

Systematic Literature Review: Biometric Technology Applied to Educational Institutions

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Abstract – Biometric technology, founded on recognizing distinctive individual features, enhances identification and automation, yielding personal and institutional benefits. This literature review employs the Kitchenham and Charters methodology to analyze recent perspectives on biometric technology in educational time and attendance. The analysis identifies benefits, such as preventing impersonation and enhancing data security, but emphasizes concerns about biometric alterations and hardware/software failures hindering optimal outcomes. A noteworthy trend is adopting a bimodal behavioral approach in biometric technologies in education. The study recommends research avenues focusing on privacy safeguards, biometric system robustness, and technological resilience. Beyond mere identification, a shift towards quantitative and descriptive methods is proposed, guiding future research. The results underscore the importance of a multimodal approach and stringent security measures to address biometric system vulnerabilities. Future exploration should consider integrating emerging technologies to enhance system resilience and data protection, providing a comprehensive guide for refining and expanding biometric technology applications in education.

Keywords – Biometrics, biometric technology, time and attendance, education, fingerprint.

1. Introduction

One of the most used formulas to achieve excellent academic performance is the attendance to classes by students, so to validate their presence in the classroom, it is necessary to control the integrity of the attendance record of students through an appropriate procedure that checks and manages the attendance data [1], which currently, is manual in many schools, such as universities, which leads to errors such as miscalculating the number of attendances, wasted time in collecting attendance data, false attendances, filling out the attendance list is prone to student fraud [2], among others, are recurrent problems when the attendance control process is carried out manually, this not only affects the final decision-making of an institution, as one study found a significant relationship between attendance and students' academic performance [3]; monitoring and managing attendance is essential, therefore, to assist staff interacting with the attendance monitoring process, it needs to be improved [4].

Modern technology serves diverse purposes, meeting users' needs comprehensively. In today's era, it is increasingly common to seamlessly integrate technology into our lives due to its ability to enhance speed, availability, and efficiency, providing numerous benefits. In the same way, the education sector has undergone several transformations over the years, including digital transformation, where ICTs are being implemented, thus adapting to this new environment and opening new possibilities for directing education [5], becoming more flexible and adaptable to respond to social demands, making their processes more efficient and providing more beneficial services for teachers and students who are part of it [6]. Likewise, educational data analysis (EDA) requires current and new methods to extract the data generated in the educational institution [7].

DOI: 10.18421/TEM131-60

<https://doi.org/10.18421/TEM131-60>

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Received: 25 September 2023.

Revised: 09 January 2024.

Accepted: 19 January 2024.

Published: 27 February 2024.

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Similarly, a controlled and secure environment is paramount for institutions; therefore, a biometric system is critical to provide unique features and quick responses involving high accuracy for the identification of students [8] and open possibilities for authentication and security with the help of biometrics in various sectors [9], which allows the creation of systems that are based on physical characteristics [10], [11] or behavior [10].

Biometrics is currently being applied in a wide variety of domains, such as the education sector, with 2% of participation [12], with some biometric systems being more widely used due to their low cost, ease of use, high efficiency, and accuracy, providing acceptable identification and authentication [13], [14]. Still, they also present threats and vulnerabilities, for which there are possible solutions to improve security [13] to verify that a student is who they claim to be when entering the institution [15], [16].

On the other hand, there are systematic reviews dedicated to exploring biometric applications in education. This article aims to provide an overview of biometric technology applications, discuss challenges in implementation, and highlight potential trends [6]. Another article focuses on hardware aspects, emphasizing the microcontroller platform, biometric sensor, communication channel, database storage, and other components. It is intended to assist future researchers in designing the hardware for biometric-based assistive systems [12]. Additionally, studies on security and accuracy in biometric system design need to be adequately explored simultaneously [17]. In-depth examinations of authentication systems, particularly multi-factor authentication systems, are conducted to understand better their security, usability, risk mitigation, and potential threats compromising users' credentials [18]. Yet another study aims to offer a comprehensive and structured overview of existing research in unimodal and multimodal biometric systems. This includes focusing on feature extraction techniques, classifiers, datasets, system efficiency, and reliability. The study also seeks to raise awareness among researchers about the multiple dimensions to be considered for improving security in biometric systems and anticipates the future of 3D biometrics [19].

