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A Bibliography Review on Facial Expression Recognition System by Conventional Approaches

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Abstract: The Facial Expression Recognition system is the process of identifying the emotional state of a person. It plays a crucial role in the area of human-machine interaction. Automatic facial expression recognition system has many applications but is not limited to, human behavior understanding, detection of mental disorders, and synthetic human expressions. Research in this field has drawn much attention given the continually increasing number of publications in the last 10 years. In this paper, bibliographic research was used and a comprehensive review of relevant publications was taken from the Scopus database. The research is defined as any research requiring information to be gathered from published materials. This bibliographic research gives descriptive information about a piece of work, such as author, title, date of publication, etc. The analysis also allows mapping of the scope and structure of discipline; locating the established collaboration patterns among countries. This analysis also identifies the current research interests and potential directions for future research.

Keywords: Facial expression recognition, Emotion recognition, Bibliographic survey, Deep learning and machine learning.

1. Introduction:

In recent years, many developments have been accomplished in the areas like face recognition, and face tracking and it anticipated interest in the facial expression recognition field. A facial expression is one or more motions or positions of the muscles beneath the skin of the face. Most of the visual modalities are featured facial expressions [1]. It is always considered as one of the essential tools for human interaction. Integrating the ability to detect and synthesize facial expressions into machines provides a natural and smooth interaction [2]. Such efficient perception of facial expressions is advantageous because it plays an important role in signaling potential positive or negative outcomes [3]. It is considered as an attention-grabbing mechanism because the information read from a facial expression can denote the possible threats or pleasures in the environment [4]. Detection of negative facial emotions such as fear and sadness, but not happiness, was also faster in the lonely relative to non-lonely controls. Identifying angry faces also was more accurate in the lonely relative to non-lonely controls [5]. Therefore, facial expression is observed as the first tool to communicate feelings to the outside world, interact with others, and which it will understand how others communicate [6]. There was much architecture observed to be the best in image classification for facial expression recognition [7, 8]. Figure 1 explains the Different kinds of expressions in facial expression recognition.

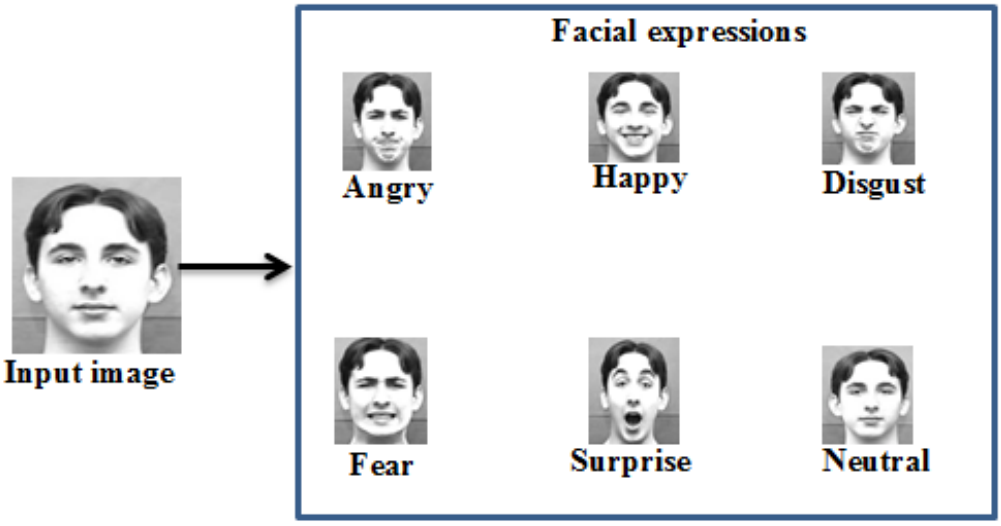

Figure 1: Different kinds of expression in facial expression recognition

Most of the available techniques endeavor to classify emotion experienced by a subject based on the external manifestation of his/her emotion, such as a change in facial expressions, voice qualities, and physiological characteristics [9, 10] There are some of the following different Machine learning (ML) techniques as well as DL techniques for classification tasks in facial expression recognition [11, 12]:

- **Linear Regression** [ML]: It helps to predict the value of a variable based on the value of another variable.
- **Artificial Neural Networks (ANN) [ML]:** It uses learning algorithms that can independently make alterations in a sense as they obtain new Input.
- **Convolutional Neural Networks (CNNs) [DL]:** It is differentiated from other neural networks by their superior performance with image, speech, or audio signal inputs.
- **Multi-Layer Perceptron (MLP) [DL]:** It utilizes the back propagation for training the network

Initially, humans can recognize emotions and report what they recognized in an understandable way. After that, other applications of artificial intelligence are also benchmarked against human performance [13, 14]. From only a short history, it can be declared that facial expression recognition is a valid research tool for intense and prototypical emotional facial expressions [15]. Thus, this technology is a promising candidate to assess emotional facial expressions on a non-contact basis also.

The bibliographic survey paper is explained as follows: section 2 summarizes the survey on facial expression recognition using different techniques with its methodology and data analysis; section 3 indicates the bibliographic analysis, and the paper is concluded in section 4.

