Neuromarketing and Facial Recognition: A Systematic Literature Review

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Abstract. Companies and marketing departments are devoting many resources to the implementation of neuromarketing with facial recognition. This document presents a systematic review of the literature whose main objective was to look for computer systems and technologies of facial recognition that are available to support neuromarketing. As a result, it was found that very few academic and scientific articles focus on this topic in a systematic way. None carry out an analysis for a complete solution and the studies are limited with databases that do not offer a group of images which are sufficiently broad to allow the performance of complete tests. Many works emphasize research on algorithms that increase the level of accuracy of the information analyzed at the time of facial recognition.

Keywords: Software · Neuromarketing facial recognition · Technology

1 Introduction

Marketing is a discipline that has been developed under this term for the last century. It responsible for analyzing the behavior of markets and consumers, always oriented to the satisfaction of the costumer. Companies want to increase their economic benefits, getting new clients and reinforcing the loyalty of the existing ones. That is why they make use of diverse techniques and tactics through equipment and tools that allow to detect the clients' needs in a more efficient way. They even create wishes for a specific product.

Avendaño Castro [1] considers that advances in the areas of psychology, neuroscience, the cognitive field and understanding of the functioning of the human brain have enabled other disciplines and areas of knowledge to formulate new theories. This is the case of marketing. It relies on the latest discoveries about the brain, and has incorporated strategies to attract clients. Neuromarketing considers the true essence of man's thought, uncovering more information about the consumer. This information is qualitatively richer and more truthful [2].

Neuromarketing applies neuroscience techniques to marketing stimuli in order to understand how the brain is activated and reacts to marketing actions. The use of facial

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recognition in neuromarketing pursues the collection of the face image with a camera; The main advantage over other techniques or equipment is that when using a camera, it is not necessary to physically connect any device to the person; that is, no cables will be placed or added. It is a very simple and non-invasive way for the consumers, which is very important when trying to know their tastes and preferences.

This review was made following the process described by Kitchenham [3], who points out that a systematic review synthesizes existing work in a way that is fair and seen as fair. For example, systematic reviews should be carried out according to a predefined search strategy, which explains how effective these studies have been when used for software engineering issues.

The main aim of this review is to compile the most complete list of software that allows facial recognition, to support neuromarketing and present these results as a visual summary (map) of classified characteristics. The classification of the tools will be based on characteristics which are common to all the studies (mainly related to the facial recognition due to its importance).

This work contains four more sections: the first one outlines the methodology used to carry out the systematic review of the mapping, including the formulation of questions, the selection of sources and studies, the extraction of information and the mapping process; in the second, the results obtained after carrying out the systematic mapping of the review are shown; the third one presents the interpretation of those results and finally the conclusions and the planning of future works are shown.

2 Systematic Review

2.1 Generality

The aim of this study consists of carrying out a systematic mapping of literature review of facial recognition tools that support neuromarketing, and obtain information on which computer systems are available and the characteristics they include.

2.2 Definition of the Research Question

The availability of computer systems for facial recognition was obtained by asking the following question: What facial recognition computer systems are available to support neuromarketing?

The list of keywords used to carry out the research were the following: software, neuromarketing, facial recognition and technology.

Once the systematic mapping review was completed, the research question was formulated and it provided the following results:

- Recognize the software or hardware tools that are used or available for facial recognition.
- Distinguish the main characteristics of computer systems and technologies related to facial recognition.
- List the areas supported by the facial recognition computer technology, especially neuromarketing.

2.3 Selection of Sources

The objective of this phase is to identify the sources used for searching; in order to do so, the selection criteria described below were defined: (1) search for digital versions of articles, journals and conferences on neuromarketing and facial recognition using the established key words; (2) bibliographic sources must have a search engine that allows executing advanced search queries; and (3) all the studies had to be written in English.

On the basis of the criteria above, searching was done in the following digital research libraries: Ebscohost.com, ACM Digital Library and IEEE Xplore.

Although the defined digital sources index the most relevant investigations, other sources of information were added in the present study, separately for their analysis, such as web pages of recognized commercial companies that offer software for facial recognition applied in the neuromarketing.

2.4 Search Strategies

A series of terms and key words were selected to answer the posed question and obtain the expected results. The search strategy was based on key words and/or synonyms, see Table 1.

Table 1. Key words and concepts used in the systematic review.