For this reason, this study aims to provide a comprehensive overview of how biometric technology has been used to solve problems related to time and attendance, analyzing its advantages and challenges. It is also essential to explore the latest trends in the field and to understand the research approaches used by proposing a systematic review comprising literature from the last five years.

2. Methodology

This literature review follows the guide established by Kitchenham and Charters, which guides researchers in assessing and interpreting research. This guide consists of three phases for the overall search process: planning the review, conducting the study, and the review results [20].

2.1. Planning the Review

Consequently, the search process consisted of collecting information, analyzing and finding studies related to the topic to be investigated, which in this case is: "Biometric technology applied in the control of student attendance in educational institutions," taking into account the research questions posed and the respective justification for their approach, which will allow a greater possibility of finding related studies (see Table 1):

Table 1. Literature search questions

Id	Research questions	Question justification
P1	What are the benefits and limitations of biometric technology?	To raise awareness of the benefits and limitations of biometric technology.
P2	What are the recent trends in biometric technology used to solve time and attendance problems?	Identify recent trends in biometric technology applied to time and attendance.
P3	What are the research approaches used in the previous studies on the application of biometric technology in time and attendance?	Recognize the research approaches used in biometrics studies to identify where they are focused for evaluation

2.2. Carrying out the Review

To conduct an adequate review, starting the process with a thorough initial search is essential. This initial stage provides an overview of the relevant literature and is a starting point for further research. This is followed by a systematic search involving a more structured and methodical approach to identifying and selecting relevant information. The key steps of these crucial phases in the review process are detailed below.

2.2.1. Initial Search

The search process started with the objective of answering the questions formulated.

Therefore, when the first searches were carried out, terms such as "Technology," "biometric," "control," "attendance," "fingerprint," "biometrics," "Identity," "Student Attendance," "Attendance," "education," "attendance," "student", "biometric technology" and "Assist Control" were linked, which were used in the following bibliographic databases: ProQuest, Scopus, EbscoHost, ScienceDirect, IEEE Xplore. Subsequently, the Boolean operator "AND" was used to obtain a cleaner search type.

The searches produced significant outcomes; moreover, many needed to be more varied and offered minimal value.

2.2.2. Systematic Search

Finally, search strings were made based on the English terminology mentioned above since they showed more results related to the topic than the Spanish terminology. Subsequently, the results obtained in the previous search will be filtered (see Table 2)

Table 2. Search strings applied

N°	Database	Search equation
1	ScienceDirect	((Biometrics) and (Control) and (Identity) and (Student Attendance)) ((biometrics) and (education) and (attendance))
2	Scopus	((biometric technology) and (Assist Control)) ((biometrics) and (education) and (student))
3	Ebsco	((Biometrics) and (Control) and (Identity) and (Student Attendance))
4	ProQuest	((Biometrics) and (Control) and (Identity) and (Student Attendance)) biometric technology and Assist Control
5	IEEE Xplore	((Attendance) and (student) and (biometric))

In Table 3, the criteria for filtering the results obtained with the highest percentage of acceptance in the literature search were defined:

Table 3. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Primary research studies and international conference contributions.	Theses, books, newsletters, books.
Research over the last five years.	Research that does not have a DOI.
Peer-reviewed articles, including DOI.	Articles that do not meet the criteria for biometrics and attendance control.

After a complete review of the articles initially found, the filtering was carried out according to the inclusion and exclusion criteria, and a small group of selected articles was obtained to provide an answer to the research questions posed, as shown in Table 4.

