

# Bibliometric Analysis of Ethics in Embedded and Mobile Systems

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## Abstract

When it comes to commonplace gadgets like cell phones, automobiles, household appliances and medical equipment, embedded systems ethics place a higher priority on privacy, security, dependability and possible abuse. The desire for convenience in family life has risen because of its comfort, control and safety. Smart houses alter interior areas with computers and artificial intelligence (AI), while embedded technologies provide minimal power consumption and many functionalities. As a result of social and technical improvements, smart homes and embedded systems are becoming more and more popular around the world and developing countries are adopting this technology, which aligns with ethics. However, the incorporation of ethics in embedded systems and mobile systems tends to be ignored in Africa. The purpose of this study is to investigate the prevalence of ethics in embedded and mobile systems, looking at the African context. The data was collected from the Scopus database and the Web of Science between 2002 and 2023. To recognize the trends in ethics in embedded and mobile systems, bibliometric analysis is used to judge the current situation and development trends in the African region. The results revealed the keywords with the highest occurrence and countries and affiliations that are contributing to the ethics in embedded and mobile systems. Additionally, embedded and mobile systems have been identified as an active area of research, experiencing an annual growth rate of 5.37% in Africa, with 30% of contributors being international co-authors. The results of this study will facilitate an understanding of the progress and trends in embedded and mobile systems for researchers interested in understanding them from an African perspective.

**Keywords:** Embedded system, mobile systems, African region

## 1. Introduction

Embedded systems, which are frequently built around microcontrollers, are computer systems that manage standard components found in larger mechanical or electrical systems. These systems are designed to be more dependable and perform better than other types of controllers while being smaller and less expensive (Pasricha, 2022). Digital watches, MP3 players, washing machines, security systems, scanners, printers, and other electronic devices all have them (Hautemo and Mushaandja, 2024). Africa's mobile-centric outlook on technology presents an exciting future for mobile technology. Embedded systems play a crucial role in people's lives by revolutionizing science and being integral to the Internet of Things (IoT). These systems enable devices to have unique identifiers and facilitate data transfer without human intervention, fundamentally changing how products are developed, introduced, and used in everyday life (Anikwe et al., 2022). A new generation of African innovators is emerging who understand market challenges and opportunities, implying that the continent could become a new innovation hub (Hautemo and Mushaandja, 2024).

Digital technology includes electronic tools, devices and systems used by organizations to process and store data, enhance employee productivity, and process information using digital signals and An embedded system is a collection of computer hardware and software designed to perform certain tasks and can be found in a variety of sectors, including industrial machinery, consumer electronics, cars, medical equipment, and mobile devices (Anikwe et al., 2022). The growing significance of software artifacts in our daily lives, amplified by social media tools that influence decision-making and information flow, has raised ethical concerns for businesses, consumers, and regulatory bodies

(Dimigen, 2020). The ethical challenges in embedded and mobile systems are inherent in software development and should be addressed by developers, designers, and operators (Azari & Vrudhula, 2020). Two agile approaches that offer features for products that are ethically sound are Scrum and Extreme Programming. These approaches have not been properly implemented into entrepreneurial culture, despite past awareness, and the majority of African countries are plagued by this problem (Tarn & Wang, 2023). In order to comprehend interactions between individuals and systems, Mpinganjiraa and Madukub (2019) propose a systems theoretical approach that emphasizes the developer's role in the system and focuses on different facets of the digital-technical system. This approach is based on rationality theory, which ensures logical consistency and practical coherence (Batool et al., 2023). Technology's social effects are hard to forecast and manage, which creates a control challenge. Change is frequently necessary yet unpredictable, which makes it expensive and time-consuming.

Although Gulbrandsen and Simensen (2024) integrate ethics into procedures using well-known software engineering techniques, it is still unknown what, other than chance, drives ethical decisions. Consequently, it is essential to incorporate ethical frameworks that can identify relevant normative issues within such a software engineering methodology. The limitations of embedded and mobile systems on the African continent are that non-users are influenced by several variables, such as perceived danger, cost, complexity, unsuitability of device, lack of information, and observability. In this regard, the purpose of this study is to investigate the prevalence of ethics in embedded and mobile systems from an African perspective. The research uses bibliometric analysis to investigate the prevalence of ethics in embedded and mobile systems in Africa and highlight the growth rate, the affiliation that publishes most of the articles in Africa, and the collaboration around the world.

