FINAL REPORT

EXPLORATORY STUDY ON THE APPLICATION OF COMPUTER VISION TECHNOLOGY FOR E-COMMERCE SECTOR GROWTH IN NIGERIA

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TABLE OF ACRONYMS

Acronyms	**Meaning**
AI	Artificial Intelligence
AR	Augmented Reality
CV	Computer Vision
CVT	Computer Vision Technology
DIY	Do-It-Yourself
ET	Emerging Technologies
IT	Information Technology
ML	Machine Learning
NITDA	Nigeria Information Technology Development Agency
ROI	Return On Investment

SECTION ONE: INTRODUCTION

1 INTRODUCTION

1.1 Background of the study

Computer vision technology involves utilizing algorithms and artificial intelligence to process visual data from images or videos. The adoption of computer vision in retail has rapidly gained traction, revolutionizing the way businesses operate and transforming e-commerce by enhancing efficiency in various ways. In the retail sector, it enables automated product categorization, visual search, object recognition and even virtual try-on experiences. It's leveraged for tasks like inventory management, customer analytics, automated checkout, and enhancing the overall shopping experience.

Traditionally, retail operations relied on manual processes for inventory management and customer service. However, the influx of e-commerce and changing consumer expectations necessitated a shift towards efficiency and personalization. Computer vision addresses these needs by enabling retailers to automate inventory tracking, detect trends in consumer behavior, optimize store layouts, and implement cashier-less stores.

The use of computer vision in retail operations can lower operational costs, increase inventory management accuracy, improve consumer interaction, and ultimately boost sales. Computer vision has a significant and intriguing potential to transform the retail environment as technology develops and becomes more affordable.

This research endeavors to explore the potential integration of computer vision to augment e-commerce in Nigeria. It seeks to assess the existing adoption status of visual search within Nigerian e-commerce retailers, pinpoint obstacles that could impede technology uptake, and propose practical solutions. Additionally, the study aims to advocate for best practices and elucidate how Nigerian consumers can derive benefits from the implementation of Computer Vision in various e-commerce applications.

1.2 Objectives of the study

The overall objectives of the study are:

i. To investigate the possibility of adopting computer vision in enhancing ecommerce in Nigerian.

ii. To evaluate the current level of adoption of visual search among Nigerian ecommerce retailers.

iii. To identify challenges that may militate against the adoption of the technology in Nigeria and recommend pragmatic solutions.

iv. To recommend best practices and other ways in which Nigerian consumers can benefit from implementing Computer Vision in Ecommerce Applications

1.3 Scope of the study

i. The project shall carry out in-depth research with empirical data supporting this exercise within a set of purposively sampled Commercial organizations in Nigeria, Information Technology Managers, Experts, and top Executives and assess the challenges, level of e-commerce adoption and proffer solutions using the best model or framework

ii. The scope of service shall also cover specifically the level of computer vision application among Nigerian ecommerce start-ups.

iii. The Study shall benchmark and present ICT innovation activities and adoption practices from other developing countries, and consider the impact of ICT innovation activities in those countries in recent times.

iv. The Study shall identify the most significant constraints and challenges faced by ecommerce start-ups in Nigeria.

v. Document findings from key informant interviews/discussions/communications with major ecommerce start-ups, and review of available data sources related to the project scope, shall be collated and reported

1.4 Evaluation Methodology

The study adopted a mixed-methods design, integrating both quantitative and qualitative research techniques. This approach was chosen to ensure a comprehensive and multi-dimensional understanding of the subject matter. By combining these methods, the research captured the breadth of statistical data and delved deep into the intricacies of individual experiences and perspectives. This synergy of methods ensured that the research not only provided empirical evidence but also contextual insights, making the findings both robust and richly detailed.

1.4.1 Method of Data Collection:

- **Quantitative Data Collection:** The primary tool for quantitative data collection was the standardized questionnaire. These structured survey instruments were designed to gather data from the selected sample consistently. The questionnaires were tailored to the objectives of the study and were informed by existing literature, industry knowledge, and expert insights. Pilot testing was conducted to refine the questionnaire before its distribution to the participants. Goggle form was used for the administration of the survey tool.

- **Qualitative Data Collection:** Key informant interviews were conducted with representatives from selected e-commerce companies and regulatory bodies. These interviews provided in-depth insights into the experiences, challenges, and perspectives of these organizations regarding computer vision technology. The organizations included in the study are listed in Table 1 below:

Table 1: Selected Organisation for Data Collection

Category	Organisation
E-commerce Companies	Jumia, Konga.com, OLX, Flutterwave, Payporte, Jiji.ng, Interswitch, Opay, Palmpay, Moniepoint, Paystack, Shopify
Regulators	Nigeria Information Technology Development Agency (NITDA)

1.4.2 Sample Size:

The study used a total of 108 participants for the quantitative data collected, which included e-commerce companies and their customers. This diverse sample was chosen to capture a wide range of perspectives and experiences related to the application of computer vision technology in the e-commerce sector.

1.4.3 Method of Data Analysis:

- **Quantitative Data Analysis:** The collected quantitative data underwent rigorous statistical analysis. Descriptive statistics, such as means, medians, and frequencies, summarized the data's characteristics. Inferential statistics, including Chi-Square tests, were employed to examine relationships between categorical variables and test research hypotheses. Data mining and machine learning techniques were applied to large datasets to uncover patterns and trends. Economic analysis, including ROI estimations and cost-benefit analyses, quantified the economic implications of adopting computer vision technology.

- **Qualitative Data Analysis:** The qualitative data were analyzed using NVivo, a qualitative data analysis software. This involved thematic analysis, where transcripts from the interviews were meticulously reviewed to identify recurring themes and patterns. The software facilitated the organization and coding of the data, ensuring a systematic and comprehensive analysis. Observations and document analyses were integrated to provide a deeper understanding of the context.

1.5 Limitation of Analysis

1. **Sample Representation**: While the sample size of 108 e-commerce companies and customers was substantial, it may not fully represent the entire e-commerce sector in Nigeria. There might be nuances and perspectives from companies or customers not included in the sample. To address this, the study ensured that the selected sample was diverse, encompassing a range of e-commerce companies of different sizes and customer demographics. This aimed to capture a broad spectrum of experiences and perspectives.
2. **Response Bias**: As with any survey-based research, there's a potential for response bias. Participants might have provided answers they deemed socially acceptable or favorable rather than their true opinions. The research team ensured that all participants were informed about the importance of honest responses and were assured of the confidentiality of their answers. Clear and unbiased instructions accompanied each questionnaire to minimize any potential bias.
3. **Temporal Limitations**: The study provides a snapshot of the application of computer vision technology in the e-commerce sector at a specific point in time. The rapidly evolving nature of technology means that the findings might have a limited shelf-life. The research incorporated a review of current trends and expert predictions to ensure that the findings remained relevant and forward-looking. This approach aimed to make the research findings adaptable to future developments.
4. **Data Interpretation**: Qualitative data, in particular, is open to interpretation. While the research team took utmost care to ensure objective analysis, personal biases and perspectives might have influenced the interpretation of qualitative data. Multiple researchers were involved in the data analysis process to ensure diverse viewpoints and reduce individual biases. The use of NVivo software also provided a systematic approach to data coding and theme identification, ensuring consistency in analysis.
5. **External Factors**: The study did not account for external factors, such as economic fluctuations, political changes, or global events, which might influence the adoption and perception of computer vision technology in the e-commerce sector. While it was challenging to account for all external variables, the study incorporated a comprehensive

literature review and expert interviews to understand the broader context and potential external influences on the research findings.

1.6 Structure of Report

The introduction is succeeded by an extensive literature review delving into the utilization of computer vision technology to drive e-commerce sector expansion in Nigeria, juxtaposed against exemplary practices observed in developing nations. Following this, the third section delineates critical discoveries, categorizing them as principal accomplishments and challenges based on the objectives and scope of study. Lastly, a succinct conclusion encapsulates a summation of the prior analysis, summarising key insights and offering prospective recommendation and directions for further research.

SECTION TWO: LITERATURE REVIEW ON COMPUTER VISION

2 LITERATURE REVIEW ON COMPUTER VISION

2.1 Definition of Computer Vision Technology

Computer vision technology (CVT) is a subfield of artificial intelligence (AI) that focuses on enabling computers to identify, process, and understand objects in images and videos, similarly to how humans do (Szeliski, R., 2010). This technology has advanced significantly in recent years due to developments in machine learning algorithms, increased computational power, and access to large datasets (LeCun, Bengio, Y, & Hinton, G. , 2015). In the e-commerce sector, CVT has the potential to revolutionize various aspects of the industry, such as product search and discovery, personalised recommendations, fraud detection, and inventory management (Wang, 2019). Adopting CVT in e-commerce can increase efficiency, cost savings, and improved customer experiences (Krizhevsky, Sutskever, I., & Hinton, G. E. , 2012).

Computer Vision entails giving computers or machines the ability to comprehend and interpret visual information from the outside world, such as pictures and movies, in a manner that is analogous to how people do. The development of deep learning, artificial intelligence, and machine learning has considerably boosted computer vision's capabilities and uses. In recent years, remarkable progress has been achieved in computer vision algorithms and models, particularly with the advent of deep learning frameworks like Convolutional Neural Networks (CNNs). These advancements have fueled breakthroughs in various domains, including autonomous vehicles, medical imaging, robotics, surveillance, augmented reality, and, notably, ecommerce and retail.

2.2 Algorithm and data types employed in Computer Vision

Although there are many different kinds of algorithms, image processing and feature extraction techniques are the most widely employed. Applications for CVs use three different forms of data: depth maps, videos, and photos. As they are the easiest to record and analyse by computers, images are the most common sort of data used. Videos are also frequently employed since they offer a steady stream of data that may be processed to find persons or items in a scene. The creation of a three-dimensional representation of a scene

using depth maps, however less frequently used, can be helpful for applications like object detection and navigation.

By sequentially combining the following three basic processing steps, (Karunakaran, Paliwal, & Digvir Jayas, 2014) computer vision aims to mimic human vision using digital images:

1. Image acquisition

2. Image processing

3. Image analysis and understanding

Image Acquisition

According to (Automation), Image Acquisition contributes to 85% of Machine Vision solution success. The act of obtaining an image from sources is known as image acquisition. Hardware systems like cameras, encoders, sensors, etc. can be used to do this. It is without a doubt the most important phase in the CV workflow because a bad image will make the workflow ineffective as a whole. Gaining an image with the proper quality and contrast is crucial since machine vision systems only evaluate the digital image of the thing that has been captured, not the actual object.

Image processing

As per the insights shared by (Reem M. Hussien, Karrar Q. Al-Jubouri, & Mohaimen Al Gburi, June 2021), delving into the realm of digital image processing is an endeavor embraced by researchers to meticulously scrutinize images, extracting pivotal data and comprehending the embedded information within them. This discipline employs a methodological approach involving multi-range implementation and substantial analysis of voluminous data.

At its core, image processing is a dynamic field focused on the refinement of visual data by precisely adjusting numerous parameters and intrinsic features of the images. Positioned as a subset within the expansive domain of computer vision, it operates through the application of diverse transformations to an input image, yielding a refined output image.

These transformations encompass a spectrum of operations, including sharpening, smoothing, stretching, and more.

Image analysis and understanding

The fundamental objective of image analysis is the deconstruction of an image into its elemental components, allowing for the extraction of profound and insightful information. This analytical process spans a spectrum of tasks, ranging from shape identification and edge detection to noise reduction, object quantification, and the computation of statistics. Texture analysis and assessments of image quality stand as significant dimensions encompassed within this holistic approach to image analysis (Priyanka & Leena Prema Kumari, 2022).

2.3 Evolution of Computer Vision Technology

The origins of computer vision can be traced back to the 1950s and 1960s, with the development of simple pattern recognition systems aimed at replicating the human visual system. Early efforts in computer vision were focused on edge detection, feature extraction, and basic object recognition (Marr, 1982) (Nagel, 1988) (Ballard, 1982) . In the 1970s and 1980s, computer vision began to be used commercially for tasks such as distinguishing between typed and handwritten text, optical character recognition (OCR), and industrial automation applications, such as robotic vision systems for manufacturing.