Table 4. Potential items, filtered and selected

Repository	Potential articles	Filtered articles	Selected articles
ScienceDirect	834	168	0
Scopus	250	32	7
Ebsco	24564	330	0
ProQuest	27800	159	1
IEEE Xplore	81	61	15

From the 53,529 articles initially found, the corresponding filters were applied, where more accurate and detailed reports were obtained, resulting in 23 eligible pieces.

2.3. Review Results

In addition, the 23 studies found are detailed in Table 5, which shows the content related to biometric technology applied to time and attendance.

Table 5. Results found

Ref.	Description
[21]	It addresses implementing an integrated attendance system using biometric sensors and real-time cloud-based DB. A population of 15 participants was chosen to prove that it is efficient and beneficial for educational institutions.
[22]	A facial recognition system was proposed to help overcome the potential for impersonation and fake attendance.
[23]	The article mentioned that a biometric technology system has the advantage of generating more accurate reports, eliminating time theft, and saving employee time and personnel overheads, among others, since physical attributes cannot be 100% duplicated or falsified.
[24]	A biometric application is implemented that uses fingerprint recognition as a biometric feature for authentication and access control. The application comprises a hardware module, including an Arduino Yun microcontroller and an R305 fingerprint reader. The application has an authentication success rate of 83.3%.
[25]	The article implemented a biometric application to recognize the periocular region (the area around the eye, including eyelids, eyelashes, and eyebrows). This alternative way allows access to the system using periocular biometrics.
[26]	A fingerprint-based biometric application was implemented, resulting in 82 valid fingerprints scanned out of 100 attempts; keypad access via system code entry worked smoothly with an input response time of less than 20 seconds, consuming less time than the previous solution.
[27]	The study developed an application where students register their attendance in less time through fingerprinting and complying with data privacy features. The project results reveal that 90% of the students are satisfied with the student attendance registration application.
[28]	A biometric attendance recorder using the fingerprint sensor in conjunction with Arduino UNO was made for students in schools or universities. They evaluated the device's performance by comparing it with conventional attendance methods through enterprise resource planning (ERP) companies. They found that the device saves an average of 11:53 minutes per class and 57:30 minutes per day, which can be used for adequate teaching-learning time.
[29]	The design of an automatic class attendance register was carried out. Using biometric fingerprint technology and a card with radio frequency identification technology (RFID) as a backup, it was designed to be less complex.
[30]	A robust and efficient attendance marking system was made using face detection and recognition algorithms. Using a popular Viola-Jones algorithm, then recognition using a convolutional neural network trained on the student face database. The system can mark multiple attendances from a single group image captured by a video surveillance camera.
[31]	In the research, face recognition is performed using convolutional neural networks with data input, dataset training, face recognition, and attendance input to develop an automatic attendance system. The application detected and recognized students in the class with a maximum accuracy of 92%.
[32]	An automatic attendance management system was realized based on face detection and face recognition methods under Haar's Cascade method and CNN algorithm. They compared three face detection methods, of which the Viola-Jones method obtained the highest accuracy (87.71%). Fifteen students were needed to obtain the images (60 for each student). The images for training were 720 and for testing 180.
[33]	It aimed to efficiently identify the individual's fingerprint, verify its authenticity, and store data such as time and date of entry. A general approach has been proposed for attendance administration using a WI-FI system.
[34]	Facial recognition and mask detection (which are not misused) were used, and various algorithms were applied to perform the automatic attendance registration process, saving these records in a database, where it is concluded that it provides greater accuracy in conditions of higher illumination.
[35]	An intelligent automatic attendance monitoring system was developed with the biometric facial recognition system. Using principal component analysis (PCA), nominal eigenvalue detection, and convolutional neural network (CNN).
[36]	The study indicates that fingerprints are the most widely used form of biometrics. Also, for the research, according to their registration and storage process, different sensors were used to collect data from 42 students when registering their entries.
[37]	It was concluded that automating attendance by face reading is a less intrusive method and establishes accurate registration at different levels of image identification.
[38]	He shares results obtained from applying biometrics through iris recognition, showing that a total percentage of 0% was obtained in the false match rate and the false identification rate, concluding that its application is a more accurate alternative to taking attendance. The number of students enrolled in the system was 5.
[39]	It seeks to contribute new knowledge by creating a prototype of a facial recognition system to study the requirements to be taken into account for counting class attendance. It also discusses its benefits and the comparison of algorithms to be used. The novelty lies in the author proposing an algorithm that recognizes faces based on an algorithm for detecting faces in an image.