2. Conventional Facial Expression Recognition System:

Facial expression recognition is a technology, which uses biometric markers to detect emotions in human faces. It is the automatic detection of the emotional state of a human face using computer-based technology. Facial expression recognition aims for a higher-level interpretation of fine-grained and high-level interpersonal relation traits, such as friendliness, warmth, and dominance for faces that co-exist in an image. Facial expression recognition is normally done with single-frame images (Static) or sequences of video images (Dynamic). In dynamic images, stable features of the face in all the images of fixed sequence and transient features are caused by facial expressions and there is a change from each frame to the next frame of the sequence [16, 17]. However, the task of facial expression recognition remains a challenging problem because of its individual variations in facial expressions [18, 19]. From the approach of Sourabh, et al. [20], it had been shown that some of the facial

expression recognition is specially planned for an application and required real-time data. It includes spontaneous and posed expression data, pain detection, a music system based on mood, human-computer interaction, security, driver fatigue detection, and an intelligent tutoring system. There are many models used in the classification of facial expression recognition [21]. Figure 2 explains the block diagram of the facial expression recognition system using different techniques.

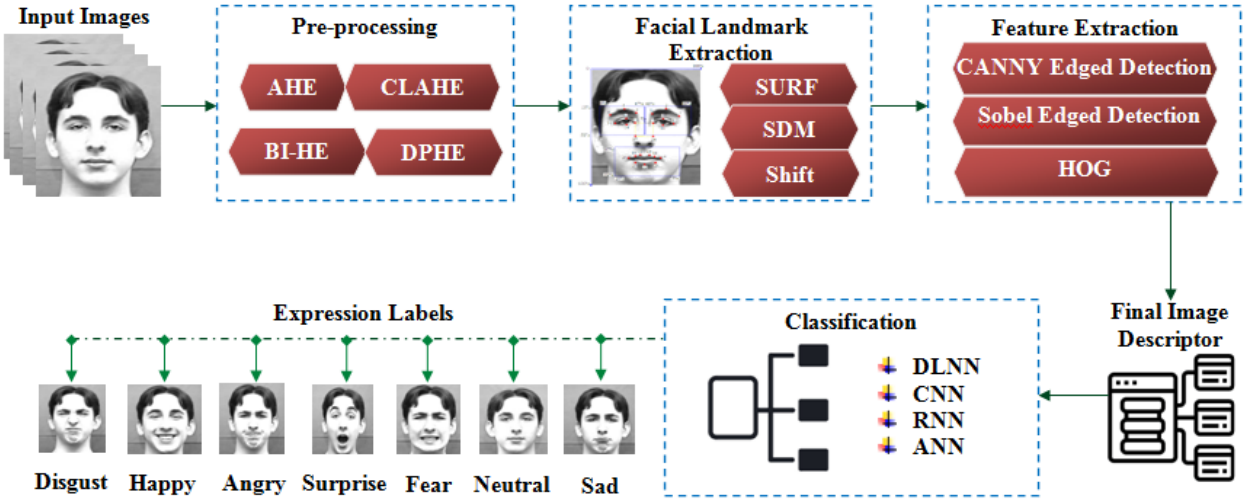

Figure 2: Conventional block diagram of the facial expression recognition system

Different models from machine learning and deep learning including CNN, Long Short-Term Memory Networks (LSTMs), MLP, and Extreme Learning Machine (ELM) are just a few to be named among the well-known classifiers used for the classification task of facial expression recognition. Gomutbutra, et al. [22] explained the classification of elderly pain severity from automated video clip facial action unit analysis. Findings showed that the SVM model using Facial Action Unit (FAU) of 1, 2, 4, 7, 9, 10, 12, 20, 25, and 45, and gender had the best accuracy of 58% among the machine learning selection features. Other than the machine learning and deep learning models, there were still some models for facial expression recognition [23, 24]. Selvaraj, et al. [25] explored the Hierarchical Model and X" (HMAX) model for bio modal facial expression recognition with the features from the human visual and auditory perception system. There were extensive surveys of facial expression recognition using different techniques that have been described on various topics. But, through bibliographic investigation, it is worth mapping the scope and structure of the particular discipline, recognizing the authoritative papers, and finding key research topics accurately.

- ✓ **Pre-processing**

Pre-processing is the fundamental step of image processing in the computer vision field. Before the extraction of facial features, pre-processing techniques are needed toapply to extract significant features. Usually, the purpose of using preprocessing steps in facial recognition systems is to speed up the detection process and reduce false positives. A preprocessing step should reject an acceptable amount of non-face windows [26, 27]. Preprocessing improves the performance of facial expression recognition since it addresses the noise present in images. Image preprocessing includes a number of types of processes such as image clarity and scaling, contrast adjustment, and additional enhancement process to improve the expression frames. Expression representation can be delicate to translation, scaling, and rotation of the head in a picture. To battle the effect of these pointless changes, the facial image may be geometrically institutionalized before classification. Generally, the preprocessing methods include geometry normalization, brightness normalization, histogram equalization, image filtering, and facial effective area segmentation.

Algorithms such as Histogram Equalization (AHE), Contrast Limited Adaptive Histogram Equalization (CLAHE), Bi-Histogram Equalization (Bi-HE), Double Plateau Histogram Equalization (DPHE), etc histogram equalization algorithms are used effectively for preprocessing in facial expression recognition [28].