The evolution of computer vision has been a remarkable journey, marked by significant milestones and technological advancements. Initially emerging as a theoretical concept, it has transformed into a practical and impactful field with diverse applications. The timeline below highlights key stages in the evolution of computer vision:

i. Early Foundations (1960s-1970s): Computer vision started with basic pattern recognition and image processing techniques. Researchers focused on edge detection, character recognition, and simple feature extraction algorithms. An idea to connect a camera to a computer and have it "describe what it saw" first surfaced

in 1966. 3D modeling, representing objects as connections of smaller structures, removing edges from photos, labeling lines, and estimating optical flow and motion surfaced in the 1970s.

ii. Symbolic AI and Knowledge-Based Systems (1980s): During this era, symbolic AI gained prominence, emphasizing rule-based systems and expert knowledge for image interpretation. However, it struggled to handle real-world complexity due to limitations in rule creation. Scale-space, form inference from cues including shade, texture, and focus, and contour models (snakes) were all developed in the 1980s.

iii. Transition to Machine Learning (1990s-2000s): The shift towards machine learning marked a turning point. Image segmentation using graph cuts, dense stereo correspondence problem, multi-view stereo approaches, sparse 3D reconstructions of scenes from many images. Algorithms like neural networks, support vector machines, and decision trees became fundamental in processing images and recognizing patterns. The introduction of large labeled datasets facilitated the training of these models.

iv. Deep Learning Revolution (2010s): The breakthroughs in deep learning, especially convolutional neural networks (CNNs), revolutionized computer vision. CNNs demonstrated superior performance in image classification tasks, winning competitions and setting new benchmarks. Deep learning leveraged the availability of massive computing power and big data to achieve remarkable accuracy.

v. Diversification of Applications (2010s-2020s): Computer vision expanded into various domains including autonomous vehicles, medical imaging, robotics, augmented reality, and more. Object detection, segmentation, pose estimation, and facial recognition became common applications with practical implementations.

vi. Domain-Specific Architectures (2020s): Tailored hardware and specialized architectures like Graphics Processing Units (GPUs) and Tensor Processing Units (TPUs) emerged to optimize deep learning algorithms for specific computer vision tasks. These advancements significantly enhanced efficiency and speed.

vii. Ethical and Privacy Considerations (2020s): As computer vision technology became pervasive, ethical implications concerning privacy, bias, and misuse came to the forefront. Researchers and practitioners started addressing these concerns, aiming for responsible development and deployment.

The evolution of computer vision showcases a progression from theoretical concepts to powerful practical applications, continually pushing the boundaries of what machines can perceive and understand in visual data. Ongoing research and innovation continue to shape the future of computer vision, promising even more exciting possibilities and societal impact. Computer vision has continued to advance in a variety of industries, including autonomous vehicles, facial recognition, healthcare, and more.

2.3.1 State-of-the-Art and Current Trends in Computer Vision

The most recent developments use a technique known as Edge AI, which combines Edge Computing with on-device machine learning. Building scalable computer vision apps and running computer vision machine learning everywhere are made possible by moving AI computation from the cloud to edge devices. Increasing computing efficiency, reducing hardware prices, and new technologies (model compression, low-code/no-code, automation) are all contributing to a downward trend in computer vision costs. As a result, an increasing number of computer vision applications are now practical and affordable, which is accelerating computer vision adoption.

The past decade has seen rapid advancements in computer vision, driven primarily by the development of deep learning techniques, particularly convolutional neural networks (CNNs), which have shown remarkable performance in image classification and object recognition tasks (LeCun, Bengio, Y, & Hinton, G. , 2015) (He, Zhang, X., Ren, S., & Sun, J.)

The accessibility of large datasets, such as ImageNet, and powerful computational resources, including GPUs and cloud computing, has further accelerated the progress in the field. These advancements have resulted in significant improvements in the accuracy and

capabilities of computer vision systems, enabling them to outperform humans in certain tasks, such as image recognition and classification.

2.4 The role of Computer Vision Technology in E-commerce Sector

Computer Vision in retail is an emerging and rapidly evolving field. Computer vision technologies are being used by an increasing number of retail and e-commerce businesses to better meet customer requests and manage inventories. Potential AI applications and computer vision are clearly transforming the retail business by enabling merchants to acquire important information, optimize processes, and improve the consumer experience.

According to an article written by (Gaudenz Boesch, n.d.) He examined how computer vision is being utilized in retail, including brick-and-mortar stores, wholesale, fashion stores, grocery stores, cosmetics and personal care stores, electronics stores, and more. It is obvious that advancements in computer vision technology will have a huge impact on the future of retail.

Computer vision is leveraged within the retail and e-commerce sectors to facilitate interaction-free shopping experience. This technological advancement is fundamentally reshaping these industries, propelling quicker, more intelligent, and highly efficient solutions for both customer engagement and operational processes.

2.4.1 Examples of Usage and Case Studies

Potential Use Cases of CV in E-commerce

A. **Computer Vision Technology in product search and discovery**

   Computer vision can significantly improve product search and discovery in e-commerce by enabling visual search capabilities. Visual search allows users to search for products by uploading images, leading to a more intuitive and user-friendly shopping experience. For instance, customers can find similar items to those seen in a photo, making it easier to find desired products. Companies like Pinterest and

Google have already implemented visual search features, enhancing user experience and increasing engagement (Johnson et al., 2019).

B. Application in personalised recommendations and customer targeting

Computer vision technology can analyse user-generated images to better understand customer preferences and deliver personalised recommendations (Girshick, R, Wang, Gupta, A., & He, K. , 2018)By analysing the visual features of products and customers' browsing history, CVT can create more accurate and relevant product recommendations, increasing customer satisfaction and higher conversion rates (Zhang, Zhao, J, & LeCun, Y, 2018). Furthermore, CVT can enable better customer targeting by identifying patterns in user-generated content, such as social media images, allowing businesses to create targeted marketing campaigns based on visual preferences (Liu et al., 2017). CV analyze customer moods and help personalize ads and offers accordingly.

According to a comprehensive survey undertaken by Accenture, an overwhelming majority of consumers, precisely 91%, showcase a notable propensity to favor brands that exhibit a keen capability to remember and understand their individual preferences. Furthermore, these consumers highly value brands that not only grasp their preferences but also proactively offer pertinent recommendations and alluring incentives, further solidifying their loyalty and likelihood to engage with such brands. This aspect underscores the paramount importance of personalized and targeted approaches in contemporary consumer interactions within the market landscape.

C. Use of Computer Vision Technology for fraud detection and prevention

Computer vision technology (CVT) assumes a crucial role in fortifying fraud detection and prevention within the e-commerce sphere. It proves highly adept at identifying counterfeit products by scrutinizing product images and promptly flagging suspicious instances for subsequent in-depth investigation, as pointed out by. (Zhou, Zhu, Q., Ye, J., Chen, Q., & Wang, W. , 2020). Additionally, CVT offers a powerful tool for

verifying user identities during transactions, significantly mitigating the risk of identity theft and unauthorized account access, a claim supported by (Saini, Kumar, R., & Roy, P. , 2019).

Integration of computer vision-based fraud detection systems into e-commerce operations presents an array of benefits. Primarily, it aids businesses in curbing financial losses associated with fraudulent activities. Simultaneously, it serves to uphold the integrity of the brand by ensuring the authenticity of the products being sold. Moreover, by bolstering security measures, it creates a reassuringly safe shopping environment for customers, thereby fortifying their trust and enhancing their overall shopping experience.

Notably, the domain of retail is also leveraging AI-powered vision solutions to monitor shopper behavior discreetly and in a manner conducive to a positive customer experience. This approach showcases the multifaceted applications of computer vision technology across various sectors, underscoring its versatility and value in contemporary business landscapes.

D. Facial Recognition

Apple and Microsoft utilize computer vision for facial recognition, enhancing security measures and authentication processes. Amazon Go stores leverage this technology, allowing a seamless shopping experience where customers can enter, shop, and exit without traditional checkout. Likewise, Walmart employs AI-powered computer vision to manage inventory and analyze customer flow. The continuous advancements in computer vision are anticipated to introduce a multitude of innovative technologies, reshaping the retail and e-commerce landscape.

E. Virtual Reality and Augmented Reality

Virtual and Augmented Reality revolutionize immersive and interactive entertainment by leveraging computer vision algorithms to detect real-world objects. This allows applications like Google Glass and smart eyewear to overlay and integrate virtual elements into actual surroundings. These cutting-edge technologies can track head movements, detect emotional expressions, and precisely position virtual objects in the physical environment. An example of this is the widely-used Ikea Place app, which employs AR to assist users in visualizing furniture in their living space and determining its suitability.

For instance, Journey (Journeys, n.d.) allows customers to virtually try on thousands of shoe choices, while Warby Parker offers the same for glasses from the comfort of their homes. Apps like Sephora Virtual Artist enable experimentation with makeup virtually, and platforms like Houzz allow users to virtually preview and arrange furniture in their living spaces.

F. Interaction-free

Interaction-free shopping experiences, implemented by companies such as Amazon through the use of computer vision, transform the way customers shop. When customers enter a store or facility, computer vision technology is deployed to track and monitor their movements and selections. This enables a seamless shopping journey where customers can browse, choose items, and leave the store without needing to interact with staff or go through traditional checkout processes.

Computer vision algorithms detect which items a customer has taken from the shelves and automatically add them to a virtual shopping cart. This eliminates the need for physical scanning or manual checkout, significantly saving time and enhancing convenience. The system is designed to accurately identify and record the items chosen by customers, ensuring a precise and efficient shopping experience.

Working Examples of Use Cases:

- **ASOS: Enhancing Product Search and Discovery through Visual Search**

  ASOS, a leading online fashion retailer, integrated computer vision technology into their mobile app to enhance product search and discovery. They introduced a visual search feature called "Style Match," which allows customers to upload photos of clothing items they like, and the app then displays similar products available on their platform. This innovative feature has led to increased customer engagement, a more seamless shopping experience, and higher conversion rates.

- **Stitch Fix: Personalized Recommendations and Customer Targeting with Computer Vision**

  Stitch Fix, a personalised styling service, utilises computer vision technology to analyse customer preferences and offer tailored product recommendations. By examining the visual features of items in their inventory and customers' browsing history, Stitch Fix's algorithms can suggest products that align with each client's unique style. This approach has contributed to increased customer satisfaction and retention rates, as well as a more efficient inventory management.

- **Alibaba: Fraud Detection and Prevention through Image Analysis**

  Alibaba, a major e-commerce platform, has implemented computer vision technology to combat the issue of counterfeit goods on its platform. Their system, known as "Tianji," uses deep learning algorithms to analyse product images and identify potential counterfeits by comparing them with authentic items. Once flagged, these products undergo further scrutiny, enabling the platform to remove fraudulent listings and protect both consumers and legitimate sellers. This has significantly reduced the number of counterfeit goods on Alibaba and bolstered its reputation as a reliable marketplace (Alibaba Group, 2020).

- **Mastercard: Identity Verification for Secure Transactions using Computer Vision**
  Mastercard has introduced a biometric authentication system called "Identity Check Mobile" that employs computer vision technology to verify users' identities during transactions. This system uses facial recognition technology, requiring users to take a selfie to confirm their identity. This has led to a more secure payment ecosystem and increased consumer trust in the Mastercard brand (Mastercard, 2017).

2.4.2 Global trends and adoption rates

Computer Vision Technology (CVT) is experiencing a significant global upswing in adoption within the e-commerce landscape. This surge can be attributed to the transformative potential of CVT in revolutionizing various aspects of the e-commerce sector, enhancing user experiences, and driving business efficiency.

Globally, there is a growing interest in adopting computer vision technology in e-commerce, with organisations recognising its potential to boost revenue, save time, and improve operational efficiency. A study by (IDG, 2021) found that 96% of respondents believed computer vision could increase revenue, and 97% believed it could save their organisations time and money. While only 10% of organisations currently use computer vision technology, 37% have definite plans to implement it, and 44% are investigating its potential applications.

One of the notable trends is the widespread adoption of CVT for product visualization and augmented reality (AR) applications. E-commerce platforms are leveraging CVT to enable customers to virtually try on clothing, visualize furniture in their homes, or preview how cosmetics will look on them. This enhances the online shopping experience, mitigating the traditional challenges of not being able to physically interact with products.

Visual search is another burgeoning trend powered by CVT. Consumers can now search for products using images, making the search process more intuitive and efficient. This is particularly significant with the increasing reliance on smartphones for online shopping, where users can simply snap a picture and find similar products.

CVT's role in automating and optimizing supply chain and logistics is also a prominent trend. E-commerce companies are utilizing CVT for automated quality control in warehouses, monitoring inventory levels, and streamlining the packaging and shipping processes. This leads to operational cost savings, quicker delivery times, and improved customer satisfaction.

Within the e-commerce sector, CVT is experiencing a surge in interest, captivating numerous companies keen on exploring its diverse applications. In terms of adoption rates, major players like Amazon, Alibaba, and Google have been at the forefront of integrating CVT into their e-commerce platforms. These industry leaders have set the pace for others, encouraging widespread adoption. Small and medium-sized enterprises are also increasingly integrating CVT into their operations, with the proliferation of accessible and cost-effective CVT solutions. A prominent example is Amazon, where CVT has been seamlessly integrated into Amazon Go stores. This integration involves a sophisticated system of cameras and sensors that meticulously track customer movements throughout the store. Through this, customers can conveniently pick up items, and the system automatically charges them accordingly, exemplifying a seamless and efficient shopping experience (Amazon Go, 2021). Furthermore, in the realm of e-commerce, various companies harness the potential of CVT for visual search capabilities. This functionality empowers customers to seek out products by either uploading images or capturing photos with their smartphones, showcasing how CVT is advancing the way users navigate and interact with online shopping platforms (Wang, 2019).