[40]	It points out that fingerprints are frequently used in biometric-based applications since a unique pattern governs them and are reliable and applicable in various fields, such as time and attendance. The paper's novelty is that it proposes a biometric attendance system that can use a central identification repository for online verification of fingerprints, which can avoid maintaining a separate database for storing fingerprints and reduce memory overhead.
[41]	Fingerprint technology was applied because of its ease of use, accuracy, and low cost. The population analyzed in this study was 136 workers, concluding that the application was practical and met the characteristics of adaptability, efficiency, and job satisfaction in the attendance control process.
[42]	A novel bimodal behavioral biometric verification scheme was designed and developed for physical access control, using two behaviors: hand movement and walking. The system achieves an actual acceptance rate of 97.25% with a false acceptance rate of 0.01% on a dataset of 1600 samples collected from 40 participants.
[43]	It was established whether fingerprint biometrics could achieve greater accuracy and increase student teachers' participation when attending lectures. A total of 180 student teachers participated in the research. The result was an 18% increase in class participation.

After analyzing the articles, there is a clear interest and innovation in using biometrics for student attendance registration (see Table 6).

Table 6. Number of articles per year of publication

Year	Quantity	Related studies
2017	5	[26], [33], [37], [38], [40]
2018	3	[23], [24], [28]
2019	3	[22], [25], [43]
2020	8	[21], [29], [30], [31], [32], [34], [35], [36]
2021	3	[27], [39], [41]
2022	1	[42]

3. Analysis of the Results Obtained

After collecting articles, we will proceed to carry out an analysis with the respective questions posed in the literature review methodology. Where the interest in the topic is raised, and the continuous growth of related studies is visualized, where future work is also proposed concerning biometric technology and its evaluation, thus covering, as mentioned above, the questions posed for the literature review and the comparison made between the results found.

Q1. What are the benefits and limitations of biometric technology?

The collected studies present a broader and more precise picture of the benefits and limitations of different types of biometric technology (Table 7).

Table 7. Benefits of biometric technology

Benefits	Related studies
Prevent impersonation and false assistance	[21], [22], [27], [28], [30], [31], [32], [34], [35], [38], [39], [40], [41]
Saving time and work for teachers and students	[21], [23], [33], [34], [37], [38], [41], [43]
Increasing the security and reliability of data	[21], [24], [25], [26], [27], [28], [29], [35], [36], [37], [38], [42]
Increases productivity	[23]

Improving work culture, accountability, and transparency	[23], [40], [41], [43]
Generates a clear audit trail for attendance records	[23]
Biometric traits do not change or are difficult to alter over time.	[24], [31], [43]
Biometric technology can be used for several applications in different sectors.	[25], [37]
Improves verification accuracy in constrained scenarios.	[25]
Profitable	[28], [29], [30]
easy to use and reliable	[28], [30]
Avoiding the risk of human error	[31], [33]
Ensures minimal human intervention and manipulation of records	[33]
Avoid paper waste	[33]
Increases accuracy	[34], [35]
Check compliance with regulations (such as the use of masks).	[34]
Improved usability	[36]
Integrate with other technologies to create better classroom environments and improve student learning and motivation.	[36], [38]
Non-intrusive	[37]
Facilitates distance learning and examinations	[39]
Reduces memory overhead and maintenance cost	[40]
Provides reports that facilitate reporting of attendance, evaluations, and rewards (educational grants and additional incentives to students).	[40], [41]
It provides smooth and frictionless interactions for users.	[42]
Exploit natural and distinctive user behaviors.	[42]