Area	Key words	Related concepts
Marketing	Neuromarketing	
Systems	Facial recognition software, technology	Facial recognition technology

The structured search chain was the following: facial recognition software or facial recognition technology and neuromarketing. The string was applied to: summary and full text. When the summary fit the subject of the investigation, the complete article was obtained and revised. The language or language of searching for the publications was English. The first year of the publications was 2013.

2.5 Inclusion and Exclusion Criteria

Inclusion criteria: (1) Articles published since 2013; all software has a certain support time, and then they stop receiving updates; for those who evolve, new studies are created quickly with the new functionalities; therefore, it is considered that any document that studies a tool before this year could be considered obsolete. (2) Software contents for facial recognition and neuromarketing. (3) Articles from conferences, magazines and international workshops. (4) When an article is repeated in several digital libraries as a result of the query, only one of them is selected.

Exclusion criteria: (1) Articles of which content is not related to neuromarketing, software for facial recognition or something similar. (2) Works on slides and books. (3) Works which are published outside the specified time range. (4) Gray literature.

2.6 Extraction of Information and Review of Works

This phase allowed to identify the relevant documents, with respect to the objectives of this systematic review and the scope of the research question. The main difficulty in achieving this goal was that the terms used in the question led to results that were too broad. For example, the word "software" is widely used in many types of publication, and therefore a large number of documents appeared in the results obtained, see Table 3.

In order to obtain the most valuable documents and do a deeper analysis in relation to the aim and the research question, the search chains and additional options applied were defined, see Table 2.

Table 2. Chain and additional options for search in sources.

Source	Chain of specific search	Included additional options
Ebscohost.com	facial recognition software **or** facial recognition technology **and** Neuromarketing	Software and technology of facial recognition, neuromarketing in the option "any field"
ACM Digital Library	facial recognition software facial recognition technology	In the option "any field", for each search
IEEE Xplore	facial recognition software **or** facial recognition technology **and** Neuromarketing	Software and technology of facial recognition, neuromarketing in the option "any field"

Table 3 contains the number of articles found, the chains of search and the different inclusion criteria.

Table 3. Selection of studies.

Phase	Inclusion criteria	Articles found		
		EBS	ACM	IEEE
Based on chain of search in any field	None	930	167	14
Based on chain of search in selected fields	Facial recognition software in field title	25	1	3
	Facial recognition technology in field title			
	Neuromarketing in field summary			
Based on chain of search in selected fields	All the search terms in field summary	29	19	3
	Additional filter in academic publications			

Ebscohost.com (EBS), ACM Digital Library (ACM), IEEE Xplore (IEEE)

Initially the most relevant documents were obtained through the realization based on search chain in "any field", see Table 3. In this first phase, a large number of results were obtained, but these results were not useful, since they consisted of comments, letters or repeated works that were not only limited to the search of software or

technology for facial recognition, but all kinds of articles were visualized, in which software applied to different activities was analyzed. The second phase, based on search chain in fields selected by "titles", allowed to eliminate some unusable results and repeated works, making the search of software and facial recognition technology only in titles; search whose results were not yet adequate to satisfy the investigation. Finally, in order to obtain the definitive list of primary studies, a search based on the search chain is performed with fields selected by "summary" and from academic sources.

During the process of extracting information and reviewing works, it was assumed that the quality of the work obtained would be guaranteed by the evaluation made in the sources from which they were taken, since the studies are shown by their relevance. As regards the collection process, these documents are taken from those that were in line with the approach of the research question and the systematic review.

3 Results of the Review

Table 4 shows the studies selected for the present work, as well as a comparison between them, which is based on the relevant information that was found and established under the parameters described in the previous section. They are arranged alphabetically and their order does not determine their importance with respect to the objectives of this work. This table contains the following information for each analyzed work: (1) work, (2) ad hoc development, (3) software evaluated, (4) programming framework or tool, (5) integrated to software or technology, (6) test database, and (7) related devices.

There are several areas in which we work with facial recognition. Many researchers have opted for developing their own algorithms in order to be sure that they will provide reliable results for each area, while others have used available technology to verify and validate their data. As an attempt to give more validity to their research, some authors present the programming tools with which they have worked and the methods used in the analysis of facial expressions and recognition of emotions.

Many articles show that facial recognition algorithms will be integrated to other technologies and they pursue greater agility in the processing of the information they have. Opportune feedback is sought mainly by taking their emotions and data are collected through a webcam and a microphone [12]. There are several databases with photographs that are currently available to make facial recognition tests, but there are also many cases in which the authors are creating their own databases. Padrón-Rivera et al. [22] tested the accuracy of a tool with the Cohn-Kanade images and the results of the comparisons showed an accuracy of 70%.