As CVT technology continues to advance and become more accessible, it is anticipated that adoption rates will continue to rise. Businesses are recognizing the competitive advantages and efficiency gains offered by CVT, which will likely drive a further surge in its adoption across the global e-commerce landscape.

2.4.3 The situation in Nigeria

Nigeria's e-commerce sector has experienced substantial growth recently, propelled by several factors: the upsurge in internet usage, a burgeoning middle class, and the

transformative impact of the COVID-19 pandemic on online shopping trends (Adeoye & Eze, S. C. , 2020). This growth has garnered significant investment, notably highlighted by Jumia, a leading e-commerce platform in Nigeria, going public on the New York Stock Exchange in 2019.

However, the integration of computer vision technology within the Nigerian e-commerce landscape is still in its nascent stages. Research from the Nigerian Communications Commission underscores a pertinent challenge: less than 40% of the country's population has internet access, thus limiting the potential reach and application of technology-driven solutions like computer vision (Nigerian Communications Commission, 2021). Moreover, the scarcity of skilled professionals and constrained access to funding pose substantial hurdles to the widespread adoption of computer vision within Nigeria (Adeniji, 2021)

Yet, amidst these challenges, select local startups and enterprises are embarking on the exploration of computer vision applications in the e-commerce domain. Jumia, for instance, has successfully integrated computer vision into its platform, empowering customers to seek out products using images and receive personalized recommendations based on their preferences.

As Nigeria's e-commerce sector continues to grow, the adoption of computer vision technology is expected to increase, offering new opportunities for growth and innovation. However, to fully realise the potential of computer vision in Nigerian e-commerce, there is a need to address the challenges associated with infrastructure, talent, and funding.

2.4.4 Benefits of Computer Vision Technology adoption in the Nigerian e-commerce sector

In accordance with the detailed analysis and research conducted by Allied Market Research, the expected growth of 17.4 billion dollars in revenue by 2023 and $41.11 billion by 2030 indicates a significant expansion in the computer vision market, aligning with its increasing applications across diverse industries. This growth signifies the rising importance and

adoption of computer vision technologies, resulting in numerous advantages for the e-commerce industry.

1. **Increased Efficiency and Cost Savings**

   Adopting computer vision technology in the Nigerian e-commerce sector can increase efficiency and cost savings. Businesses can reduce manual labour requirements and associated costs by automating tasks such as product search and discovery, personalised recommendations, and fraud detection. Furthermore, computer vision technology can help optimise supply chain processes, inventory management, and pricing strategies, ultimately improving overall business operations.

2. **Enhanced Customer Experience and Satisfaction**

   Implementing computer vision technology can significantly enhance customer experience and satisfaction within the Nigerian e-commerce sector. By offering more accurate and relevant product search results and personalised recommendations, customers can easily and quickly find what they are looking for. Additionally, improved fraud detection capabilities can increase customer trust in e-commerce platforms, leading to higher satisfaction and loyalty.

3. **Boosted Revenue and Economic Growth:**

   The adoption of computer vision technology could increase profits and promote economic development in Nigeria. E-commerce companies can boost sales and revenue development through increasing efficiency, raising customer satisfaction, and increasing client retention. This can then result in the creation of jobs, increased investment in technology, and national economic growth.

4. **Improved Inventory Management and Reduced Waste**

   Computer vision technology can significantly enhance inventory management in the Nigerian e-commerce sector by automating tracking and monitoring stock levels; computer vision systems can help businesses avoid stockouts and overstocking, reducing waste and improving overall efficiency. Accurate inventory data can also help businesses make better-informed decisions about procurement and product offerings.

5. **Greater Accessibility and Inclusivity**

   CVT plays a pivotal role in enhancing the accessibility and inclusivity of e-commerce platforms, catering to a wider spectrum of users, including those with visual impairments or language constraints. Through the integration of image-based search and navigation capabilities, computer vision empowers users to locate products and access information with heightened efficiency, irrespective of their reading proficiency or language proficiency. This proactive approach fosters a diverse and inclusive customer base, thereby stimulating revenue growth for businesses in the e-commerce domain.

6. **Enhanced Precision in Marketing and Advertising Effectiveness**

   The analysis of user behavior and preferences through computer vision technology empowers companies to craft highly tailored and effective marketing campaigns. By gaining insights into the visual elements that resonate with consumers, businesses can create promotional materials that are precisely designed to captivate and convert their intended audience. This strategic approach has the potential to significantly enhance the return on investment derived from marketing and advertising endeavors.

7. **Streamlined Returns and Customer Service Processes**

   Computer vision technology can also automate and improve the handling of product returns and customer service inquiries. For instance, businesses can use computer vision to verify product returns, ensuring that the correct item is returned and in the appropriate condition. Additionally, computer vision can quickly and accurately identify products in customer service inquiries, leading to faster resolution times and improved customer satisfaction.

8. **Enhanced User-Generated Content Analysis**

   By leveraging computer vision technology, e-commerce businesses can better analyse and understand user-generated content, such as customer reviews, photos, and videos. This can help businesses identify trends, preferences, and areas for improvement,

ultimately leading to better-informed decisions and strategies for product development and customer engagement.

2.4.5. Use Cases and Comparison across Africa.

For Africa, the Level of adoption of Computer Vision Technology (CVT) in the e-commerce sector is progressive, this is due to the fledging nature of the e-commerce space in most African countries. Apart from Northern African Countries such as Morocco, Tunisia, and Egypt with significant influence from European markets, most other African countries are still trailing in the adoption of Computer Vision Technology in the E-commerce sector.

North Africa – Egypt

A 2022 MDPI Sustainability Report revealed that investigations are situated at realizing the capability of Computer Vision applications being used to analyze user experiences in metro stations and efforts are proposed for the implementation of a computer Vision system for the extensive analysis of orphanages in Egypt, since traditional methods of monitoring and evaluation orphanages often fall short in capturing the nuanced aspects of child-wellbeing and caregiver performance. However, no Reports were given for the adoption of CVT for their e-commerce sector.

East Africa – Rwanda

A Report by Access Partnership in June 2023 said that the adoption of the National AI Policy is a significant step towards harnessing the potential of AI for the country's progress. Developed by its Ministry of ICT and Innovation in collaboration with the Rwanda Utilities Regulatory Authority (RURA) and others to set out the vision for integrating CVT across various sectors of its economy.

East Africa: Kenya

While there is no reporting on Computer Vision, there is evidence of Computer Vision start-ups developing in Kenya. There is a growing community of computer vision learners owing to the online courses in artificial intelligence and introduction to AI degrees in Kenyan

universities. This indicates that there is the possibility of more developments of AI in the future that will solve the underlying problems in Kenya.

One of the reasons why Kenya may be lagging in terms of the adoption of Computer Vision compared to other African countries is because Kenya is not documenting many initiatives since they do not lead to company creation. In addition, there are high entry costs to the formal sector, which may affect the entrepreneurial space.

South Africa - Botswana

Data gathered showed that Botswana lags behind in the list of "informed nations" within Africa as it lacks a coherent framework for ICT. Hence, there's no CVT in the country.

West Africa: Senegal

The use of Computer Vision Technology is not new in Senegal, as reports shows that it has been tested within the health sector, however, its usage within the e-commerce sector is still very progressive in nature.

Overall, in comparison to other Africa countries, Nigeria shows significant stride in both awareness and utilization of computer vision technology.

2.5 Potential Use Cases for Visual Search Technology

Visual search technology is a way of searching the web using images instead of words. It can help users find information about objects, products, places, and more by simply taking a picture or uploading an image. Visual search technology uses artificial intelligence and computer vision to analyze the image and provide relevant results.

The adoption of visual search technology often depends on factors such as the size of the retailer, available budget for technology investments, and the retailer's focus on enhancing the online shopping experience.

Visual search technology can be applied to various use cases in Nigerian e-commerce to enhance the shopping experience and improve customer engagement. Here are some potential use cases:

1. **Fashion and Apparel**: Nigerian e-commerce platforms can implement visual search for fashion and apparel items. Shoppers can upload images of clothing they like, and the system will provide similar products from the catalog, helping users discover fashion items more easily.

2. **Home Decor and Furniture**: Visual search can assist customers in finding home decor and furniture products by allowing them to snap a picture of a room or a piece of furniture they want to match, and the system can suggest complementary items or similar styles.

3. **Beauty and Cosmetics**: In the beauty industry, customers can use visual search to find makeup products that match their desired look. By uploading a picture of a makeup style, they like, they can receive product recommendations.

4. **Electronics and Gadgets**: Visual search can help shoppers find electronics and gadgets by allowing them to take a photo of a specific device or accessory. The system can then display matching or compatible products.

5. **Food and Groceries**: Visual search can assist in identifying food items. Shoppers can take a picture of an ingredient or a packaged food item, and the system can provide information about it or suggest related recipes.

6. **Art and Crafts: For art enthusiasts**, visual search can help users discover artworks or craft supplies by analyzing images of artwork or DIY projects they admire.

7. **Automotive Parts**: Customers looking for specific automotive parts or accessories can use visual search to identify and purchase the right products by uploading pictures of their vehicles or the parts they need.

8. **Antiques and Collectibles**: Visual search can assist collectors in identifying and valuing antiques and collectibles by analyzing images of items they're interested in.

9. **Local Artisans and Handmade Products:** Visual search can support local artisans and sellers of handmade goods by helping customers find products that match a specific handmade style or aesthetic.

10. **Product Authentication**: To combat counterfeit products, visual search can be used to verify the authenticity of items by scanning product labels or images.

11. **DIY and Home Improvement:** Visual search can help DIY enthusiasts find tools and materials by analyzing images of their home improvement or craft projects.

12. **Local Marketplaces:** Visual search can be integrated into local online marketplaces to make it easier for buyers and sellers to find relevant products among a diverse range of offerings.

2.6 Challenges of Computer Vision Technology Adoption by E-commerce Start-ups in Nigeria

It is anticipated that e-commerce would play a bigger role in the economy of Nigeria as it moves into the future. Nigeria, with its sizable population and high internet penetration, is ideally positioned to become the dominant African nation in the e-commerce sector.

To ensure the successful adoption of computer vision technology in e-commerce, a number of obstacles must be overcome. The following challenges could make it more difficult for Nigeria to embrace computer vision technology:

1. **Size of Required data set**

   According to a survey (Garanhel, 2023), the size of required data sets was highlighted as the biggest limitation in computer vision, receiving 42.3% of votes. High costs (at 20.4%) were indicated as the second biggest limitation. It's also important to note that individuals who selected "Other" in response to the question highlighted

constraints such as a lack of appropriate silicon, privacy or data security, a lack of data, and a lack of resources.

2. **Poor data quality**: Computer vision technology relies on large and diverse datasets of labeled and annotated images to train and test the algorithms. However, collecting and curating such datasets can be challenging in Nigeria, where there may be a lack of data sources, data standards, and data protection regulations. Furthermore, the datasets may not reflect the local context, culture, and diversity of Nigeria, leading to biased and inaccurate computer vision models.

3. **Lack of experienced professionals**

   In response to the growing prevalence of computer vision applications, ensuring a qualified workforce to translate ideas into reality is crucial. While the number of artificial intelligence professionals globally is in the hundreds of thousands, the burgeoning demand for roles in this field exceeds millions, highlighting a significant skills gap. This gap has been exacerbated by the widespread accessibility of AI and deep learning, motivating both established corporations and startups to venture into the domain. To address this issue, enhancing resources for digital, technical, and mathematical education is key. Notably, industry leaders like Amazon and Google are investing on a global scale to enlarge their talent pool. Additionally, businesses can concentrate on retraining and upskilling their existing employees to bridge the skills divide effectively.

4. **Inadequate hardware**

   Computer vision technology requires high-resolution cameras, sensors, and other devices to capture and process images effectively. However, these hardware components can be costly and difficult to install and maintain in some areas of Nigeria, especially in rural and remote regions. Moreover, the availability and

reliability of electricity and internet connectivity can also affect the performance of computer vision systems.

5. **Ethical concerns:**
   Computer vision technology presents ethical concerns encompassing privacy, consent, accountability, and fairness. Instances include the potential infringement on individuals' and groups' rights and freedoms in Nigeria through systems like surveillance, facial recognition, or biometric identification. Moreover, these technologies can manifest bias or discrimination, disproportionately affecting specific segments of the population, including women, minorities, and people with disabilities.

6. **Lack of awareness and skills:**
   computer vision technology is an emerging field in Nigeria, but it's relatively new, leading to limited awareness and comprehension of its advantages and possible uses among the general public and prospective users. Additionally, there is a scarcity of proficient professionals capable of creating, implementing, and overseeing computer vision systems in the country. Hence, there's a pressing requirement for increased education, training, and skill development in computer vision technology across Nigeria.