Table 7 provides several benefits associated with the use of biometric technologies, especially in the context of attendance and records management. The analysis is presented below:

Several articles point out that one of the benefits of using biometric technology is the prevention of identity theft and attendance forgery [21], [22], [27], [28], [30], [31], [32], [34], [35], [38], [39], [40], [41], [27], [28], [30], [31], [32], [34], [35], [38], [39], [40], [41] which contributes to the integrity of records [21], [24], [25], [26], [27], [28], [29], [35], [36], [37], [38], [42]. Likewise, biometric technology saves time and work for teachers and students, as these technologies simplify attendance taking and reduce the administrative burden for both teachers and students [21], [23], [33], [34], [37], [38], [41], [43], thus fostering a culture of accountability and transparency in the educational environment [23], [40], [41], [43]; it also provides a detailed and audited record of student attendance [23], taking into account that biometric traits over time makes them reliable for identification because they do not change or are difficult to alter over time [24], [31], [43], which makes it applicable for different industries and contexts [25], [37], as biometrics can improve

accuracy [34, 35] in identity verification in specific situations [25], which makes it cost-effective [28], [29], [30], i.e., it enables economic savings due to automation and error reduction. Although some are easier to use [28], [30], [36], it always avoids human errors in taking attendance [31], [33] by limiting human interference, manipulation of records [33], and reducing costs such as paper waste [33]; also, biometrics can be applied to verify compliance with specific rules, such as the use of masks in the context of the pandemic [34], making it seamless to integrate with other technologies to contribute to a more efficient and motivating learning environment [36, 38] and non-intrusive, respecting the privacy of individuals [37], allowing for improved user experience [42], facilitating online education and testing [39], reducing memory overhead and maintenance cost [40]; It can also generate reports that facilitate educational decisions and the distribution of rewards [40], [41]; all this, by exploiting the traits, natural behaviors, and distinctiveness among users, makes it effective in identification [42].

Concerning the limitations, the following Table 8 is available:

Table 8. Limitations of biometric technology

Limitations	Related studies
Attendance does not occur at intermediate times between the start and end of the school day.	[21], [41]
Hardware or software failure	[21], [25], [27], [41]
Biometric characteristics may be altered.	[24], [25], [28], [30], [34], [36], [37], [39]
Biometric characteristics can be falsified.	[24]
Tackling privacy issues	[25], [38], [41], [43]
Scanning errors	[26]
Scanning and registration of biometric characteristics is required prior to use.	[27], [28], [34]
They could be very costly.	[29]
They could be very complicated to implement.	[29], [33]
The quality of verifying biometric characteristics may vary from one system to another.	[29], [36]
Compatibility errors.	[33]
False positives and false negatives.	[37]
Require authorization from a superior entity.	[40]
They remain prone to attacks.	[42]

Table 8 provides several limitations associated with the use of biometric technologies, especially in the context of attendance and records management. The analysis is presented below:

Several articles state that a common problem with biometric-based attendance-taking systems is that

they do not take attendance in real-time and only capture the entry and exit of students [21], [41]; another limitation is that these biometric systems could stop working due to technical problems such as power outages, network problems, or hardware and software failures [21], [25], [26], [41].

However, also the accuracy of biometric identification could be diminished due to scanning errors [26] and alterations in biometric features (skin lesions, among others) [42], [43], forgery [24] or climatic changes [24], [25], [28], [30], [34], [36], [37], [39]; Privacy issues are another limitation to be taken into account due to the collection and storage of inadequate biometric data [25], [38], [42], [43], which leads to biometric data theft and being subject to attacks [42], and the scanning of biometric traits is an inconvenient and time-consuming process; also, some biometric technologies could be costly [29] and complicated to implement [29], [33]; Also, the accuracy and reliability of these biometric systems may vary depending on the vendor and the quality of the system [29], [36], as well as compatibility errors, due to the need to integrate them [33]; also, biometric systems can generate false positives and negatives [37]; another limitation is that in some cases authorization from a higher entity is needed to validate the biometrics [40].

