonic Varicam 35, Sony F65 and F55 cameras, which are used in film and TV industries in the West are now also common features in production of Nollywood movies (92).

The advances in technology have indeed caused a significant structural transformation within Nollywood Film industry. Mauya Kufa and Pradham remark that: based on the quantities of film produced per year, Nigeria has jumped to second place as the world’s leading film producer by overtaking the United States and only remains behind India. The evolution of technology in filmmaking resulted in low cost, effective and user friendly film processing equipment. It also removes the barrier to entry for new filmmakers in the industry. The democratization of filmmaking by technology has resulted in the production of 50 new films per week by Nigerians, more than Bollywood (15 films per week) and Hollywood (10 films per week) (Economist 4; UNESCO 29). Over the years, film distribution in Nollywood has been characterized by shrewd marketers and pirates who had access to the finished work via VHS, tapes and DVD. Film piracy thrived over the years as a result of ineffective regulation, arrest and prosecution of offenders by relevant governmental agencies. Tade reports that in July, 2014, less than three weeks after the release of Half a Yellow Sun.....Lagos film vendors were found hawking pirated copies of the film around the metropolis. Similarly, in 2015, Kunle Afolayan was notified that his classic film October 1 had been pirated and was already being sold on Lagos streets at ₦500.00 per copy (the conversation.com n. p).

The process of releasing films for public consumption round the world is through theatrical exhibition. Nollywood though the 2nd largest producer of films next to Bollywood does not have enough cinema theatres to serve the nation’s population. Today, there are however some established active distributors of cinema releases in
Nigeria. These distributors/exhibitors are: Silverbird, Blue Pictures, Film One and Metro Classic amongst others. As Liman and Ihidero affirm, there are content aggregators who produce and sell directly to international television stations or online streaming services (301). There are also some producers who release their films to the public immediately on DVD which is direct to video or straight to video. This method of release is risky as the film producers can easily be victims of pirates. The films have other alternatives such as Video on Demand (VOD) where one needs to work out the business deal to place such contents on their platform. Nollywood film producers have the following video on demand platforms to choose from:

- Iroko
- 9Flix
- Dobox
- Iflix
- Nollywood

The emerging technologies have made it possible for Nollywood producers to utilise the services of Pay television such as Digital cable and Satellite Television via terrestrial and internet television to distribute content. Filmmakers have a choice to sign agreements with the following companies for the exhibition of their films; DSTV (Multichoce), Star Times, MyTV, G0tv and Kwese. The new technological possibilities made available through the digital video and internet have created an innovative business attitude which has revolutionized the operations of Nollywood. Ukadike affirms that Nigerian films are rapidly penetrating local screens and distribution outlets. They have also begun to conquer the internet. There are now numerous internet sites where anyone can gain access to view or buy Nigerian films. In addition, Nollywood films are now available on Netflix. Nigerian films have been made available for rental in the United States through internet websites (190).

Furthermore, Alaje, an independent creative director in a chat with Frank Eleanya noted that the growth in streaming services has taken the Nollywood film industry to the universal stage: compared to previous years, I can say technology has made Nollywood a lot bigger in the year 2021. We are now technologically inclined; there is more emphasis on camera quality, unlike previous years when the camera quality was really nothing to write home about (Businessday.ng. n.p.). With the technological development over the years within the time frame of just a decade, the conventional cinema associated with production as well as the mechanical process of projecting film prints (celluloid) is gradually giving way to digital projection. Digital cinema as a replacement for film print projection is a new platform for creative interventions that offers greater “image clarity and quality at lower cost, greater security and more flexibility and efficiency” (Swartz 1). With the establishment of streaming services such as the Amazon Prime Video and ShowMax (platforms which are the quickest way to reach global audiences), Nollywood filmmakers can take advantage of these platforms as major revenue outlets.
The Challenges of Technology

From the foregoing, it is evidently clear that the rapid growth of the Nigerian film industry (Nollywood) is as a result of the emerging digital technologies, resulting in a paradigm shift from celluloid which today has opened up business avenues for people to get into the business of filmmaking. Jedlowski notes that: from the economic perspective, the Nigerian “video boom” is the result of two factors: the informality of the Nigerian economy and the adoption of digital technologies... Home video technologies (VHS and VCD) generated a straight-to-video distribution model (27-28). To further reap the benefits of the emerging new digital technologies, technical skill is required to translate ideas into a visual form and, whilst all things mechanical must be subordinate to creation, perfection can only be obtained by a thorough understanding of the techniques of the medium. Nollywood film practitioners therefore must take cognizance of the following challenges:

a) The array of complex software new digital technologies provide require a sound knowledge of implementation and data integration hence the need for users to get acquainted with the intuitive integrated systems.

b) There is need to train operators to be proficient with operational tools.

c) A skilled high performance IT team must be available to carry out operations.

d) Acquisition of software technology and training requires money, without which a project cannot be executed. Hence the need for financial resources to acquire materials as well as training.

These challenges are surmountable provided money is available and a digital transformation consultant is at hand to offer the required services.

Conclusion

The interface between film arts and technology is a great plus to the advancement of all facets of film worldwide. This study has examined the significant progress made in the development of the motion pictures (cinema) and the way technology has changed the film industry. Technology has completely altered the mode of production, distribution and exhibition of films. The impact of technology on Nollywood film industry is almost unquantifiable as it has served as a driving force for the rapid growth of the industry. With technologically advanced editing tools and soft wares like computer graphics and animation special effects, specialized computer systems, non-linear editing systems, etc. digital technology have paved the way for Nollywood to compete favourably with other film producing nations. This paper recommends that to sustain the tempo and be in tune with the global best practices in film production, Nollywood needs to acquire the latest production soft wares backed up by a highly trained innovative personnel that would continue to support filmmaking in the areas of production, distribution and exhibition.
Works Cited


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