SECTION THREE: DATA ANALYSIS AND RESULTS OF THE STUDY

3 ANALYSIS OF FINDINGS

3.1 Demographics

The primary objective of this research to explore the application of Computer Vision Technology for E-Commerce sector growth in Nigeria. This study involved individuals who are currently working in e-commerce organizations within Nigeria.

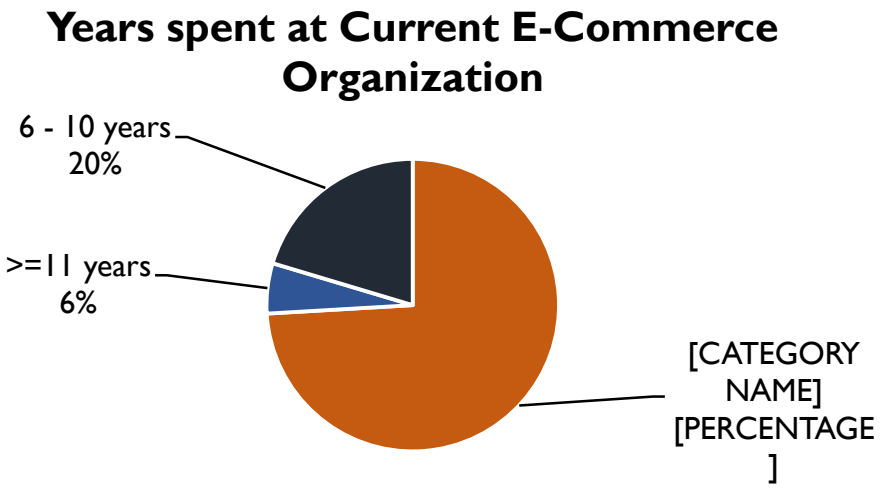

Figure 1Number of years spent at current Ecommerce Organization

In Figure 3 above, we observe that majority (74%) of the respondents in this study have worked within their current e-commerce organization of employ for between 0-5 years. About 20% of the respondents had worked within their organizations for about 6-10 years and only 6% of respondents had worked in their organizations for more than 10 years.

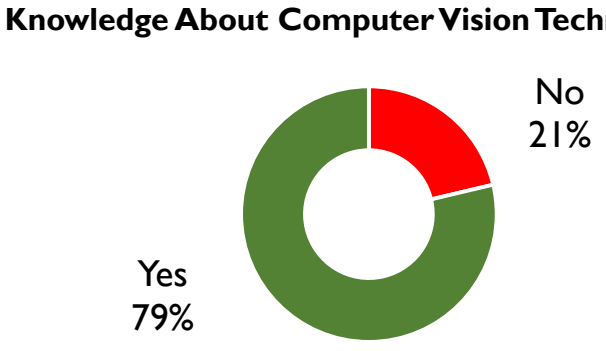

Figure 2- Knowledge about Computer Vision Technology

The respondents were asked if they had ever heard about Computer Vison Technology; we can observe from Figure 2 that 79% of the respondents affirmed that they had while 21% said they knew nothing about the technology.

3.2 Objective 1:

The first objective of this study was to investigate the possibility of adopting computer vision in enhancing e-commerce in Nigeria. In view of this, the following research questions were asked;

1. What are the potential benefits of adopting computer vision technology in the e-commerce sector in Nigeria?
2. What challenges will be associated with adopting computer vision technology in the e-commerce sector in Nigeria?
3. How can these challenges be mitigated to increase the chances of adoption?

3.2.1 Research Question 1:

What are the potential benefits of adopting computer vision technology in the e-commerce sector in Nigeria?

In order to answer this, the respondents were asked if they believed computer vision technology could improve the e-commerce sector in Nigeria;

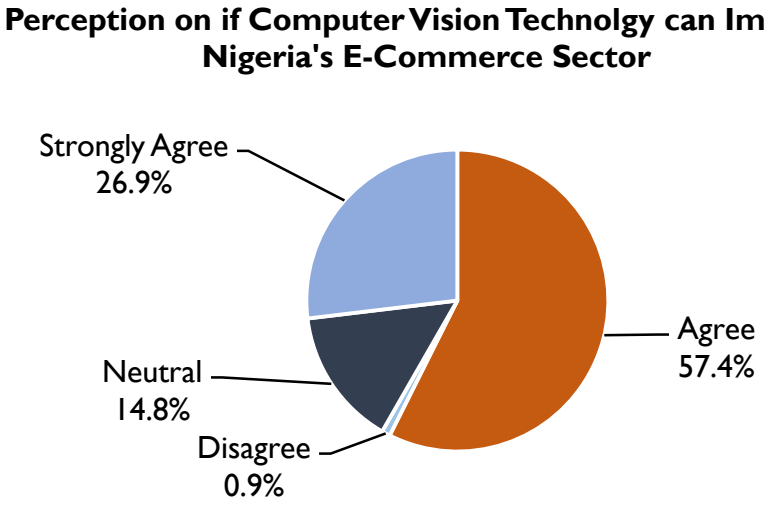

Figure 3 Perception on Computer Vision's ability to improve Nigeria's E-commerce Sector

From Figure 3 above, we note that 57.4% of the respondents agreed that Computer Vison Technology can improve the E-commerce sector in Nigeria. 26.9% strongly agreed while only 0.9% disagreed.

The respondents were then asked what they opined was the most significant benefit of using computer vision technology in e-commerce.

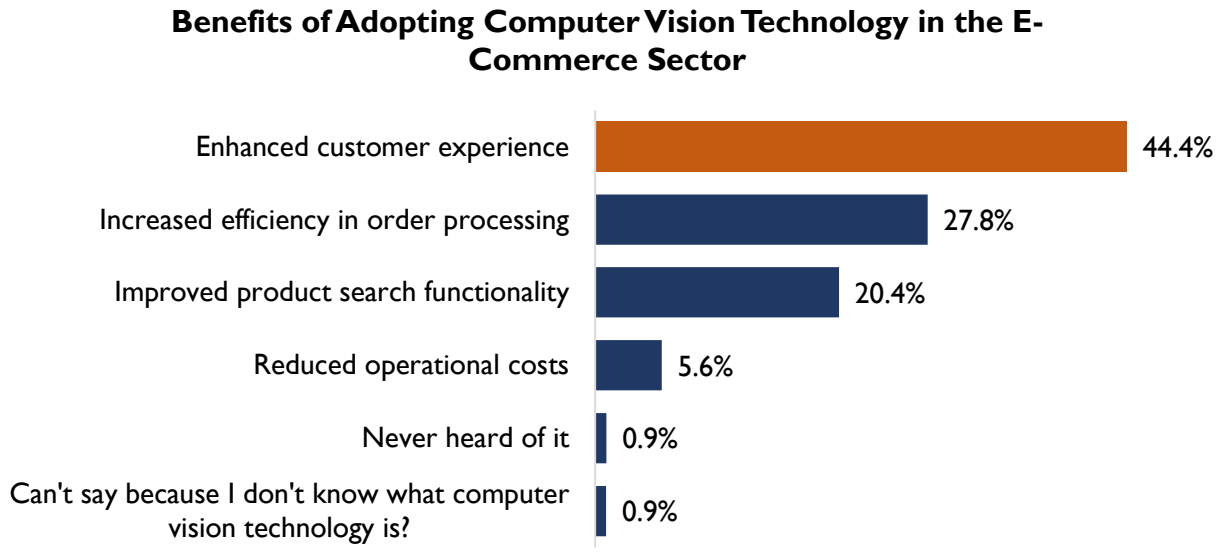

Figure 4Benefits of Computer Vision Technology to Ecommerce Industries

In view of the posed question, we see in Figure 4 that majority of the respondents (44.4%) agreed that the most significant benefit of adopting computer vision technology in the e-commerce industry in Nigeria is "Enhanced Customer Experience". A stark example of this is seen in Amazon whose sales increased by nearly 30% after making use of Computer Vision Technology to develop the online recommendation system from browser history. Additionally, Pillarisetty & Mishra, 2022 also said that implementing Recommender Systems; Augmented Reality, Interactive Image and Virtual Try-On's and ChatBots are innovative ways the technology is being used to enhance customer experience. This leads to an increase in customer satisfaction (Valenzuela-Fernández, Nicolas, Gil-Lafuente, & Merigó, 2016) and customer retention (Mondal, Das, & Vrana, 2023) and by proxy improving the growth of the ecommerce industry.

Improved Product Search Functionality and Increased efficiency in Processing orders were the next most agreed with options with 20.4% and 27.8% agreeing with the option. Reduced operational cost was the least significant benefit of the technology identified in this study.

3.2.2 Research Question 2

What challenges will be associated with adopting computer vision technology in the e-commerce sector in Nigeria?

In order to answer this research question, the respondents were also asked to identify the most significant challenge companies are likely to face when attempting to adopt the technology.

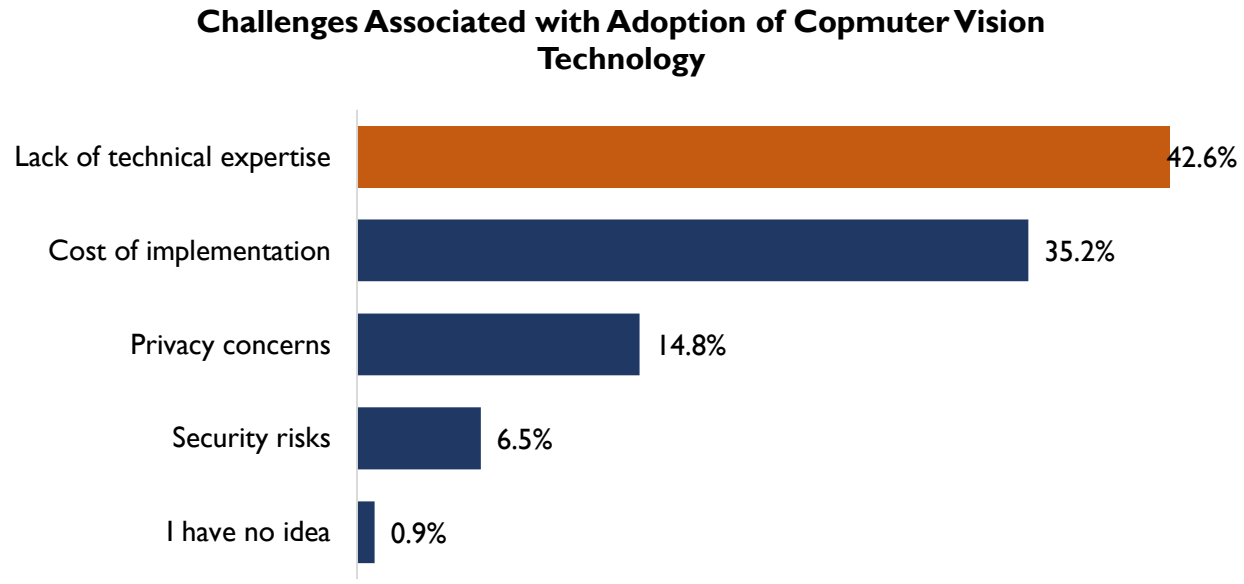

Figure 5 Challenges associated with adoption of Computer Vision Technology

According to the respondents making reference to Figure 5, Lack of Technical Expertise (39%) is the biggest and most likely challenge that companies will face when trying to adopt the technology. The lack of technical expertise has remained a great barrier to the adoption of technology including AI across many sectors like agriculture (Owino, 2023), education (Madu, Obidi, & Genevive, 2015) and even in government (Nath & Kanjilal, 2018). Cost of Implementation also poses a significant threat to the adoption of the technology according to 30.6%. are likely to face. According to Igwe, et al., 2021 who observed that cost of

adopting technology in Nigeria is one of the issues pf the ecommerce industry. However, a few respondents (19.4%) opined that unfavorable policies by the government also play a role in hindering the adoption of the technology.

3.2.3 Research Question 3

How can these challenges be mitigated to increase the chances of adoption?

Based on the identified challenges with adopting computer vision Technology, the respondents were asked to identify solutions to the challenges that companies might encounter while trying to adopt the technology.