- ✓ **Facial feature extraction**

Facial feature extraction is very much important for the initialization of processing techniques like face tracking, facial expression recognition, or face recognition. It plays an important step in automated visual interpretation and human face recognition. Detecting facial feature is a crucial role in a wide variety of applications, such as human-computer interface, facial animation, face recognition etc [29]. Algorithms like Canny edge detection, Sobel edge detection, and Histogram of Oriented Gradients (HOG) were used in facial feature extraction [30]. Canny edge detection uses linear filtering with a Gaussian kernel to smooth noise and then computes the edge strength and direction for each pixel in the smoothed image. The Sobel operator performs a 2-D spatial gradient measurement on an image and so emphasizes regions of high spatial frequency that correspond to edges.

- ✓ **Face tracking algorithms**

Facial recognition uses computer-generated filters to transform face images into numerical expressions that can be compared to determine their similarity [31]. Scale-Invariant Feature Transform (SIFT), Speeded Up Robust Features (SURF), and Supervised Descent Method (SDM) was the algorithms. SIFT features have been shown to have many interesting properties (including a high discriminative power), one of the most important of them being the possibility of their automatic extraction from stable interest points in the image. SURF is a local feature extraction method. It uses a local invariant fast key point detector for extracting image feature key points. SDM is a highly efficient and accurate approach for facial landmark locating and face alignment.

- ✓ **Classification algorithms used in facial expression recognition**

Classification analysis is an important component of facial recognition, mainly used for finding valuable data distribution and data models in the potential data. At present, it has further study of the database, data mining, statistics, and other fields. It has achieved great success. The hybrid Adaptive Kernel-based Extreme Learning Machine (HAKELM) algorithm was one of the recent algorithms to identify human facial expressions based on certain image processing techniques. Using these algorithms, the accuracy, sensitivity, and specificity achieved better in many works of facial expression recognition [32]

Deep learning neural networks (DLNN), Convolutional Neural Networks (CNN), and Artificial Neural Networks (ANN) were also the classification algorithms used in facial expression recognition [33]. DLNN has many hidden layers for deeply analyzing the input features to recognize facial expressions. Recurrent Neural Network (RNN) works on the principle of saving the output of a particular layer and feeding this back to the input in order to predict the output of the layer.

- ✓ **The database used by the authors for the work of facial expression recognition**

Many datasets have been introduced for face analysis, while the numbers of public datasets in the wild environment are few [34]. There are some of the camera-based datasets in facial expression recognition that include Chinese Academy of Sciences Macro-Expressions and Micro-Expressions, Acted Facial Expression in Wild (AFEW), Static Facial Expressions in the Wild, Radboud Faces Database, Extended Cohn–Kanade, Auto-encoder, and Web-Based Database. High accuracies were achieved using this dataset for recognizing facial expressions [35].

3. Bibliographic Analysis:

This section explains the key words analysis, analysis of the journals taken with their metrics, and journal analysis with the number of authors in each year between the years 2012 to 2022.

3.1. Data collection:

For the purpose to have a general proportion of literature on facial expression recognition, the data were connected to the number of published articles that are indexed in the web of science database. The bibliographic data were collected from the Scopus research database. Scopus is considered as the largest abstract and citation database of

peer-reviewed literature; scientific journals, books, and conference proceedings. The data were collected and kept in the journal articles by using the keywords and title search in the Scopus database.

3.2. Data Analysis:

Initially, a detailed analysis was conducted. A Sequence of graphs was generated for detecting the path related to the published articles on facial expression recognition using different techniques. The bibliographic methodology was used in the upcoming stage. This research uses citations to recognize the worthiest papers, researchers, and journals enclosed by certain domains. The number of times a scientific paper had been cited by another article in the index was recognized by utilizing the citation analysis. The facial expression recognition using different techniques was quantitatively and qualitatively analyzed through normal data analysis. For normal data analysis, bibliographic measures like journals, countries, authors, scientific papers, and publishers were utilized.

3.3. Key words analysis:

Keywords are important in any research. The keywords have an important on the findings of the research. The key words were classified into two types such as the main keyword (primary) and the backup keyword (secondary). The main key word is “Facial Expression” and the other 3 secondary key words are “Machine learning”, “Deep Learning” and “Image Processing”. After analyzing the entire journals belonging to the main keywords, 50 Reputed journals that were filtered, which were most suitable for this study were considered for bibliography research.

3.4. Analysis of the journals taken with their metrics:

There will be a number of journals for the research of facial expression recognition by different techniques. In this analysis, there were 50 journals taken with mentioning their metrics such as impact factor (IF), SJR, SNIP, Citation score (CS), publication frequency, and publisher. Table 1A and 1B explains the analysis of the journals taken with their metrics for the research of facial expression recognition.