## 2. Related Works

Many scholars study morality and ethics. Morality is based on personal convictions about right and wrong, fairness, and honesty, whereas ethics is a set of concepts that society propagates to promote positivity in embedded and mobile systems (Abtahi et al., 2023). Chen et al. (2023) propose that the Ironclads program enables safe data

transport to remote workstations by removing vulnerabilities such as buffer overruns and data leaks. For secure paths, it makes use of safe hardware and encryption but the limitation of the methodology is that it is a low-level verification tool. The majority of recent studies on health monitoring systems have concentrated on mobile and sensor-based technology, such as fall detection and prevention apps for smartphones. A problem is that the research does not address important aspects of the architecture, application domains, and general problems and solutions of health monitoring systems,

On the other hand, Chinedu and Wickramasinghe (2023), used embedded deep neural networks (E-DNN) in Python for word embedding and sentiment polarity classification of user comments, enhancing prediction accuracy through deep layers and k-fold leave-one-out cross-validation technique. A smart home remote control platform based on sophisticated web technologies was proposed. It combines intelligent home management and monitoring functions, giving users remote access to electrical equipment, environmental monitoring, and appliance control. This solution minimizes expenses and maintains current appliances; however, it is unable to provide flexibility in demand-side energy control (Venu et al., 2022). The technology that is used to control household equipment through voice control is proposed to enhance its intelligence and technology. The limitation of this advanced technology is that there is no backup system when the network is available; this technology is then unable to function (Guo, 2024). This problem is having a severe effect on people's lives and has an effect on the entire system. The development of smart home systems for homes is still in its early stages. As a reaction to the requirements of distinct clients, the systems are created apart from one another. RetinaNet and EfficientDet models are not suitable for embedded applications due to their heavy mathematical operation rate, and other networks like ResNet50 and ResNet101 are not effective solutions for embedded and mobile systems (Hajizadeh et al., 2023). Embedded and mobile system users contribute to mobile crowd sensing applications like Medwatch, supporting government services like air quality monitoring and traffic monitoring, and promoting voluntary reporting of medical issues, such as pollution or motor vehicle accidents. This system is complicated when it comes to ethics because it is

very difficult to accommodate all of society (Suhag & Jha, 2023). In this regard, hardware support for computation and implementation of the motion detection algorithm was proposed and achieved higher speeds up with a large area penetration, but this issue is problematic for mobile and embedded devices with limited hardware footprints (Krzysiak et al., 2022).

### 3. Methodology

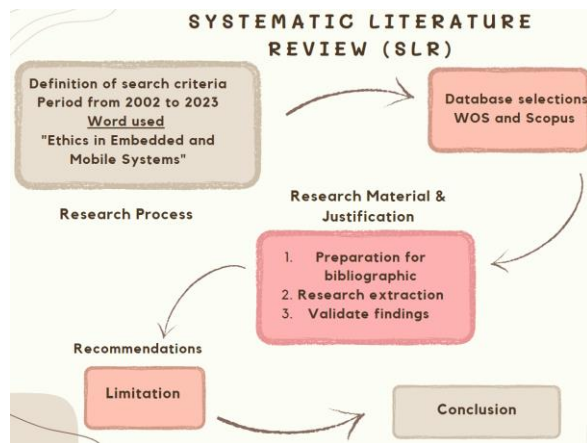


Figure 1. Systematic literature review

The study searched two databases and used bibliometric analysis and Rstudio software to analyze the data and produce the results. The following analytical techniques were used in order to fulfill the research's goal (see Figure 1). Scopus and Web of Science (WOS) were searched for relevant studies from 2003 to 2023. The research question of this study is as follows: "How can African countries increase awareness of ethics in embedded and mobile systems?" In order to answer this research question, the search string used was "ethics in embedded and mobile systems."

### 4. Experiments and Results

In Figure 2, 149 authors were found with the search query for 'embedded and mobile systems'. The search found an annual increase of 5.37% in research articles on embedded and mobile systems between 2002 and 2023. There were 149 authors, six single authors, 30% international co-authors, and 253 authors who used the keywords. The average citation per document was 13.02.



Figure 2. Embedded and mobile systems

The most-searched words on ethics in embedded and mobile systems are implementation, algorithm, controller, model, and lectures. Efficient is also highlighted as one of most-searched words as indicated in Figure 3.

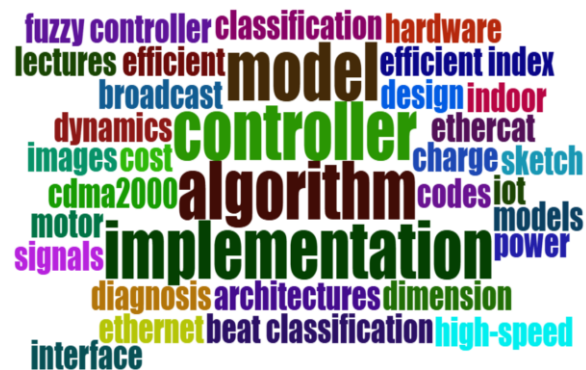


Figure 3. Most-searched word

Most documents were published in the developed world: United States which led with over 3 400 documents, the United Kingdom with 850 documents; Taiwan and Japan with 760; Italy had 745 and France had 650 documents. Germany had 110 documents. In the developing world, China led with 3 000 documents followed by India with 1 750 documents and South Korea with 110. In this regard, developed countries are publishing most of the studies in ethics in embedded and mobile systems (see Figure 4.)