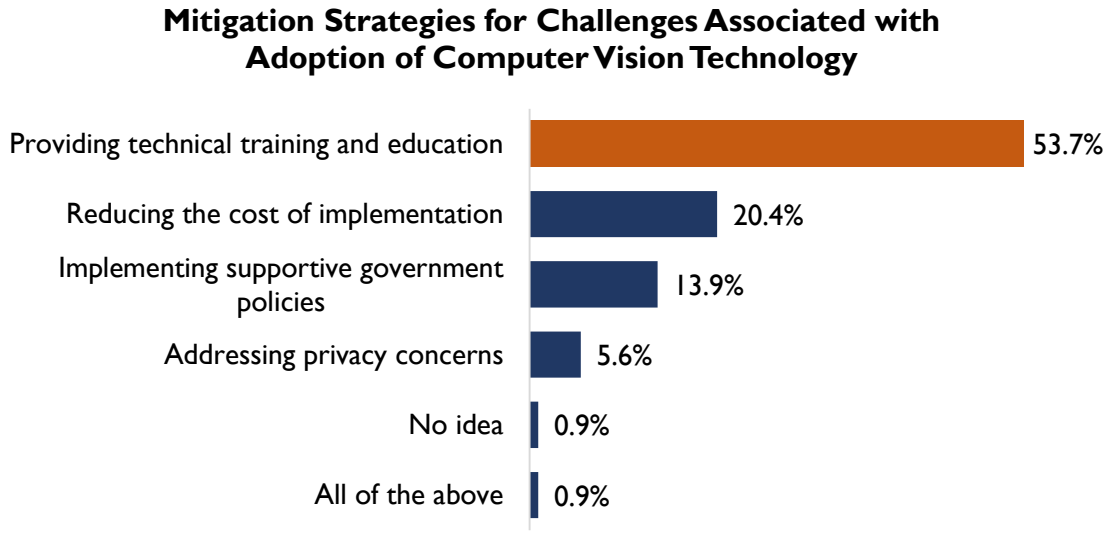

Figure 6 Mitigation strategies for the setbacks associated with the adoption of computer vision technology

According to the respondents, Lack of Technical Expertise is the biggest challenge that companies will face, in the same vein, 56.3% of the respondents noted that the best mitigation strategy to address these challenges is to Provide Technical Training and Education for the companies and organizations that want to make use of the technology. Certain other authors have also suggested training and building the capacity of the employees plays a significant role in the adoption of new technology (Mingaine, 2013; Zaied, 2012; Ibrahim, Turyakira, & Katumba, 2018). Also in line with Figure 5, Reducing the cost of Implementation was the second most suggested solution to the identified challenges

associated with adoption of computer vision technology. Indrawati, 2020 also studied barriers to technological innovations of SMEs and discovered that government support, quality of human resources, funding of technological innovation, economic conditions and lack of business partnerships were the major barriers in technological adoption especially in SMEs.

In line with previous responses, the study looked at the role of the government in fostering adoption of the technology by e-commerce organizations. The respondents were asked to suggest ways in which the governmanet can provide further support to organizations that want to adopt the technology(How can the government support the adoption of computer vision technology in the e-commerce sector in Nigeria?).

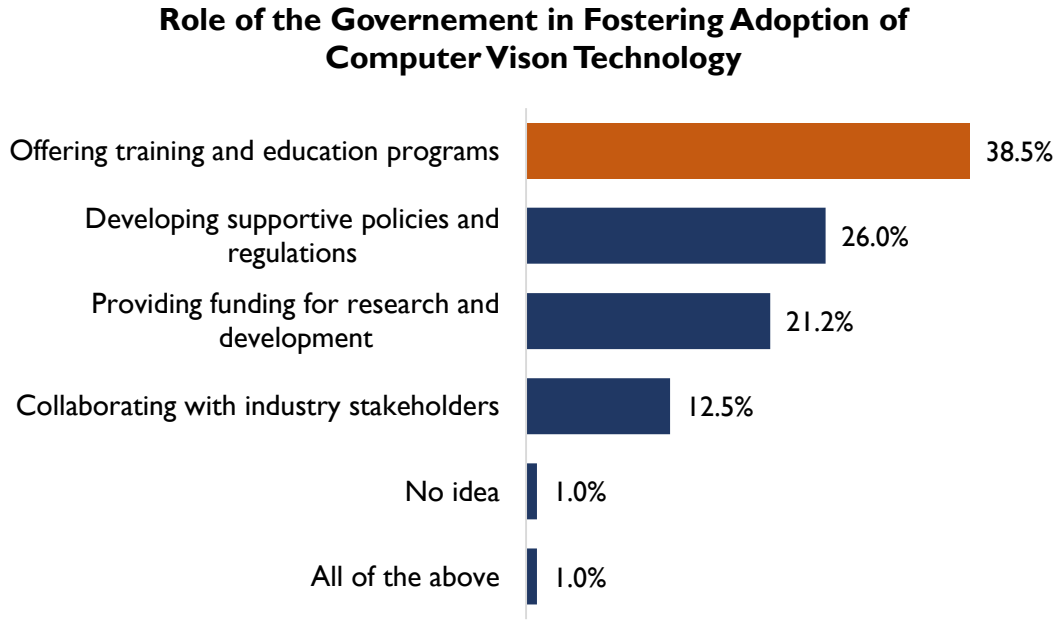

Figure 7Role of Government in Fostering Adoption of Computer Vision Technology in Nigeria

Majority of the respondents (38.5%) affirmed that the government can support by offering training programs and education to encourage more businesses to adopt Computer Vision Technolgy. 26% of the respondents agreed that the government could develop more supportive policies and regulations around the technology. Government funding was also a favored choice by 21.2% of the respondents further affirming Igwe, et al., 2021 who said that

governmnet funding for adoption of technology in the ecommerce sector plays a vital role. 12% of the respondents suggested the government collaborating with industry stakeholders to make the technology more readily availbale.

Table 2: Relationship between likeliness to adopt Computer Vision Technology and Perception of the Government's role in facilitating adoption of the technology in Nigeria.

	Do you think government policies can facilitate the adoption of computer vision technology in e-commerce in Nigeria?	Disagree	Agree	Neutral	Strongly agree	Total
How likely are you to adopt computer vision technology in your e-commerce business?	Neutral	0	13	7	0	20
	Somewhat likely	0	38	6	4	48
	Somewhat unlikely	1	1	0	0	2
	Very likely	1	15	5	17	38
Total		2	67	18	21	108

Table 1 presents data from 108 e-commerce businesses in Nigeria, exploring their likelihood to adopt computer vision technology and their perception of the government's role in its adoption. A significant majority, 67 respondents, agreed that government policies can facilitate the adoption of this technology in e-commerce, while 18 remained neutral and 21 strongly agreed. Only 2 respondents disagreed. Delving deeper into the likelihood of these businesses adopting computer vision technology, 48 indicated they were "Somewhat likely" to adopt, with the majority (38) agreeing on the government's facilitative role. Another 38 respondents were "Very likely" to adopt, with a notable 17 strongly agreeing on the government's positive influence. Meanwhile, 20 respondents were neutral about adoption, with 13 agreeing on the government's role. A minimal 2 respondents were "Somewhat unlikely" to adopt, holding contrasting views on the government's role. The findings showed that the majority of e-commerce businesses in Nigeria that are inclined to adopt computer vision technology believe in the pivotal role of government policies in facilitating its integration, emphasizing the crucial interplay between technological adoption and governmental support.

Table 3: Chi Square test of Association between likeliness to adopt Computer Vision Technology and Perception of the Government's role in facilitating adoption of the technology in Nigeria.

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	32.597[a]	12	0.001
Likelihood Ratio	34.287	12	0.001
N of Valid Cases	108		
a. 13 cells (65.0%) have expected count less than 5. The minimum expected count is .01.			

A Chi-Square test was performed to assess the association between the propensity of Nigerian e-commerce businesses to adopt computer vision technology and their perceptions regarding the government's role in facilitating this adoption. The results indicated a significant relationship between these two variables, $\chi^2(12, N = 108) = 32.597$, $p < .001$. This finding was further corroborated by the likelihood ratio, which yielded a $\chi^2(12) = 34.287$, $p < .001$. The Chi Square test with a p-value of 0.001 which suggests a very strong relationship between likeliness to adopt computer vision technology and the Government's role in facilitating adoption of the technology in Nigeria aligns with the view of Owino (2023) who opined that government support and related policies that encourage the adoption of technology for the growth of the ecommerce sector are necessary if adoption is desired. In 2020, Mudawi, et al., also affirmed that the government has a big role to play in adoption of computer based solutions and advancements. (Govinnage & Sachitra, 2019) also agreed that government support plays a role in the adoption of computer based solutions in the ecommerce sector. Government support can be financial in the form of loans and grants but it can also be non-financial in the form of supportive policies, government implemented cloud computing (Zaied, 2012; Maskus & Reichman, 2017; Owino, 2023), subsidies (Maskus & Reichman, 2017), trainings and education, incentives for organizations implementing the technology.

There is room for governments to gain from their supporting ecommerce organizations with the implementation of Computer Vision Technology. The adoption of computer vision technology in the e-commerce industry will, first and foremost, directly promote business growth (Owino, 2023). This is notably true through greater economic activity, the creation of jobs, and business expansion, all of which will improve tax revenue for the government (Al-Hudhaif & Alkubeyyer, 2011).

Secondly, if the government invests heavily in research, development, and/or funding projects, any new innovation can serve as an avenue for the government to benefit from intellectual property rights or patents (Kreishan, Elseoud, & Selim, 2018). This strategic ownership may create opportunities for licensing these innovations to companies or even foreign rivals, allowing for generation of royalties that have a favorable impact on government revenue sources. Research institutions and government-funded laboratories are poised to conceive pioneering computer vision technologies. These innovations can be effectively transferred to private enterprises via licensing agreements or strategic partnerships, consequently leading to the accrual of licensing fees or participation in equity arrangements (Kreishan, Elseoud, & Selim, 2018). If the government gives grants, subsidies, or loans to support computer vision technologies they retain the right to set complex payback conditions or buy equity stakes in the companies that benefitted from the programs (Li Y. , 2022). This creates an avenue for returns on investment if the project is successful. If the governmet of Nigeria becomes a leading body in the domain of computer vision technology advancement, it has the prospect of extending consultative services, educational programs, and technological solutions within Nigeria and internationally (Chandramouli & Izquierdo, 2012; Sophokleous, Christodoulou, Doitsidis, & Chatzichristofis, 2021). The resulting exportation of knowledge and capabilities stands to generate revenue streams.

3.3 Objective 2:

To Evaluate the Current Level of Adoption of Visual Search among Nigerian E-Commerce Retailers. In order to achieve this objective, the following research questions were posed:

1. What is the current level of adoption of visual search technology among Nigerian e-commerce retailers?
2. What are the potential benefits and challenges associated with the adoption of visual search technology in the Nigerian e-commerce sector?
3. How can the challenges facing the adoption of computer vision technology in the e-commerce sector in Nigeria be addressed?
4. What are the potential use cases and applications of visual search technology in the Nigerian e-commerce sector, and how can e-commerce retailers leverage these use cases to enhance their operations and growth?

3.3.1 Research Question 1

What is the current level of adoption of visual search technology among Nigerian e-commerce retailers? In order to answer this question, the respondents were asked if they currently make use of the technology in their organizations.

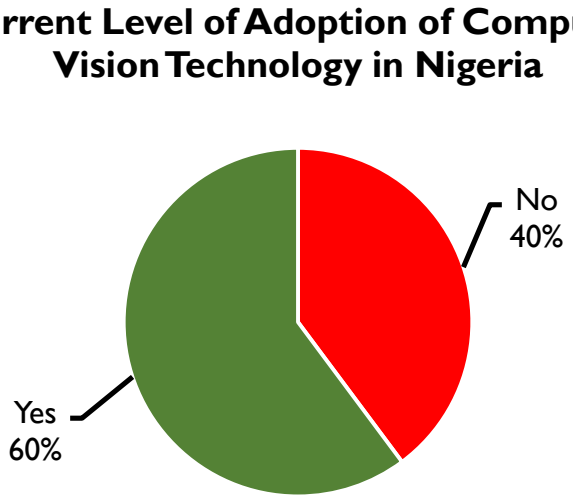

Figure 8 Current Level of Adoption of Computer Vision Technology in Ecommerce Industries in Nigeria

From Figure 8, we note that 60% of the respondents declared that they were currently making use of the technology in their operations. To further deepen our understanding of

the current adoption of the technology, the respondents were asked how long they had been making use of the technology.

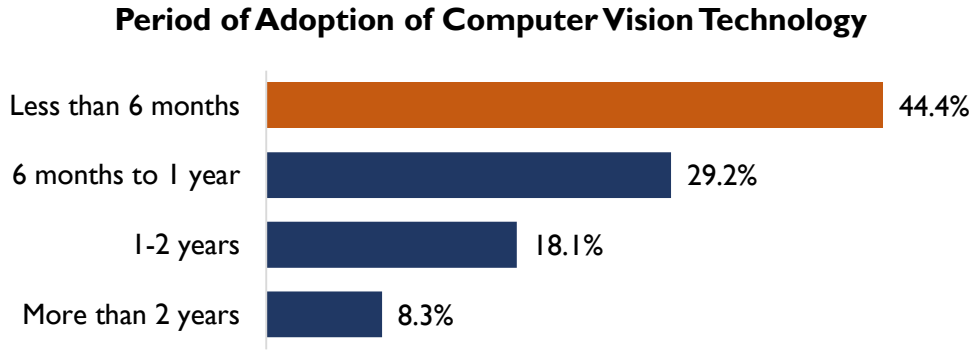

Figure 9 How long Ecommerce Organizations in Nigeria have been making use of the Technology

Based on the findings of this study with Figure 9 in view, adoption of this technology started majorly (44% of respondents) within the last six months. 8.33% of the respondents were early adopters who had adopted the technology over two years ago. Only about 29.17% had been using the technology for over a year and about 18% of the respondents had been using the technology for over a year but less than two years.