Table 1A: Analysis of the journals taken with their metrics for the research of facial expression recognition

Journal Name	Country	IF	SJR	SNIP	Citation score	Publisher	Publication frequency
Advances in Computer Vision and Pattern Recognition	US	22.39	13.73	0.89	2.6	Springer Nature	-
International Journal of Computer Vision	Netherlands	11.81	6.83	4.16	16.8	Springer Nature	Monthly
Artificial Intelligence Review	Netherlands	11.67	2.18	3.56	14.9	Springer Nature	Annually

IEEE transactions on neural networks and learning systems	United States	10.47	4.22	3.3	20.8	IEEE	Monthly
IEEE Transactions on Fuzzy Systems	United States	10.12	4.08	3.14	21.9	IEEE	Bimonthly
Computers in Human Behavior	UK	9.79	2.17	3.23	14.9	Elsevier	Monthly
IEEE Transactions on image processing	United States	9.74	4.03	3.13	16.4	IEEE	Monthly
IEEE Transactions on Image Processing: A Publication of the IEEE Signal Processing Society	United States	9.74	4.03	3.13	16.4	IEEE	Bimonthly
Expert Systems with Applications	UK	9.6	2.07	2.98	12.2	Elsevier	Quarterly
Pattern Recognition	UK	8.54	3.11	3.08	15.5	Elsevier	Monthly
Neuro computing	Netherlands	6.19	1.66	1.85	10.3	Elsevier	Bimonthly
Pattern Recognition Letters	Netherlands	5.67	1.47	1.78	8.6	Elsevier	Bimonthly
Computer Vision and Image Understanding	US	5.53	1.91	1.92	9.9	Elsevier	0 days

Journal of Machine Learning Research	US	5.41	2.39	2.99	7.5	MIT Press	Bimonthly
Human-Computer Interaction	US	5.21	0.68	1.69	8.7	Taylor & Francis	Quarterly
Journal of Ambient Intelligence and Humanized Computing	Germany	4.95	0.91	1.69	6.5	Springer Nature	Quarterly
Fuzzy Sets and Systems	Netherlands	4.76	1.33	1.89	7.1	Elsevier	Quarterly
International Journal of Machine Learning and Cybernetics	US	4.66	1	1.32	7.7	Springer Nature	Quarterly
Image and Vision Computing	UK	4.63	1.15	1.52	6.3	Elsevier	Monthly
International journal of automation and computing	China	4.28	0.79	1.61	6.4	Chinese academy sciences	Semiannual
International Journal of Fuzzy Systems	Switzerland	4.23	0.9	1.25	8.5	Springer Nature	Quarterly
Applied Computational Intelligence and Soft Computing	Egypt	4.07	0.61	1.71	4	Hindawl	Annual
Frontiers in Psychology	Switzerland	3.88	0.87	1.6	4	Frontiers Media S.A.	Quarterly

Behaviour and Information Technology	UK	3.76	0.7	1.387	5.9	Taylor & Francis	Monthly
PLoS One	US	3.58	0.85	1.368	5.6	Public Library of Science	Monthly

Table 1B: Analysis of the journals taken with their IF, SJR, SNIP, Citation score, publisher and publishing frequency for the research of facial expression recognition:

Journal Name	**Country**	**IF**	**SJR**	**SNIP**	**Citation score**	**Publisher**	**Publication frequency**
Journal of Imaging	Switzerland	3.43	0.72	1.33	4.8	MDPI	Monthly
EURASIP journal on image and video processing	US	3.24	0.65	1.47	5.7	Springer Nature	Annually
Multimedia Tools and Applications	Netherlands	3.16	0.71	1.05	5.3	Springer Nature	Monthly
Computational Intelligence	UK	3.02	0.63	1	4	Wiley-Blackwell	Quarterly
Pattern Analysis and Applications	UK	2.76	0.7	1.03	4.8	Springer Nature	Quarterly
Cognition and Emotion	UK	2.61	1.12	1.38	4.7	Taylor & Francis	Quarterly
Journal Of Real-Time Image Processing	Germany	2.34	0.52	1	4.2	Springer Nature	Bi-monthly
Journal of Information Systems	US	2.3	1.18	1.11	4.1	American Accounting Association	Yearly
Procedia Computer Science	Netherlands	2.27	0.56	1.06	4.3	Elsevier	Annually

IET Image Processing	UK	2.2	0.53	0.82	4	Wiley-Blackwell	Quarterly
Signal, Image and Video Processing	UK	1.97	0.51	0.78	3.9	Springer Nature	Quarterly
Visual cognition	UK	1.93	0.83	0.69	3	Taylor & Francis	Monthly
Journal Of Signal Processing Systems	US	1.87	0.39	0.6	3.1	Springer Nature	Annually
International Journal of Computers and Applications	UK	1.74	0.38	0.67	2.3	International Society for Computers and Their Applications	Quarterly
International Journal of Applied Pattern Recognition	Singapore	1.67	0.42	0.42	4	Inder science	Quarterly
International Journal of Fuzzy Logic and Intelligent Systems	South Korea	1.31	0.33	0.68	2.7	Korean Institute of Intelligent Systems	quarterly
Pattern Recognition and Image Analysis	US	1.24	0.35	0.82	2.2	Pleiades Publishing	Quarterly
Imaging Science Journal	United Kingdom	1.17	0.24	0.46	2.6	Taylor & Francis	Bimonthly
International Journal of Cognitive Computing in Engineering	Serbia	1.13	0.34	0.55	3.8	Elsevier	Quarterly
Image Analysis & Stereology	Slovenia	0.95	0.31	0.59	1.9	Slovenian Society for Stereology, Quantitative Image Analysis	Triannually