Q2. What are the recent trends in biometric technology used to solve time and attendance problems?

Table 9 shows the most recent trends in biometric technology focused on the time and attendance process with the ease and simplification of time and attendance recording.

As can be seen, fingerprint recognition is one of the biometric technologies most supported by a significant body of research [21], [23], [24], [26], [27], [28], [29], [33], [36], [40], [41], [43], suggesting a continued interest in research and development in this area; on the other hand, facial recognition is the second most applied biometric modality in educational institutions [22], [23], [27], [30], [31] [32], [34], [35], [37], [39], but growing, this we can notice by the year of publication, where most of these articles (7 of them) belong to the 2020s, unlike a fingerprint, where only 4 of them belong to the same decade and 7 to the last decade; Biometric trends less used in the education sector, but also important are: iris scanning [23], [28], periocular recognition [25], which are research that belongs to the past decade and behavior-based bimodal biometrics [42] which is research that is within the current decade.

Table 9. Recent trends in biometric technology

Recently trends	Related studies
Fingerprint Recognition	[21], [23], [24], [26], [27], [28], [29], [33], [36], [40], [41], [43]
Facial Recognition	[22], [23], [27], [30], [31] [32], [34], [35], [37], [39]
Iris Scan Recognition	[23], [38]
Periocular recognition	[25]
Bi-modal biometric technology	[42]

Q3. What research approaches were used in previous studies on applying biometric technology in time and attendance?

Given the articles found, we identified which approaches have been used in previous studies on the application of biometrics in time and attendance (Table 10):

Table 10. Research approaches

Approaches	Related studies
Quantitative	[21], [22], [24], [26], [27], [28], [29], [30], [31], [32], [33], [34], [35], [36], [37], [40], [41]
Qualitative	[25]
Descriptive	[23], [27], [28], [38]
Experimental	[26], [27], [33]
Exploratory	[38]
Mixed	[42], [43]

About research approaches, it can be said that the quantitative approach is the most widely used and is characterized by the use of numerical data and statistical techniques to collect and analyze information [21], [22], [24], [26], [27], [28], [29], [30], [31], [32], [33], [34], [35], [36], [37], [40], [41]. Another widely used research approach is the descriptive approach [23], [27], [28], [38], which aims to describe and document the characteristics of a particular phenomenon or population; experimental approach, in which researchers deliberately manipulate one or more independent variables to observe the effects on a dependent variable. Experiments are usually conducted under controlled conditions to establish causal relationships; there are also less commonly used research approaches, such as the qualitative approach [25], which focuses on understanding and exploring phenomena from a subjective perspective; exploratory [38], which is used when investigating a topic that has been little studied or not previously researched; and mixed [42], [43], which combines elements of quantitative and qualitative research in a single study. Relating Tables 6 and 10, most of the articles with quantitative, descriptive, experimental, and mixed approaches belong to 2020, 2018, 2017, and 2022, respectively.

4. Limitations Encountered and Future Research

This paper does not incorporate biometric technology concepts but reviews virtually all peer-reviewed international articles and conferences of the last five years. The questions asked in the study were written in clear language, trying to avoid bias.

The methodological diversity of most of the related studies has a predominance of quantitative and descriptive approaches, which may limit the exploitation of other essential aspects that could enrich the understanding of biometric trends from a more holistic perspective. The results obtained in this work are guiding us in future developments of research projects that are currently underway.