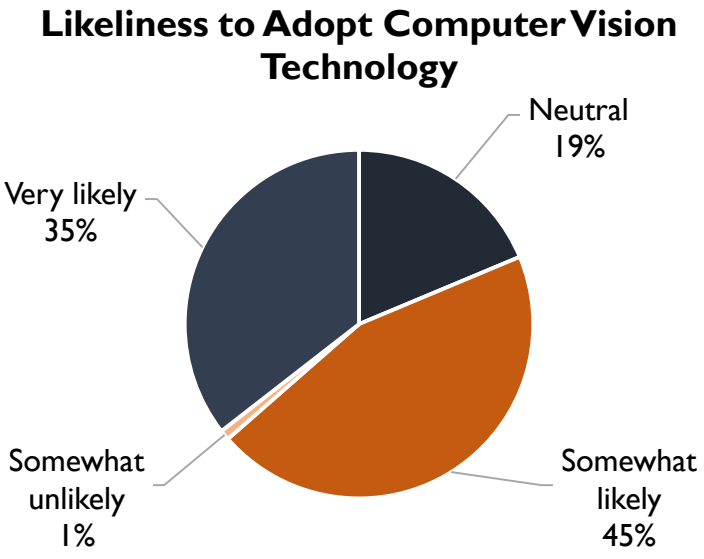

Figure 10 Likeliness to adopt Computer Vision Technology

From Figure 10, out of the 40% who had not adopted the technology yet, 35% stated that they would very likely adopt the technology in the near future and 45% indicated they are

somewhat likely to adopt. 19% were unsure while 1% out rightly declared that they would not be adopting the technology.

Relationship between knowledge of Computer Vision Technology and Likeliness to Adopt the Technology

Table 4: Cross Tabulation of prior knowledge of computer vision technology and likelihood of adoption

		How likely are you to adopt computer vision technology in your e-commerce business?					
			Neutral	Somewhat likely	Somewhat unlikely	Very likely	Total
Have you heard of computer vision technology before?	No	0	6	8	0	9	23
	Yes	1	14	40	1	29	85
Total		1	20	48	1	38	108

Table 3 presents a cross-tabulation examining the relationship between knowledge of computer vision technology and the likelihood of its adoption in e-commerce businesses, a notable trend emerged. Among the 85 respondents who were familiar with computer vision technology, a significant proportion expressed a high likelihood of adoption, while a similar number showed hesitancy. Conversely, the majority of the 23 respondents unfamiliar with the technology leaned towards being somewhat unlikely to adopt it. This suggests that while awareness of computer vision technology can influence its adoption in the e-commerce sector, other underlying factors might be at play, potentially affecting the decision-making process even among those informed about the technology.

Table 5: Chi square test of association between prior knowledge of computer vision technology and likelihood of adoption

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	2.188[a]	4	0.701
Likelihood Ratio	2.565	4	0.633
N of Valid Cases	108		
a. 5 cells (50.0%) have expected count less than 5. The minimum expected count is .21.			

A Chi-square test was conducted to determine the association between prior knowledge of computer vision technology and the likelihood of its adoption in e-commerce businesses. The Pearson Chi-Square value was 2.188 with 4 degrees of freedom, p = .701, and the Likelihood Ratio was 2.565 with 4 degrees of freedom, p = .633. Given the p-values well above the 0.05 threshold, there is no statistically significant association between prior knowledge of computer vision technology and the likelihood of its adoption. Moore & Benbasat, 1991, discussed the relationship between knowledge and technology adoption. They discovered that people's opinions about a technology have a big impact on whether they plan to adopt it or not. The study also stressed the significance of gauging the technology's views among potential adopters, as this is a crucial component in understanding technology adoption and diffusion.

3.3.2 Research Question 2

What are the potential benefits and challenges associated with the adoption of visual search technology in the Nigerian e-commerce sector?

The respondents were asked to highlight the most significant benefit they had gained while adopting and implementing the technology.

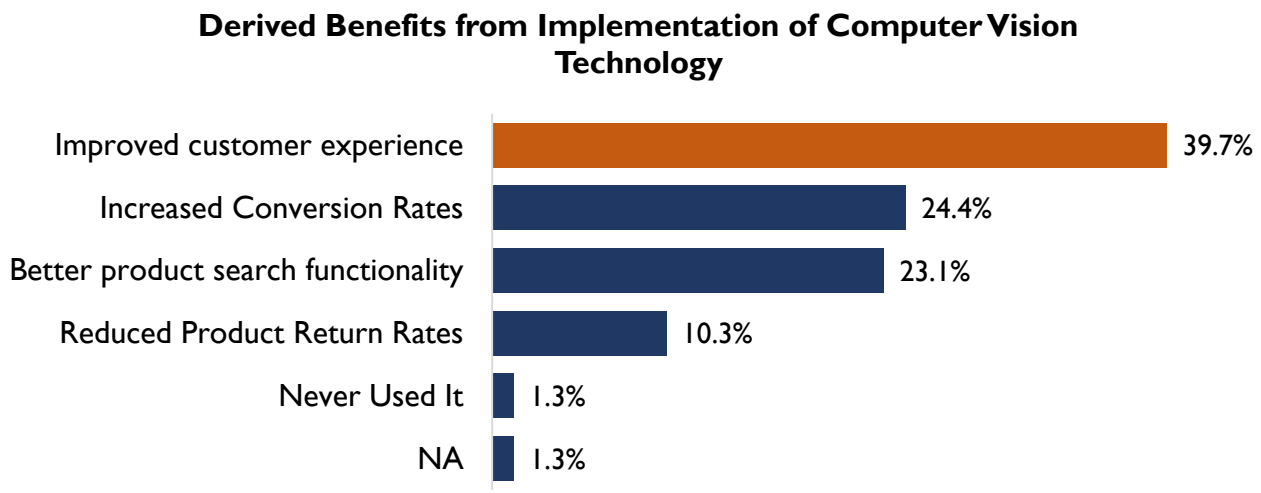

Figure 11 Benefits of Implementing Computer Vision Technology

In Figure 11 above, about 38% of the respondents stated that they had used the technology to improve customer satisfaction through improving their shopping experiences. This also agrees with Pillarisetty & Mishra, 2022; Valenzuela-Fernández, et al., 2016; both whom agree that computer vision technology improves shopping experiences of customers, lowers return rates due to more product search accuracy leading to higher rates of customer satisfaction. 24.4% of the respondents reported having Increased conversion rates (i.e more customers reacting positively to prompts such as purchasing a product). Conversion rates have been known to increase with improved product visualizations and virtual try on (Li, Wu, Jiang, Xu, & Liu, 2019), personalized product recommendations (Jiang, et al., 2022), fraud detection and prevention (Jiang, et al., 2022) etc. Furthermore, 10.3% of respondents reported having reduced returned products due to better product matching as a result of the technology.

Working with the responses from Figure 5, we also looked at factors ecommerce organizations have to consider before adopting Visual Search technology.

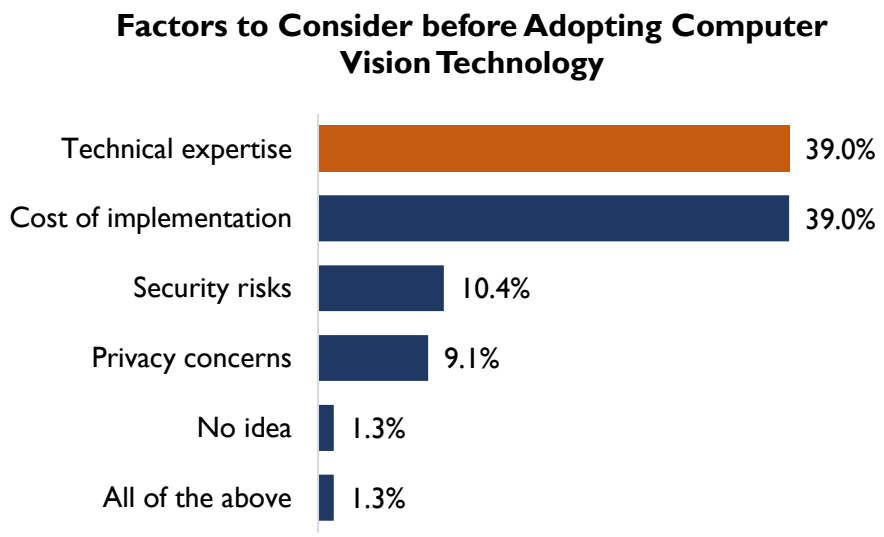

Figure 12 Factors to consider Before adoption of the technology

From Figure 12 above, the Lack of Technical Expertise (39%) and the Cost of Implementation (39%) are the most considered factors for adoption and implementation pf computer vision technology. Owino, 2023 also agreed listing Technical Expertise, Cost, and Inadequate Infrastructure as factors to onsider when trying to implement Computer Vision Technology.10.4% of the respondents cited Security Risks from the technology as the most important factor to consider while 9.1% cited Privacy Concerns. In line with this, (Chandramouli & Izquierdo, 2012) stated that data security is a big issue to consider when implementing computer vision technology. Altogether, only 1.3% of the respondents declared that all the factors listed were equally pressing.

The cost of implementing Visual Search technology is a serious challenge to ecommerce organizations in Nigeria. In that light, the respondents were asked to highlight the strategy they perceived to be the most effective in managing the cost of implementation.

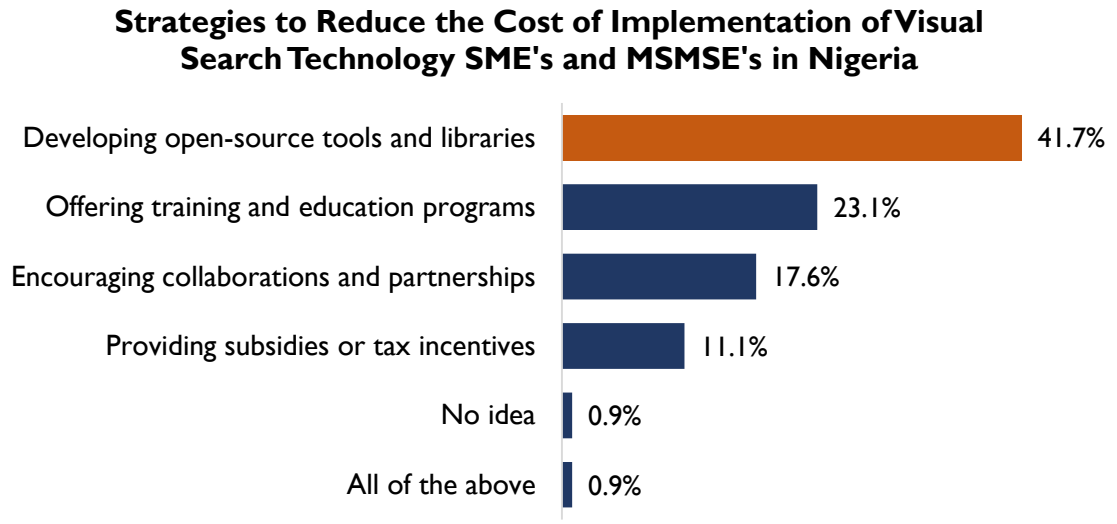

Figure 13Strategies to reduce the cost of implementation of visual search technology in SMEs and MSMEs in Nigeria

A gross proportion of the respondents as seen in Figure 13 stated that if Open-Source Tools and Libraries for Computer vision technology was available, the costs can be managed. In 2016, Gebremichael, et al., 2016 discussed open innovation as a strategy to kitigate cost of implementation of new technology by SMEs and MSMES. Small and medium-sized businesses (SMEs) can collaborate strategically with other companies, prestigious academic institutes, and other businesses by using open innovation as a channel. These partnerships make it easier to gain access to valuable external knowledge and resource collections. (Gebremichael, Hou, & Sun, 2016). In addition to Gebremichael, et al., 2016; Yaseen, et al., 2022 also stated that cloud computing another form of open innovation is a sustainable and cost effective strategy for SMEs and MSMEs to implement computer/technologically based solutions. Additionally, SMEs can utilize the infrastructure and services offered by cloud service providers by adopting cloud computing, which eliminates the need for expensive internal infrastructure and maintenance (Yaseen, Al-Adwan, Nofal, Hmoud, & Abujassar, 2022). 24.3% suggested more trainings and education programs on the technology as an effective way to manage the cost of implementation. 11.7% of the respondents agreed that Government provided subsidies or Tax Incentives is another effective way to address the challenge of funding for implementing the technology. However, more studies are veering towards the non-financial forms of government support that businesses need.