International Journal of Image and Graphics	Singapore	0.92	0.23	0.63	1.5	World Scientific	Quarterly
Journal of flow visualization and image processing	US	0.61	0.37	0.575	0.7	Begell House	Quarterly
Japanese Psychological Research	UK	0.41	0.4	0.42	2.5	willey	Quarterly

From table 1A and 1 B, it had been found that each journal is from a different country like the United Kingdom (UK), United States (US), Switzerland, Netherlands, Egypt, South Korea, Germany, Serbia, and Singapore. The journals were arranged based on the ranking priority of impact factor from high to low. Out of all the other mentioned journals, Advances in Computer Vision and Pattern Recognition showed a higher impact factor of 22.39 with its SJR rating and SNIP of 13.737 and 0.891. There were many publishers for the journals like Elsevier, Routledge, Begell House, MDPI-3, Taylor & Francis, Hindawl, Public Library of Science, IEEE, Frontiers Media S.A, Springer Nature, Pleiades Publishing, Korean Institute of Intelligent Systems, Inderscience Publishers, Wiley-Blackwell, etc. International Journal of Computer Vision achieved the 2nd position with an impact factor of 11.81; SJR rating and SNIP of 6.838 and 4.168. The impact factor metric was lower in the Japanese Psychological Research 0.41.

3.5. Analysis of authors published for facial expression research from each country:
There are numerous types of research for facial expression research by most of the effective authors from different countries. Table 2A and 2 B describes the number of authors found from each country for facial expression research between the years 2012 to 2022.

Table 2A: Number of authors found from each country for facial expression recognition research between the years 2012 to 2022:

Journal	2012 to 2015	2016 to 2018	2019 to 2022
IEEE Transactions on Fuzzy Systems	7	1	2
Multimedia Tools and Applications	11	17	43
Artificial Intelligence Review	2	0	2
Journal of Ambient Intelligence and Humanized Computing	3	3	16
International Journal of Computer Vision	8	5	10
Signal, Image and Video Processing	3	6	8
Pattern Recognition	2	6	5
International Journal of Image and Graphics	6	0	1
Computers in Human Behavior	2	0	12

IET Image Processing	0	2	10
EURASIP Journal on Image and Video Processing	6	2	3
International Journal of Pattern Recognition and Artificial Intelligence	4	5	11
Human-Computer Interaction	4	1	7
International Journal of Computers and Applications	6	7	2
Pattern Recognition Letters	10	4	35
Computational Intelligence	2	6	12
International Journal of Fuzzy Systems	9	2	2
IEEE Transactions on Image Processing: A Publication of the IEEE Signal Processing Society	21	6	19
Journal of Machine Learning Research	9	14	17
Pattern Analysis and Applications	7	6	20
Fuzzy Sets and Systems	3	3	1
International Journal of Applied Pattern Recognition	3	7	3
International Journal of Machine Learning and Cybernetics	2	3	6
International Journal of Cognitive Computing in Engineering	3	2	4
Machine Learning: Science and Technology	0	0	0

Table 2B: Count of authors found from each country for facial expression research between the years 2012 to 2022:

Journal name	2012 to 2015	2016 to 2018	2019 to 2022
Visual cognition	6	4	5
Expert Systems with Applications	33	28	35
Journal of real-time image processing	6	0	27
EURASIP Journal on Advances in Signal Processing	2	4	4
IEEE transactions on image processing	27	20	26
International Journal of Fuzzy Logic and Intelligent Systems	6	2	1
Signal Processing-Image Communication	8	11	19

The Imaging Science Journal	3	5	4
Journal of signal processing systems	4	3	8
Pattern Recognition and Image Analysis	4	7	6
Journal of Visual Communication and Image Representation	10	1	10
Advances in Computer Vision and Pattern Recognition	9	1	3
Frontiers in Psychology	16	12	12
IEEE transactions on neural networks and learning systems	8	15	16
PLoS One	0	0	0
Computer Vision and Image Understanding	12	12	13
Applied Computational Intelligence and Soft Computing	6	7	11
Image and Vision Computing	18	6	23
Procedia Computer Science	8	8	16
Behaviour and Information Technology	5	9	9
International Journal of Automation and Computing	14	12	9
Journal of Imaging	3	3	6
neuro computing	22	13	18
Cognition and Emotion	10	6	6
Vision research	14	7	7

From table 2A and table 2B, it is known that each author was from different countries such as China, India, the United States, the United Kingdom, Tunsia, Spain, Australia, Egypt, Germany, brazil, etc. Figure 2 explains the pie chart for analyzing the percentage of the author from different countries for the research of facial expression recognition.

Most of the authors are from different locations, so further the percentage of the country where the number of authors having higher citations is being analyzed in the pie chart of figure 3A.