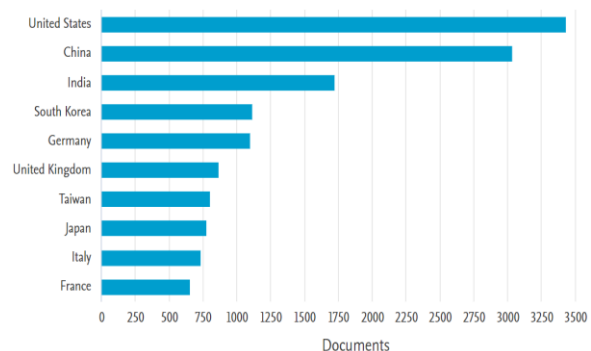


Figure 4. Papers published

Since the United States is a country that is publishing more documents than any other country in the world as far as ethics in embedded and mobile systems is concerned, in this regard, the top 10 affiliations in the United States are shown in Figure 5, where the Georgia Institute of Technology achieved the best publication rate with 105. Purdue University came in last with over 50 documents but still performed better than African universities (see Figure 5).

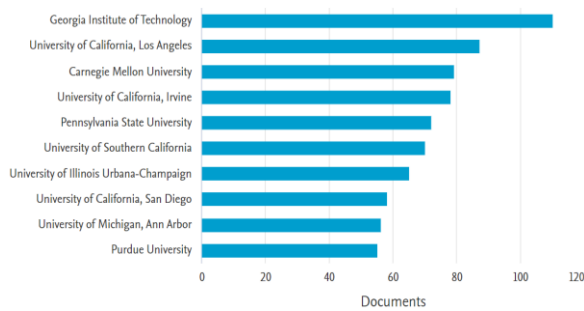


Figure 5. Top 10 affiliations in the United States

Among African countries, Morocco performed better than any African country with 100 documents published, followed by Egypt with 98 documents published, Tunisia and Algeria with just 80 documents published, South Africa with 55 documents, Nigeria with 45 documents, followed by Sudan with 15 documents, Kenya with only 10 documents, and Ethiopia, Ghana, and Mali below 10 documents that were submitted.

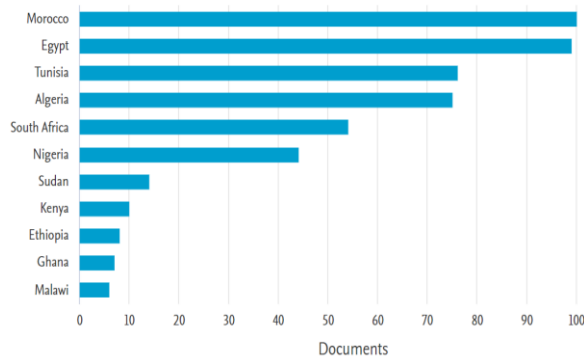


Figure 6. African countries publishing trends

Morocco outperformed countries with the promotion of ethics in embedded and mobile systems. In this regard, Moulay Ismail University, Mohammed V University, and University Hassan II de Casablanca are the top universities that published the most research in Morocco (see Figure 7).

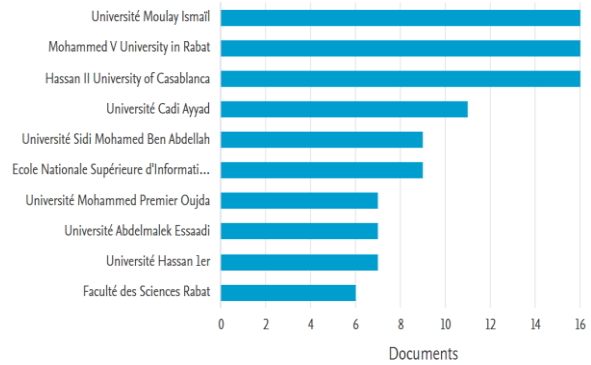


Figure 7. Morocco University publish trends.

As much as this study focused on the countries and universities that published most documents that considered ethics in embedded and mobile systems, looking at the African point of view, since this study is part of a Ph.D. thesis at the University of North-West, it is very important to review the universities that publish most of the documents in South Africa. In this regard, the University of KwaZulu Natal outperforms all universities in South Africa, followed by the University of Cape Town (see Figure 8).