3.3.3 **Research Question 4**

What are the potential use cases and applications of visual search technology in the Nigerian e-commerce sector, and how can e-commerce retailers leverage these use cases to enhance their operations and growth?

3.4 Objective 3: To Identify Challenges that may Militate against the Adoption of the Technology in Nigeria and Recommend Pragmatic Solutions. In order to achieve this objective this study sought to answer the following questions.

1. What are the perceived usefulness and ease of use of computer vision technology among e-commerce businesses in Nigeria?
2. What are the costs, technical, legal, and regulatory challenges associated with the adoption of computer vision technology in the Nigerian ecommerce sector?
3. What feasible and pragmatic solutions can be recommended to address the challenges that may hinder the adoption of computer vision technology in the Nigerian e-commerce sector

Implementing Computer Vision Technology in the ecommerce sector in Nigeria requires certain legal and regulatory hurdles to be crossed. As a result, the respondents were asked the Legal and Regulatory frame works to be considered before the adoption of the technology.

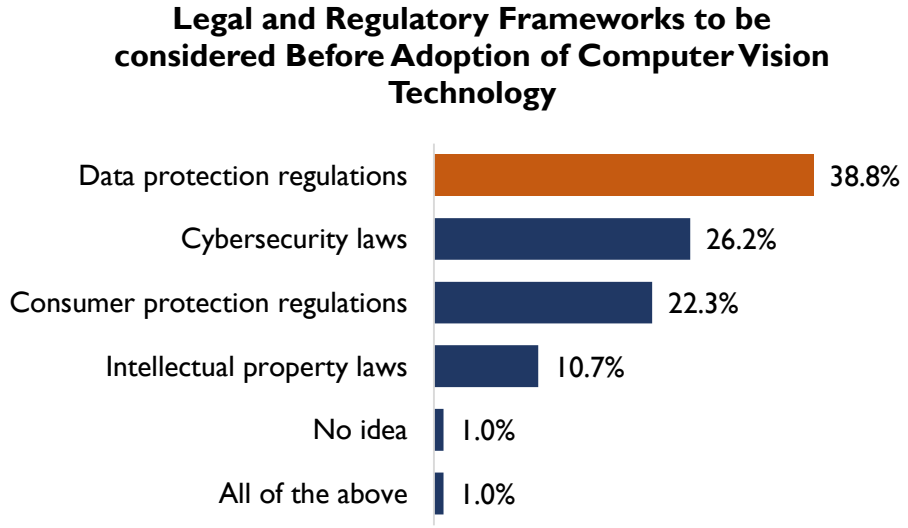

Figure 14 Legal and Regulatory frameworks to consider before adoption of Computer Vision Technology

From Figure 14, we see that 38.8% of the respondents agreed that in order for this technology to be implemented, Data Protection Regulations must be put in place to protect both the customers and the organizations. Maskus & Reichman, 2017 noted that government policies such as data protection regulations, and standards that ensure safety, interoperability, and fair market competition. We can infer that these policies can also support ecommerce industries trying to implement or already implementing Computer Vision Technology in Nigeria. 26.2% of the respondents cited Cybersecurity Laws as the most pressing issues while 22.3% cited Consumer Protection Laws as the most important legal factor to consider. Consumer Protection laws are critical for implementation of Computer Vision Technology. (Cahyani, Fitriyanti, Ahmad, & Ramlan, 2022) stated the decoy effect as a major violation of Consumer Protection laws. Tversky & Simonson, 1993 defined the decoy effect as a strategy in marketing to persuade customers to buy and boost revenue. Marketers persuade consumers to make a particular choice by subtly offering a less appealing decoy option.

3.5 Objective 4:

To Recommend Best Practices and Other Ways in Which Nigerian Consumers can benefit from Implementing Computer Vision in E-commerce Applications

1. What are the challenges consumers currently face with computer vision technology in E-commerce?
2. How can the challenges be mitigated?
3. What are the best practices for implementing computer vision technology in e-commerce applicable to the Nigerian context?
4. How can e-commerce businesses in Nigeria ensure that the implementation of computer vision technology is tailored to the needs and preferences of their target audience?

3.5.1 Research Question 1

What are the challenges consumers currently face with computer vision technology in ecommerce?

When adopting Computer Vision Technology, challenges are not limited to the organizations alone, customers also face a few challenges as well. The respondents were asked to highlight the most significant risk a customer would face when interacting with the technology.

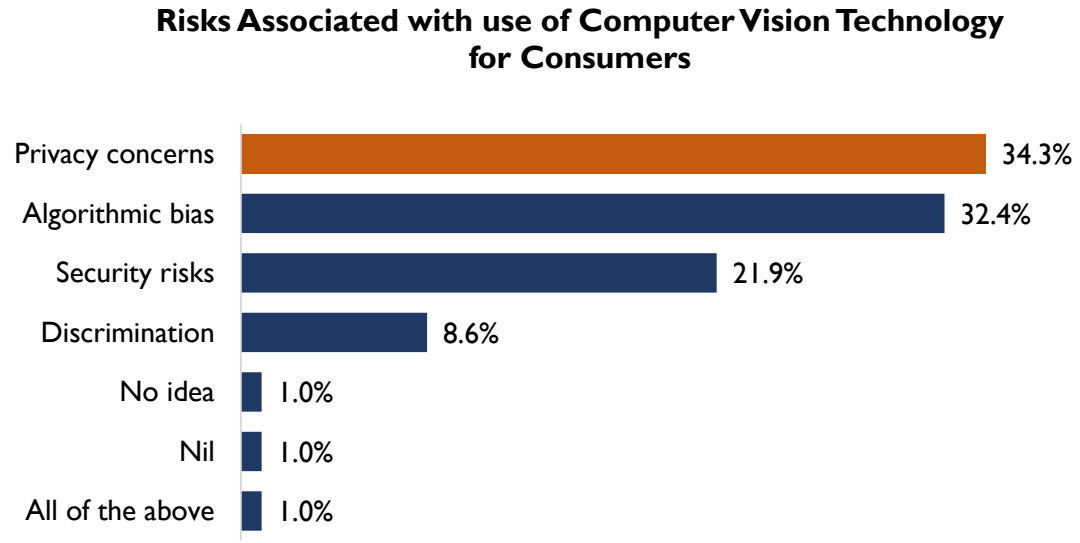

Figure 15 Risks Associated with the use of computer vision Technology

In line with Figure 15, we observe that 34.3% of the respondents stated that customers are likely to experience "Privacy Concerns" when interfacing with the technology. Certain other studies agree with this result. (Jenke, Peer, & Buss, 2014; Gu, Zhang, Liu, & Ren, 2019) agreed that because Computer Vision involves the collection and analysis of visual data, which can include personal information customers may begin to worry about the safety of their data and be concerned about the potential misuse or unauthorized access to this data. 32.4% stated that Algorithmic bias is another challenge customers are likely to face. The term "algorithmic bias" describes the possibility for algorithms to deliver biased results (Mittelstadt, Allo, Taddeo, Wachter, & Floridi, 2016). This can occur when algorithms are trained on biased data or when ethical considerations are not accounted for in the design of the technology. When alogorithms are perceived as unfair, it can undermine trust in AI

systems and lead to a loss of confidence in the systems and institutions that use them. (Hollis, 2017) 21.9% of the respondents stated that Security risks are the most likely challenge that customers are likely to face. Security risks are a concern because the use of Artificial Intelligence and in this case Computer Vision Technology can put customers at risk of data breaches, unauthorized access to sensitive information, and the potential for malicious actors to exploit vulnerabilities in AI systems (Yang, Chen, Por, & Ku, 2023).

3.5.2 Research Question 2

How can these challenges be mitigated?

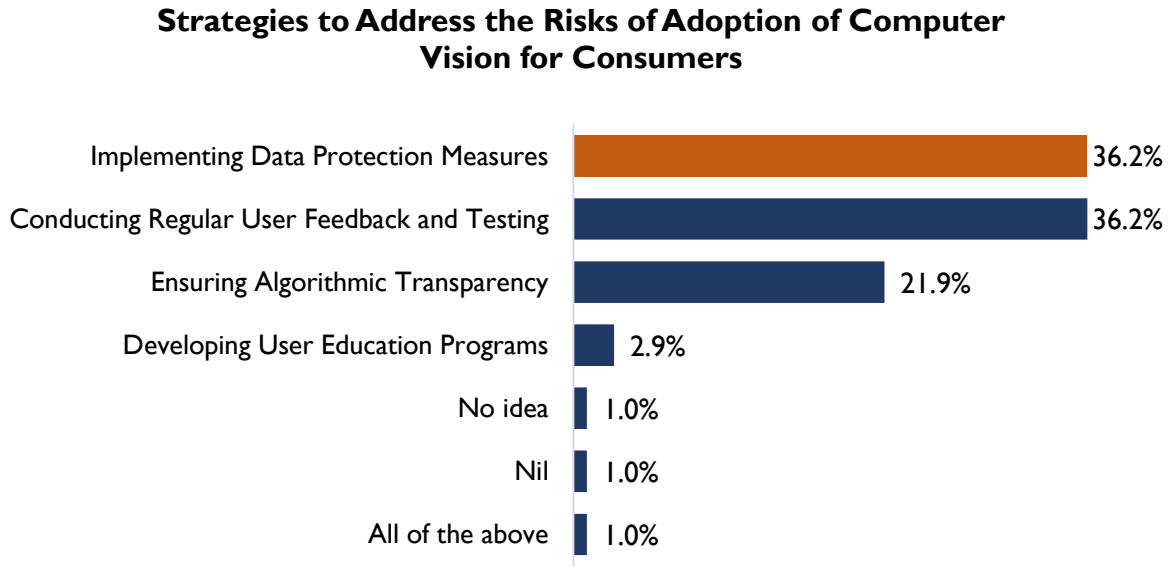

Figure 16 Strategies to address the risks of adoption of Computer Vision Technology for consumers

The study revealed that Developing User Education Programs and Implementing Data Protection Measures are the best ways to address the risks and challenges consumers are likely to face when interfacing with the technology (in view of Figure 16). Similarly, Owino, 2023, cited the challenges hindering the implementation of computer vision technology in Kenya as inadequate infrastructure, lack of technical expertise, limited funding, and unsupportive government policies. However, Owino, 2023 suggests potential solutions to address these challenges, such as more supportive government policies on subsidies and

data, research and development investments, technical trainings and education alongside capacity building.

3.5.3 Research Question 3

What are the best practices for implementing Computer Vision Technology in e-commerce applicable to the Nigerian context?

The respondents were asked to highlight the best practice they deemed most significant when implementing computer vision technology in Nigeria.

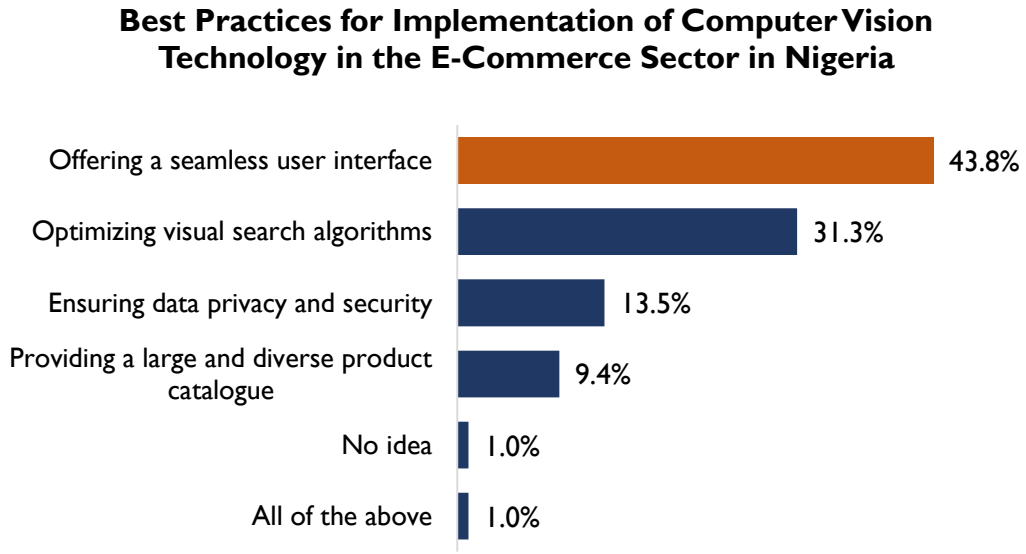

Figure 17 Best practices for Implementation of Computer Vision Technology in the E-Commerce Sector in Nigeria

From Figure 17 above, we note that most of the respondents (43.8%) stated that the ultimate best practice when implementing CVT was to Offer a Seamless User Interface while 9.4% agreed that the best practice was to Optimize Visual Search Algorithms. Only 9.4% of the respondents agreed that a best practice was to Provide a Large and Diverse Product Catalogue. Olaleye, et al., 2018 stated the ultimate best practice would be to first address the factors mitigating against the seamless implementation of the technology. (Martinez, et al., 2017) who studied the implementation of Computer Vision Technology in video telehealth for veterans with spinal cord injuries and disorders found that user demand for aesthetically pleasing and seamless interfaces is increasing, especially in touch-sensitive

interfaces used to interact with multifunctional systems. Providing a seamless user interface can enhance the overall usability and satisfaction of Computer Vision Technology systems. Additionally, optimizing visual search algorithms can improve the efficiency and accuracy of information retrieval in Computer Vision Technology systems, particularly in applications where users need to search for specific products or information within a large and diverse product catalog (Mobedi & Dede, 2019).