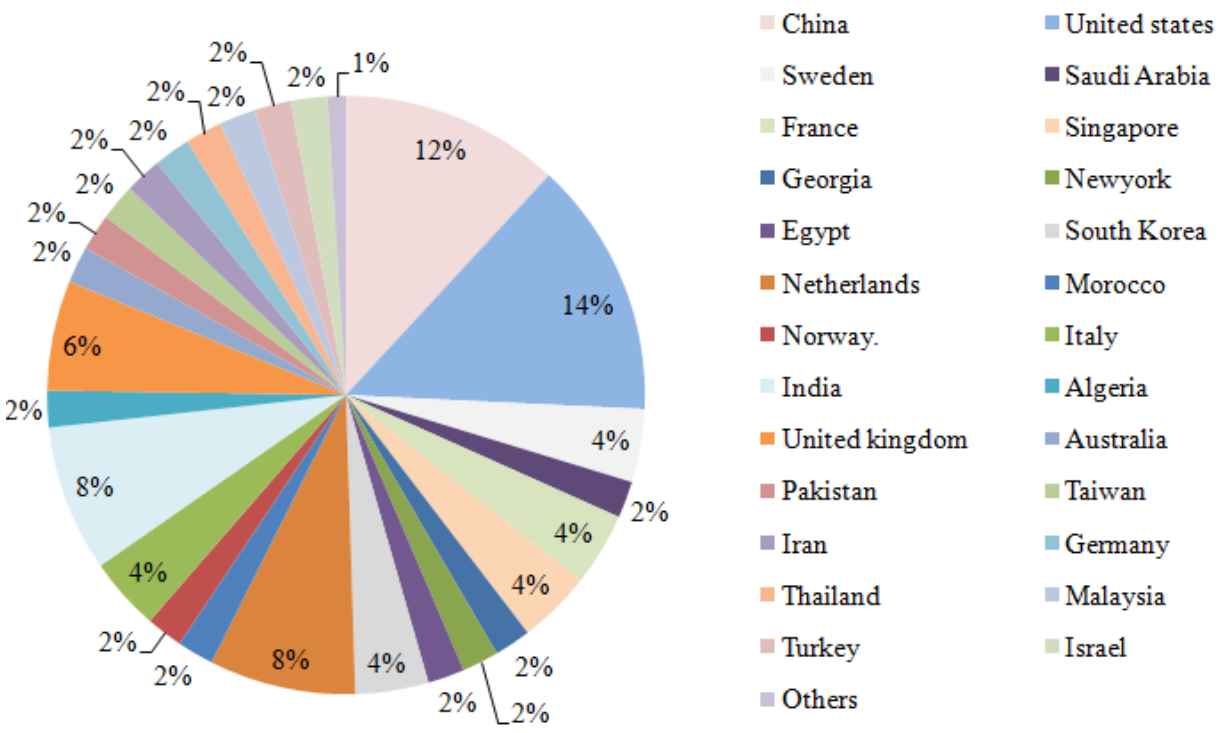

Figure 3 A: Percentage of countries where the number of authors having higher citations

From figure 3 A, it is clear that authors of country United States had more percentage (14%) of having higher citations when compared with the other countries. 2nd position was attained by the authors from the country china with a percentage of 12%. Country India authors achieved the 3rd position with 8%. It is conveyed that the country's US authors had been highly cited.

Further, the language of the last 10 years from standard publications had been analyzed in figure 3 B. Language is a structured system of communication. The structure of a language is its grammar and the free components are its vocabulary. Languages are the primary means of communication for humans and can be conveyed through spoken, sign, or written language.

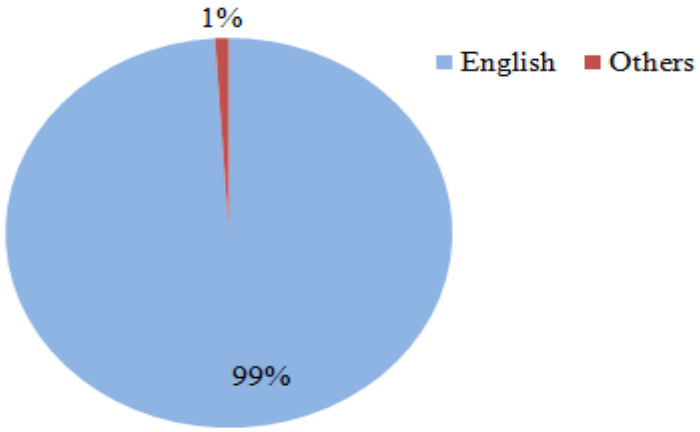

Figure 3 B: Pie chart of Language of the last 10 years from standard publications

It is understandable from figure 3 B that the English language completely dominates in the standard publications of the last 10 years between the years 2012 to 2022 for the research of facial expression recognition. Other language standard publication was only 1%.

Further, the geographical distribution of the authors country-wise for the research of facial expression recognition between the years 2012 to 2022 had been analyzed. Geographic distribution is that a map chart can use shaded areas to show how data is distributed across different regions. Darker areas represent a greater concentration in values. Figure 4 explains the geographical distribution of the list of authors' countries based on the research on facial expression recognition.