As regards hardware related to facial recognition, it was found that there are several devices that currently serve to capture the images of the faces and facial expressions of the individuals being investigated. This is somehow uncomfortable because the person must stop doing their regular activities to lend themselves as models and support the studies. Others are simply recorded while doing their tasks.

Table 4. Summary of articles with the detail of the technology used, its characteristics and the area of application.

1	Software					Hardware
	2	3	4	5	6	7
[4]	Yes	Boosted Deep Belief Network (BDBN)			Extended CohnKanade (CK+), JAFFE	
[5]	No	FaceAPI	MHP (Multimedia Home Platform, version 1.1.3)	Moodle y T-EDUCO		Camera Ip
[6]	No	S/N		TTL signals		Eyetracking, EEG
[7]	No	S/N				
[8]	No	S/N		TTL Signals		3dMDface
[9]	No	Picasa				Photographs
[10]	No	Face2Gene				
[11]	Yes	FACSGen 2.0 animation software		Facial Action Coding System, FACS		
[12]	Yes	S/N	FILTWAM y C++	EMERGO Web Service Client	Cohn–Kanade (CK+)	Web cam and microphone
[13]	Yes	S/N	Visual Studio versión 2010			Ip Camera
[14]	No	Stimulus control, versión 2.0 Software				
[15]	Si	S/N			CFEE, DISFA and CK+	
[16]	No	FaceReader software				Web cam
[17]	Yes	S/N			CASIA, 3DMAD, UVAD	Kinect
[18]	Yes	S/N			Cohn-Kanade database, JAFFE and FEEDTUM datasets	
[19]	No	Attention Tool V5.3 de Computer Expression Recognition Toolbox (CERT)			Jerusalem Facial Expressions of Emotion (JeFEE)	

(*continued*)

Table 4. (*continued*)

1	Software					Hardware
	2	3	4	5	6	7
[20]	Yes	S/N			Image Database	Laptop
[21]						
[22]	Yes	S/N			Cohn-Kanade AU-Coded	Video camera
[23]	No	FaulhaberComp, MuecasJointComp, CamaraComp, IMUComp, RGBDComp, JoystickComp	RoboComp			Multi-sensor robotic head, Microsoft Kinect and sensor Xtion PRO LIVE
[24].	No	CSIRO Face analysis SDK			Audio-Visual Emotion Challenge (AVEC) dataset	Web cam
[25]	No	G8 commercial face recognition software				Monitoring solutions package provided by L1 systems
[26]	No	Matlab 7.0, Emotient FACET SDK v4.1 (iMotions, A/S, Copenhagen, Denmark)			KDEF	
[27]	No	AdaBoost			JAFFE	
[28]	No	FaceReader 5 Noldus		Rosie 2		Eye tracker technology Tobii T60XL

1 = Work, 2 = Ad hoc development, 3 = Software evaluated, 4 = Framework or programming tool, 5 = Integrated in software or technology, 6 = Test database, 7 = Related devices

The application of facial recognition and its advances in the areas of technology, medicine and education are those that are being studied the most. Some of the characteristics found in the selected articles are shown below.

3.1 Areas of Study in the Application of Facial Recognition

Area of Technology

The highest percentage of the articles evaluated and categorized corresponds to those researches related to improving or complementing facial recognition technology. In these articles we find methods that seek to fully satisfy facial recognition regardless the circumstances in which an image is taken, such as combining the average face in 3D and improved Ada-Boost (adaptive algorithm that combines weak classifiers to obhave a robust classifier), to recognize facial expressions in motion, under conditions of poor visibility of the face [27]. Wahab et al. [13], propose an automatic image

acquisition system using multicamera to capture facial images from 50 different angular views, which extend horizontally 180° from left to right, and vertically from horizontal to 70° above the face; using 30 IP cameras that were mounted on two rigid steel arms. The technological contributions of the basic forms of emotional expression that appear on the faces of people are of vital importance for neuromarketing as well as for other areas that assist with facial recognition. Recio et al. [11], conducted a face classification study that shows facial expressions of six basic emotions in static and dynamic presentation modes and three different types of neutral movements. The stimuli were created with software that allows a detailed control of the action units and the dynamic characteristics. Those expressions are evaluated by computer vision algorithms for recognition and registration of databases of millions of images of emotion facial expressions, under different conditions and environments such as nature [15].