3.5.4 Research Question 4

How can e-commerce businesses in Nigeria ensure that the implementation of computer vision technology is tailored to the needs and preferences of their target audience?

The respondents were asked to underscore the best ways in which consumers can be educated about the technology for better outcomes after implementation.

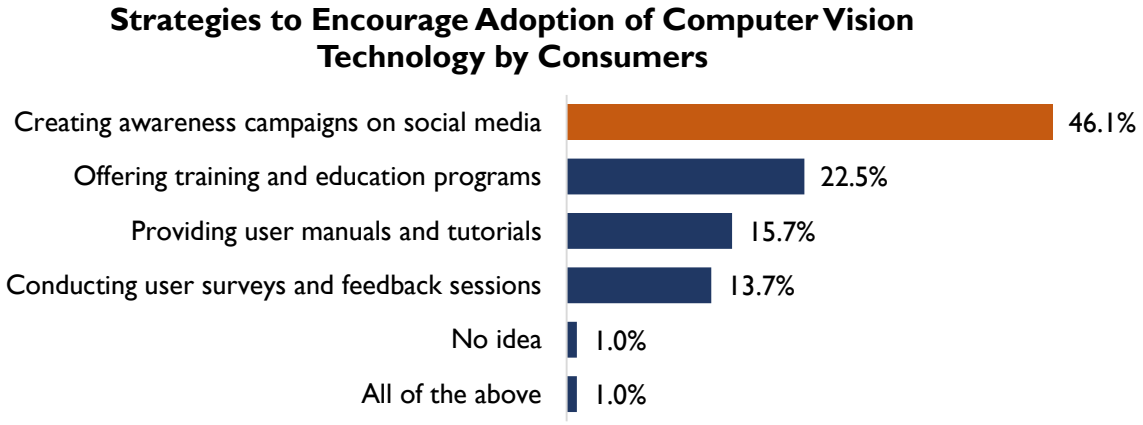

Figure 18 Strategies to encourage adoption of Computer Vision Technology by Consumers

With figure 18 above in view, we observe that 46.1% of the respondents stated that the best way to encourage adoption of the technology by consumers was to Create Awareness Campaigns on social media. 22.5% stated that Offering Training and Education Programs to the consumers was a way to encourage uptake of the technology. Only 13.7% stated that User Surveys and Feedback Sessions are a way to encourage consumer uptake. Cui et al., 2009 highlighted that a good way to encourage adoption is a customer focused approach where organizations might need to enact coping strategies to enable customers deal with

the uncertainties and stress associated with new technology like CV (Cui, et al., 2009). Additionally, Ratten (2015) noted that consumer education and awareness campaigns might be run to let people know about the advantages and uses of computer vision technology. Consumers may be more inclined to use the technology if this makes them more aware of its worth and potential. In addition, giving customers training and support can raise their levels of competency and perceived ease of use, both of which are factors in adoption behavior (Ratten, 2015).

3.6. Survey Responses from users of E-commerce Service

The study also gathered data from users of e-commerce services across major Nigerian cities such as Lagos, Abuja, Kano, Kaduna, Ibadan, Abeokuta, Port Harcourt to mention but a few. A total of about 363 respondents completed the survey instruments and the results in show below in the chart below:

3.7. Summary of Key Findings

1. **Awareness and Experience with Computer Vision in E-commerce:** 79% of respondents were aware of Computer Vision Technology. This indicates a potential readiness for its adoption in the industry.
2. **Perception of Computer Vision's Impact:** 57.4% agreed that Computer Vision Technology can enhance the E-commerce sector in Nigeria. This reflects the potential

readiness for computer vision adoption in Nigeria among the e-commerce stakeholders, suggesting a positive outlook towards its integration.

3. **Benefits of Computer Vision in E-commerce**: 44.4% identified "Enhanced Customer Experience" as the most significant benefit for adopting computer technology. Improving customer experience is a top priority for e-commerce businesses, and Computer Vision can play a pivotal role in achieving this. The success of Amazon's recommendation system, which led to a 30% sales increase, is a testament to this potential.
4. **Challenges in Adopting Computer Vision**: **Finding**: The primary challenge identified is the "Lack of Technical Expertise" (39%). For successful adoption, there's a need for skilled professionals. The industry will need to invest in training or hiring experts in Computer Vision.
5. **Legal and Regulatory Considerations**: 38.8% believe that "Data Protection Regulations" must be in place for the technology's implementation. Ensuring data privacy and protection is paramount. E-commerce businesses are looking for a clear regulatory framework to safely implement Computer Vision.
6. **Mitigation Strategies for Challenges**: 56.3% suggested "Providing Technical Training and Education" as the best mitigation strategy. The emphasis on training underscores the industry's recognition of the skills gap and the importance of capacity building in adoption of the technology.
7. **Government's Role in Adoption**: 38.5% believe the government can support by offering training programs and education. Collaboration between the private sector and government in capacity building can accelerate the adoption of Computer Vision in e-commerce. A Chi-Square test further indicated a strong relationship between the likelihood to adopt Computer Vision and the perceived role of the government. Government policies and support can significantly influence businesses' decisions to adopt new technologies like Computer Vision.
8. **Current Level of Adoption**: 60% of respondents are currently using Computer Vision in their operations. The e-commerce sector in Nigeria is already on the path of

technological advancement, with a majority having integrated Computer Vision into their operations.

- **Consumer Challenges and Risks**: The primary risk faced by consumers is "Privacy Concerns" (34.3%). As businesses adopt Computer Vision, they must address consumer apprehensions about data privacy to gain trust and ensure successful implementation.

3.8. Summary of Findings

The study sought to explore the application of computer vision technology for e-commerce sector growth in Nigeria. The study adopted a mixed method design, encompassIng a comprehensive literature review, shedding light on global trends and specific nuances within Nigeria, structured surveys and interviews with a diverse range of stakeholders, from e-commerce platform operators and tech developers to the end consumers. The findings from the data showed that computer vision, with its capabilities like visual search, virtual try-ons, and augmented reality shopping, has the potential to significantly enhance the user experiences for e-commerce. Feedback from consumers indicated a keen interest in such features, highlighting the demand for more interactive and immersive online shopping experiences.

E-commerce platform owners also expressed a growing appetite for integrating computer vision, driven by the promise of reduced return rates, improved product discovery, and heightened customer engagement. However, the journey is not without its hurdles. The high cost of implementation emerged as a significant barrier, coupled with a dearth of technical expertise in the region. Furthermore, data privacy emerged as a pressing concern, with consumers and vendors alike seeking clarity on ethical data usage.

It's evident that while computer vision offers a plethora of opportunities, its adoption in Nigeria's e-commerce sector is still in its nascent stages. For the technology to gain widespread acceptance, investments in training and capacity building are imperative. Collaborative endeavors between tech developers and e-commerce platform users can pave the way for innovative, market-specific solutions. Moreover, to address the data privacy concerns, it's crucial for regulatory bodies to step in, providing clear guidelines to ensure the

ethical and transparent use of computer vision. Conclusively, the study underscored the transformative potential of computer vision for Nigeria's e-commerce landscape. While challenges persist, the overarching sentiment is one of optimism, with the right interventions promising a future where computer vision becomes an integral part of the e-commerce experience in Nigeria.

SECTION FOUR: CONCLUSION AND RECOMMENDATIONS

4. CONCLUSION AND RECOMMENDATIONS

4.6. Conclusion

In Nigeria, the e-commerce landscape is experiencing a swift and robust expansion, driven by a population that embraces technology with enthusiasm and proficiency. The surge in the desire for online shopping establishes an opportune environment for the seamless integration of cutting-edge technologies such as computer vision. This study underscores the immense potential of employing computer vision applications within the e-commerce domain, presenting promising prospects for elevating user experiences, tailoring services, optimizing product searches, and fortifying anti-fraud measures. Enabling these advancements often necessitates e-commerce enterprises to invest in developing sophisticated computer vision models, extensive data gathering, and seamless integration with their current platforms. Despite these investments, the anticipated advantages in terms of amplified sales, heightened customer satisfaction, and streamlined operations validate the decision to embrace this transformative technology. Anticipated is a surge in the uptake of computer vision as more enterprises grasp its value, thereby gaining a competitive edge and realizing superior returns on their investments.

The evolving technological landscape calls for a symbiotic collaboration between businesses and researchers to unearth novel applications and surmount integration challenges of computer vision within e-commerce platforms. Embracing this technology could position Nigerian e-commerce enterprises at the vanguard of innovation, delivering benefits to both stakeholders and consumers. Through adept utilization of computer vision, the e-commerce sector in Nigeria stands to capitalize on the growing trend of data-powered decision-making, augmenting its competitive edge in the global market.

Looking ahead, research efforts should be directed towards refining and scaling computer vision algorithms for enhanced efficiency. Concurrently, delving into the ethical and privacy considerations linked to widespread adoption within the e-commerce realm is

imperative. Furthermore, understanding the nuanced requirements and inclinations of Nigerian consumers is vital, ensuring that the integration of computer vision aligns with the distinctive attributes of the Nigerian e-commerce landscape. Such research endeavors will underpin a judicious and tailored application of computer vision technology in the Nigerian e-commerce sector.

4.7. Recommendations

1. **Establish a National Computer Vision Strategy**: The adoption of computer vision, with 60% of e-commerce businesses already utilizing it and an additional 35% indicating that they are very likely to integrate it, underscores the need for a cohesive national direction. By developing a comprehensive strategy, the government can provide a clear roadmap for the sector, emphasizing the potential economic uplift, job opportunities, and global competitiveness. This proactive approach will ensure that the nation remains at the cutting edge of this technological wave, harnessing its full potential for the e-commerce landscape.
2. **Promote Digital Literacy Programs:** Given that 40% of the businesses surveyed are not familiar with AI and its applications for business growth, there's a clear gap in digital literacy. The government should invest in and promote digital literacy programs, especially focusing on emerging technologies like AI. Collaborative efforts with educational institutions to introduce tailored computer vision courses can bridge this gap, ensuring a consistent supply of adept professionals to cater to the industry's evolving demands. By doing so, businesses can be better equipped to understand and leverage these technologies, leading to increased competitiveness and innovation in the e-commerce sector.
3. **Promote Research and Development**: The appetite for innovation is evident, with businesses interested in channelling their resources into R&D for computer vision. By offering incentives such as tax breaks or grants, the government can further fuel this drive, accelerating advancements in the field. Such a move will not only spur businesses

to push technological boundaries but also position the country as a hub for computer vision innovation in e-commerce.

4. **Review and Update Data Privacy Regulations:** As businesses adopt AI, concerns about data privacy and security will inevitably arise. The government should proactively review and update data privacy regulations to ensure that they are in line with the latest technological advancements. This will not only protect consumers but also provide businesses with clear guidelines on how to handle data responsibly.
5. **Facilitate Industry Collaboration**: The power of collective effort cannot be understated. By fostering platforms where e-commerce entities can converge to discuss computer vision projects, share insights, and tackle shared challenges, the government can catalyze the formulation of standardized practices and a unified vision. Such collaborative endeavors can streamline the sector's approach to computer vision, maximizing its benefits.
6. **Infrastructure Development**: The bedrock of effective computer vision implementation is robust digital infrastructure. This encompasses facets like data storage, processing capabilities, and high-speed connectivity. By channeling investments into bolstering this infrastructure, the government can ensure businesses have the requisite resources at their disposal, optimizing the impact of computer vision technologies on e-commerce.
7. **Facilitate Specialised Training Programs**: Organising targeted training initiatives to cultivate and increase the number of skilled workers capable of developing and maintaining robust applications is vital for promoting the adoption of computer vision technology in the e-commerce sector. These skilled professionals can drive innovation and optimize the use of computer vision for enhanced e-commerce experiences.
8. **Establish Innovative Hubs**: The establishment of innovative hubs and centres is pivotal in propelling the widespread integration of computer vision technology within the ecommerce sector. This initiative stimulates active collaboration, in-depth research, and accelerated development, amplifying its transformative potential.

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