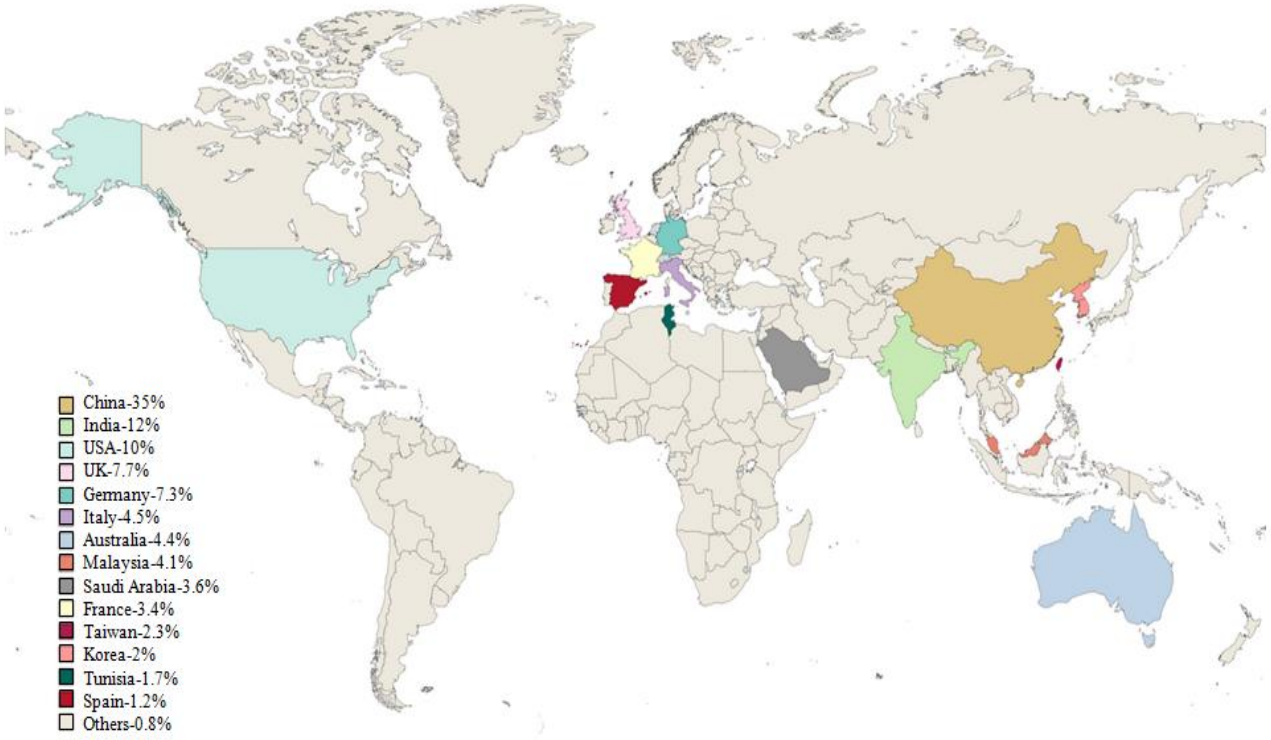

Figure 4: Geographical distribution of the list of author's country based on the research of facial expression recognition

The author's countries include China, the UK, Germany, Saudi Arabia, Malaysia, France, Taiwan, Korea, Tunsia, Spain, and India. From figure 4, it is noted that more authors have done the research. From the country china, 35 % of the authors had done research on facial expression recognition and it is having a higher percentage when compared with other countries. India is having the second-highest percentage of authors for research between the years 2012 and 2022. The author from the country USA attains the 3rd position with a percentage of 10 %. Other than the mentioned countries, there are 0.8% of the authors from other countries have done the research.

Further like the author's country, the geographical distribution of the list of journal countries based on the research of facial expression recognition had been analyzed in figure 5.