On the other hand, future work can consider overcoming limitations in the operation of the equipment due to power outages, network connection instability and students leaving without permission; detecting the identity of a specific student (for different types of images and scenarios) through facial recognition, which can increase the range of detection not only at the entrance or exit of each subject or course [21]; explore other applications of biometric technology, such as its application in bank teller machines by equipping them with facial recognition software to increase security when withdrawing money from them [22]; exploring other biometric features such as iris, face, gait or keystroke dynamics for more reliable and versatile identification and verification applications [24]; improving the accuracy and robustness of periocular recognition in unconstrained scenarios, such as variations in lighting pose, expression and occlusion; explore the fusion of periocular biometrics with other modalities, such as iris, voice, face and fingerprints, to improve the performance and security of biometric systems and convenience, and develop efficient and effective algorithms for periocular feature extraction and matching, using machine learning techniques such as convolutional neural networks and deep learning, and assess the usability and acceptability of periocular biometrics for different applications and users, taking into account the ethical and privacy issues involved; improve accuracy and reliability through the use of more advanced sensors and algorithms; assess the impact and benefits of the system on the academic performance and attendance of students and teachers, and consider conducting research focusing on the ethical and privacy considerations related to the use of biometric technologies; conduct comparative analysis over time to identify significant patterns and changes in the adoption and development of biometric trends; conducting research related to the development of advanced image processing and computer vision algorithms to take full advantage of 3D biometrics; the application of multimodal biometric technologies in different environments; taking advantage of wireless technology and cloud storage of biometric features; add chat functionality between instructors and students to help them communicate directly [27], provide versions of apps for smartphones and tablets from different technology companies; biometric systems could be connected via Bluetooth to

smartphones and through the smartphone cameras, allow photos to be taken and these files to be sent to the central system for attendance registration; Also, the system could be extended to work with different video sources and formats, such as webcams, smartphones or CCTV cameras; the system could notify when it does not detect any student in class; it could also be used in electronic voting and payment by recognising their facial features; the operation of the system in real time and notifying students' parents or guardians of their attendance status; integration of the biometric attendance monitoring system with other academic systems to improve the quality of education and student performance, provide automatic database generation for each class [34] and implementation in examinations [40].

5. Conclusion

With the documentary analysis carried out on the results of the research associated with biometric technology applied to educational institutions, it is concluded that:

Despite the great advances in biometric technology, we have some limitations (power failures, network instability, and accuracy in the recognition of the biometric characteristic) that would render the equipment inoperative [21].

An important point to improve in educational institutions is the control of attendance at any time during the course of the class and not limited only to the registration at the beginning or at the end of it; for this biometric technology to be implemented, it should be multimodal, that is to say, that several biometric technologies will be used in a single system in order to be more secure attendance control.

Among the most outstanding benefits offered by biometric technology to educational institutions are avoiding impersonation and false attendance, increasing data security and reliability, and saving time for both teachers and students; the less frequent benefits open up interesting alternatives for research along these lines as well. In terms of limitations, the most prominent ones are biometric characteristics, which may be altered (leading to a decrease in system accuracy), hardware or software failure (rendering the system unusable), and privacy issues (exposing users' data and making them vulnerable to attacks of all kinds). This also allows for future studies of improvements along these lines. The least-voted constraints are also options for generating proposals to address these problems from different angles.

In terms of recent trends, what can be observed is that fingerprint recognition is still widely used, which offers certain advantages, perhaps more oriented towards the cost of the equipment, but also offers some disadvantages, such as tactile interaction or direct contact.

On the other hand, in this decade, new technologies (bimodal or multimodal biometrics, facial, among others) that require remote or remote interaction, which makes them more efficient at the time of controlling attendance, are making headway.

As far as research approaches are concerned, most of them are quantitative and descriptive, which implies that research is being approached from multiple perspectives and methods. From the articles reviewed, we notice that in 2022, scientific articles were published with a mixed research approach, i.e., they rely on both the advantages offered by the quantitative approach (precise measurement of variables) and the qualitative approach that focuses on understanding and exploring phenomena from a subjective perspective (does not overlook factors that are not easily quantifiable).

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