Facial recognition is combined with other technological methods to avoid transgression when used in private security. Studies that involve methods to detect attempts of impersonation in facial recognition systems are proposed, with the hypothesis that during the acquisition there will be re-captured biometric samples that allow to create a discriminatory signature of the video generated by the biometric sensor [17]. According to Wahab et al. [13], you can recognize facial expressions in 3D formats, get to identify body language and have accurate biometric control with facial recognition.

Facial recognition also allows to improve many processes such as digital security and it improves people's quality of life, as shown by Carter [20]. This author proposes a password system, which is easy to memorize, graphic, and specifically designed for older users, achieving a level of password entropy comparable to traditional PINs and text passwords. It highlights how through facial recognition you can obtain an adequate selection of proposed images as part of passwords for the elderly. In the field of robotics, there are studies of mechanisms that allow direct interaction between the robot and its human companion through the different modalities of natural language: speech, body language and facial expressions [23].

Area of Medicine

Degenerative diseases can be detected in a timely manner by performing simple scans and identifying the genes that cause them. There are studies that support this solution, such as the approach of a facial recognition medical software to achieve the highest precision in the prediction of the gene that causes a disease of physical deformation [10].

The depressive states can also be clearly identified with the facial expressions accurately identified by facial recognition. In this sense, it is important to remark a depression prediction system (mood disorder) that uses a feature selection approach based on audio, visual and linguistic signals to predict depression scores for each session [24].

Studies point out that the medical and forensic sciences are finding great support for their investigations through facial recognition. Whitelam and Bourlai [25] propose an algorithm that improves facial recognition performance in terms of range identification rates, with a practical value for forensic tool operators in the field of Biometrics, to avoid manual locating the eye centers of all the facial images available in a data set. Parks and Monson [7] conducted a study to examine the accuracy with which facial CT images were extracted and paired with available photographs for identification.

Guo et al. [8] present a non-rigid registration method for mapping 3D facial images, which uses seventeen facial references through recognition of functions. They use an independent software to help with the development of an antrophotometric analysis of high content and performance, very useful in anthropology, diagnosis and forensic studies of the human facial morphology.

Area of Education

Education is another area in which researchers are looking for improvement with the use of facial recognition. Many online courses allow you to see the faces of the students, which is being used to provide them with better assistance and support. Baldassarri et al. [5] indicate that this allows them to personalize the courses so that the students take better advantage of the content provided.

Computer systems allow the best detection of the student's emotional state and transmit it to the tutor so that he or she appropriately addresses the tutoring. The development of a tutorial platform for IDTV (Interactive Digital TeleVision) that uses the automatic recognition of facial emotions to improve the tutor-student relationship is studied. The system goes beyond simply transmitting an interactive educational application, and it allows the personalization of the course content thanks to the timely detection of emotions [5].

Nowadays, information is collected on the behavior of people before academic activities, allowing the synchronization of conductual, emotional and cognitive data. This is possible thanks to various applications with sensors that incorporate facial recognition techniques. Studies are being proposed to specifically improve adaptive assessment environments, such as those by Charland et al. [6], who propose a methodology to collect and synchronize data on multidimensional engagement in learning tasks, through the collection of electro-dermal electroencephalography, eye tracking and facial emotion recognition data in four different computers. The use of specialized integration software offers a better understanding of dynamics among the multiple dimensions of commitment.

The virtual training processes are assisted by multimodal recognition, so that teachers can identify students' emotions in real time for their feedback, improving online communication and learning performance. Bahreini et al. [12] propose multimodal emotion recognition software in real time to provide more adequate feedback to students through online communication skills training.

Facial recognition studies and their application in the academic areas generate offer results for predictive use. For example, there is the research carried out by Padrón-Rivera et al. [22] that reveals that through facial recognition, students with confusion during interaction with the mathematics tutoring system had better learning gains than students who had more instances of frustration on their faces [22].

Other Areas

The systematic review revealed that facial recognition computer techniques are applied to many areas, beyond the important impact they may have on neuromarketing.

Dalton et al. [16] contribute to the economic area, through a study in which they use facial recognition and show whether exposure to poverty can lead to affective states that decrease productivity.

As for business, the application of facial recognition in the area of administration, allows to verify the effect of different types of feedback on the performance of a task and achieve the best strategies of satisfaction of those involved [14].