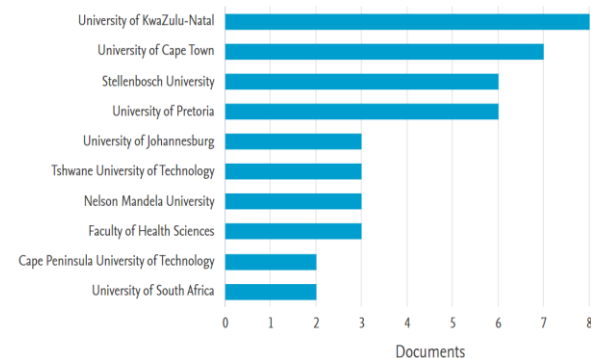


Figure 8. South Africa University publish trends.

Figure 9 shows the co-network of the relationships in publications on ethics in embedded and mobile systems, algorithms, convolutional neural networks, diagnostic accuracy, deep learning, and machine learning.

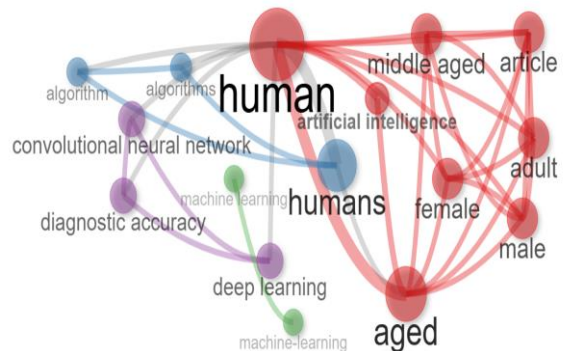


Figure 9. Co-network of the relationships in the publishing trend

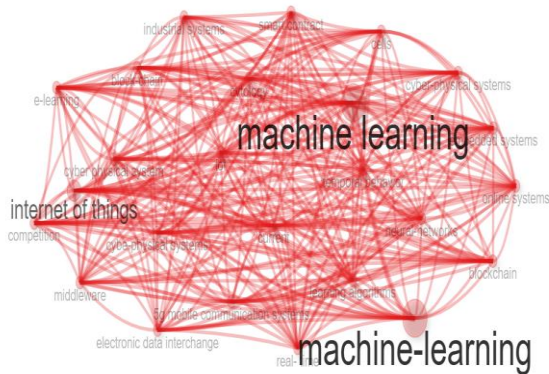


Figure 10. Co-network for ethics in embedded and mobile systems

Embedded systems allow devices to connect with each other and with other devices within a network by collecting and analyzing data and generating predictions. When combined with machine learning, embedded systems reach new levels of intelligence, enhancing hardware performance and improving the efficiency of business-critical systems. This integration results in increased functionality and automation, allowing systems to operate more effectively and intelligently. In this regard, Figure 10 shows the relationships and tools that can be used to encourage the adoption of embedded and mobile systems, where machine learning plays a critical role in the ethics of embedded and mobile systems.

### 5. Evaluation and Discussion

Africa's economic growth may be considerably boosted by embracing digital economy advances, which include investment and international assistance for locally developed digital solutions. In this study, only 30% of the authors were international co-authors and 253 authors used the keywords, with the average citation per document being 13.02. In this regard, Africa needs to increase collaboration with international countries to support the adoption of embedded and mobile systems. The United States is publishing documents more than any other country in the world regarding ethics in embedded and mobile systems, African countries are improving with publishing documents, while Morocco performs better than any African country with 100 documents published. Therefore, the study recommends that African universities collaborate more in terms of research regarding the adoption of embedded and mobile systems.

### 6. Conclusion

The increasing importance of software artifacts in our lives, together with the use of social media as tools that help decision-making and information flows, has raised ethical questions for businesses, consumers and regulatory bodies. The ethical challenges in embedded and mobile systems are in software development and should be addressed in the approaches employed by developers, designers and operators. Africans are often excluded from decision-making about ethics in embedded and mobile systems. This system is having a severe effect on people's lives and has an effect on the entire system. The development of smart home systems for homes is still in its early stages. As a reaction to the requirements of distinct clients, this study explored awareness of ethics in embedded and mobile systems in Africa and it was clear that the African countries were not often involved in this research. The United States and China are leading in this area. It is recommended that Africa increase collaboration in research on embedded and mobile systems. In the future, this study will be expanded by adding another research database, as it only used the Scopus and Web of Service databases. Future goals will include raising awareness among African researchers about embedded and mobile system ethics and pressuring nations to step up international cooperation.

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