In the area of human resources, software and technology are considered useful to examine the emotional responses shown by social workers and those in charge of health in a child protection center [28].

Facial recognition used by the police is oriented from different perspectives, for example, independent tools of the standard of suspicion are incorporated, which allow restricting the scope of criminal investigations and discard innocents, using facial recognition software and combining it with data mining [21].

In the area of neuromarketing there is few but important research, such as Lopes et al. [4], who present the evaluation of a simple solution for the recognition of facial expressions using a combination of standard methods, such as the convolutional neuronal network and the step of image preprocessing specific to convolutional networks, and machine learning methods [4]. Likewise, Mostafa et al. [18] offer a system that uses the facial action units of the face that identify a person recognized by CNN (Convolutional neural networks) first and incorporate the recognition of the seven basic emotional states.

An important contribution related to marketing is posed by Calvo et al. [26], who present the evaluation of a software that measures basic emotions through calculations. They show very low levels of intensity in order to know if they can be recognized, since they have considerable practical relevance for everyday life, where many emotional expressions are subtle due to social restrictions.

Results are not always favorable for the applications created. For example, Yitzhak et al. [19] present a study that reveals that a facial recognition software can identify the classic prototypical facial expressions of images recorded in the available databases, but unfortunately it could not analyze or capture the natural ones as a reaction to a pipeline, which contain the wealth of everyday emotional communication.

Facial recognition applications can be complex or simple but useful for different areas, for example when incorporating them to the Picasa software, used by the photographic archives personnel. It allowed to identify ways in which the creation of metadata could be automated, giving them time to focus on those areas where human judgment is most valuable [9].

3.2 Facial Recognition Software

Below there is a short detail of software for facial recognition that has specialized in supporting the area of neuromarketing at the commercial level, brought from outside the digital research libraries:

- Software iMotions Neuromarketing Startup Package is characterized by combining different biometric sensors. iMotions exactly reveals what a person is looking at (Attention), if he or she is having a positive or negative feeling (Valence), the intensity of that feeling (Arousal) and the emotions that are expressed at a specific point [29].

- Facial Action Coding System is an online platform to measure emotions and understand human behavior through face analysis. Together with emotional analysis and moods, they allow a much more accurate prediction of consumer behavior [30].
- Affdex allows facial coding and emotional analysis. Advertisers can measure unfiltered and unbiased consumer emotional responses to digital content [31].
- E-Prime is a more complete software available for behavioral research. It performs analysis of patterns of attention, behavior and visual search with the eye Tobii Pro [32].
- Face recognition made easy Kairo is used for collecting unique information in real time about people who interact with the company, brand or product, through face detection, face verification, emotional detection, etc. [33].

Most of the neuromarketing software found on commercial websites has online testing platforms. You must learn to manage them or cancel consulting to reach an adequate and correct interpretation of the obtained results.

4 Discussion

Having established that there was a need for this systematic review and that no other need had been published in this area and approach, the mapping study was carried out. After conducting the systematic mapping review one of the goals was to identify which software or hardware tools are used and available for facial recognition.

When reviewing the primary articles, it was found that in some of them the Noldus FaceReader software was used, which is the one that has been used the most for tests, since it analyzes data (live, video or still images) saving time in the tests. It can be downloaded from the web, but it can also be used as an online application on the Internet. This software is found in some articles because it has been used for more than a decade, in more than 600 universities, research institutes and market companies. According to Reeves et al. [28], FaceReader includes several user-selectable models that provide optimal performance for different groups of people and conditions; it serves as support for the areas of psychology, education, neuromarketing, etc.

Cohn-Kanade was the most used test database to obtain images, followed by the Jaffe database and in third place is the Casia database. Cohn-Kanade has become one of the most widely used test banks for the development and evaluation of algorithms with the purpose of promoting research to automatically detect individual facial expressions.

In the facial recognition article published in 2016 [34] it was already pointed out that improvement in this technology is constantly evolving due to the fact that we want to improve the detection of facial features, even if the person's face has shadows. It even detects faces in the dark. At the present time it allows to interact with different branches of science that facilitate the recognition of an individual through his physical features of his face and his gestures.

It was found in the review that there are several scientific articles in which there was an ad hoc development, that is, the application of algorithms created to improve the times and effectiveness of facial recognition was created and documented.

Among the articles in which new software and algorithms were found, it is evident that the characteristic they have in common is the search for ways to achieve greater speed when performing facial recognition, considering the six basic emotions, which allows a greater productivity and efficiency, and reaches more than 95% accuracy in the information analyzed. Most studies find the main weakness when performing facial recognition, that is, the angle in which the face to be recognized is found or the equipment malfunctions in low light situations, in addition to long hair, sunglasses or other objects that cover part of the face, which makes facial recognition very difficult to do.

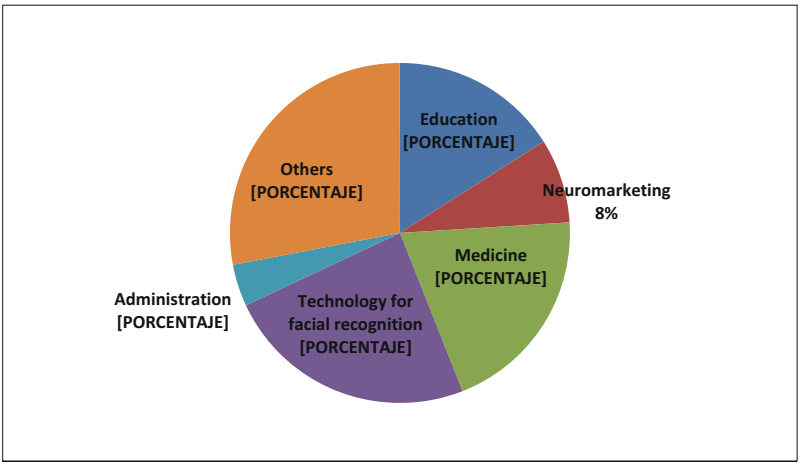

Fig. 1. Main areas supported by facial recognition studies

According to Fig. 1, the two areas in which the facial recognition studies have focused the most are: improvement of general facial recognition technologies and medicine. The percentage of the area called "neuromarketing" corresponds to two articles specifically related to this area. Both are similar in their goals and contain a similar scheme of presentation of the research. The two authors make it clear that they are aimed at supporting the activity of neuromarketing.

Leaving digital research libraries aside, neuromarketing gains commercial interest, for example in the big industry of Hollywood or in developed countries that have technology, market and distribution [35]; such is the case that Disney tracks the facial expressions of an audience when watching a movie in order to evaluate the emotional reactions to it, recognizing a series of facial expressions of the audience such as smiles and laughter.

Another very representative case in the use of neuromarketing is the corporation of Walmart stores, which are even patenting the use of video cameras in the register boxes or store exits, with which they will analyze the facial expressions and the movements of the clients in such a way that they will be able to identify unsatisfied customers. The goal is for as few dissatisfied customers as possible to leave a store without a Walmart employee coming to listen to their possible problems or dissatisfaction.

5 Conclusions and Further Research

This work presents a systematic literary review of neuromarketing mapping with facial recognition and was carried out following the Kitchenham guidelines [3]. In most of the articles reviewed, what is documented in the abstracts does not provide specific information about the potential of the tools, the programming language or framework used, which makes the literary systematic review process more complex.

After the review had been carried out, a first conclusion was reached that points out the existence of few published neuromarketing articles about facial recognition. Most research efforts are focused on finding algorithms that improve the effectiveness of facial recognition assisted by computer programs. It was difficult to find detailed and specialized information, but in any case several serious documents were found that make it possible to clarify terms and find analysis to technical solutions that have been in the market for several years.

It has become very important to know the reactions of human beings doing facial recognition through a series of technological tools and equipment, for which algorithms have been developed that try to solve or improve a series of events and situations such as: achieving greater productivity in industry, improving people's quality of life, facilitating the forensic work, improving teaching methods and expediting the decisions to buy finished products.

Cohn-Kanade, Jaffe and Casia databases are extensive databases that provide images of faces (faces) and the complete human body. They have been used to carry out the algorithms tests.

Although the comparative review shows that there are studies and analysis of software to perform facial recognition, no significant studies were found that emphasize its direct application in neuromarketing, so that gaps have been detected that must be filled. This shows that new lines of research are open to learn more about proposals that get deeper in neuromarketing with facial recognition, so that these gaps are filled. Yet, there is not scientifically documented a technique that provides a robust solution for all kinds of situations in which an image is captured in order to analyze and identify a face under any circumstance.

As future work, this systematic review of the literature is intended to include more innovative technologies when reviewing a broader set of digital libraries. Future work is expected to bring about more findings on the use of hardware and software that support facial recognition in neuromarketing as the main axis, based on continuous improvement.

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