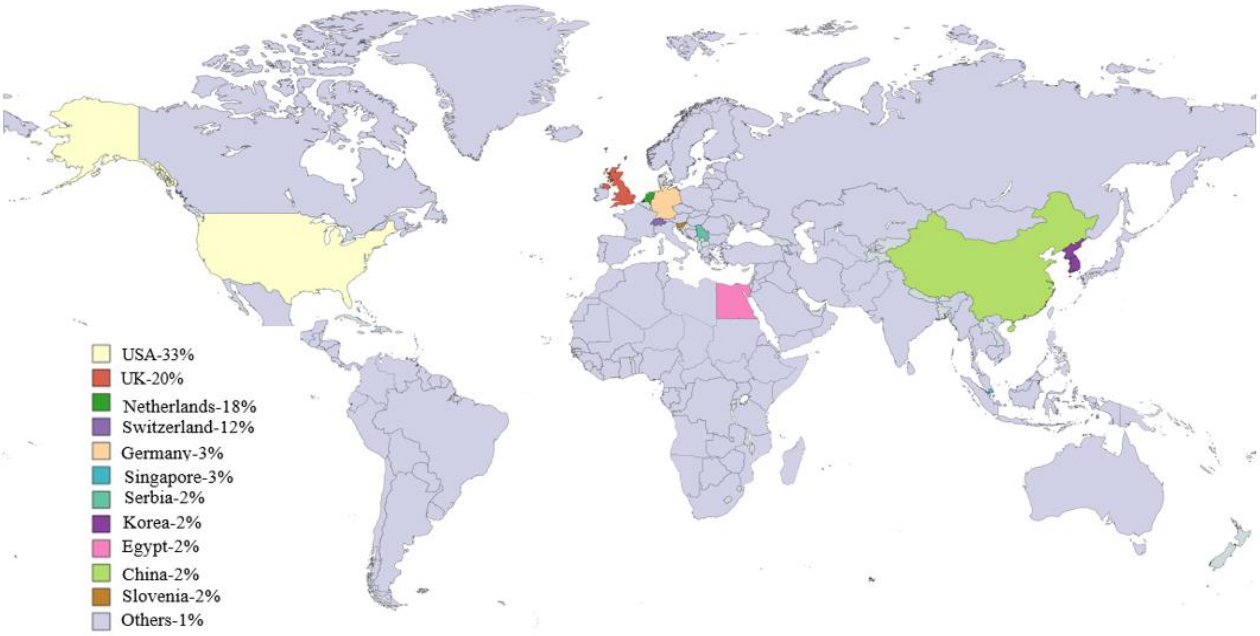

Figure 5: Geographical distribution of the list of journal countries based on the research of facial expression recognition

It is clear that like the author's country, there are journal countries for the research of facial expression recognition. From figure 4, it is noted that from more countries, journal publications have been done for the research. USA holds the highest percentage of 33 for having the journal based on the research of facial expression recognition. 2nd place was achieved by the country UK with 20%. The Netherlands attained the 3rd position with 18% and Switzerland achieved the 4th position with 12%. Unfortunately, for the research of facial expression recognition, the journal from country India is not there between the years 2012 to 2022.

3.6. Effective authors and citations:

Author credentials are the education, skills, and/or biographical information, which make them qualified to write/speak on a specific topic. Based on their work on the paper, it is easier to validate the top authors. The top 25 authors were shortlisted from table 2 considering their number of citations. Table 3 explains the top 25 authors and the citations.

Table 3: Top 25 authors and the citations:

AUTHOR NAME	TITLE	YEAR	MAJOR FINDINGS	AUTHOR CITATIONS	JOURNAL NAME
A.K.Jain, et al. [36]	50 years of biometric research: Accomplishments, challenges, and opportunities	2015	Analysis indicated that good-quality face images captured from cooperative subjects in the facial expression recognition	624	Pattern Recognition Letters

Rivera, et al. [37]	Local Directional Number Pattern for Face Analysis: Face and Expression Recognition	2012	Gradient faces had excellent results under illumination variation but failed with expression and time-lapse variation	569	IEEE transactions on image processing
Atkinson, et al [38]	Improving BCI-based emotion recognition by combining EEG features election and kernel classifiers	2016	The SVM method recognizes a higher number of emotion classes without using additional emotion classifiers.	538	Expert Systems with applications
Shan, et al [39]	Learning local binary patterns for gender classification on real-world face images	2012	SVM with the selected LBPH bins achieved the highest classification rate in facial expression recognition	484	Pattern Recognition Letters
Yong, et al. [40]	Occlusion aware facial expression recognition using CNN with attention mechanism	2018	ACNNs outperformed other state-of-the-art methods on several widely used in-the-lab facial expression datasets under the cross-dataset evaluation protocol.	424	IEEE Transactions on Image Processing
Gu, et al [41]	Facial expression recognition usingr adial encoding of local Gabor features and classifier synthesis	2012	Results showed that a hybrid combination of the HVC structure with a hierarchical classifier significantly improves expression recognition accuracy	376	Pattern Recognition
Haghighat, et al [42]	CloudID: Trustworthy cloud-based and cross-enterprise biometric identification	2015	CloudID performed the identification of clients with high accuracy and minimal overhead and proven zero data disclosure.	366	Experts system with applications
Valstar, et al. [43]	Meta-Analysis of the First Facial Expression Recognition Challenge	2012	The best result was attained with a simple k-nearest neighbor technique that attained a 93% classification rate on the Cohn–Kanade database	363	IEEE transactions on systems, man, and cybernetics
Wieser, et al. [44]	Faces in context: a review and systematization of contextual influences on affective face processing	2012	Results suggested that facial expression and their body contexts were integrated automatically with modulating effects on perception in both directions	354	Frontiers in pshycology

Chen, et al [45]	Face Illumination Manipulation Using a Single Reference Image by Adaptive Layer Decomposition	2013	Analysis demonstrated that the weighted least squares (WLS) filter method was effective and advantageous in preserving the identification structure and skin color of the input face	339	IEEE transactions on image processing
Wang, et al [46]	Region Attention Networks for Pose and Occlusion Robust Facial Expression Recognition	2015	Region Attention Network (RAN)achieved 86.9% on RAFDB with a default setting in facial expression identification	318	Japanese Psychological Research
Yang, et al [47]	Regularized Robust Coding for Face Recognition	2012	Extensive experiments on representative face databases demonstrated that the RRC was much more effective and efficient than state-of-the-art sparse representation-based methods in dealing with face occlusion	309	International Journal of Cognitive Computing in Engineering
Xie, et al. [48]	Weighted Schatten p-Norm Minimization for Image Denoising and Background Subtraction	2016	Weighted Schatten p-Norm Minimization (WSNM) results more effectively remove noise in facial expression recognition when compared with other methods	287	IEEE transactions on image processing
Herlitz, et al [49]	Sex differences and the own-gender bias in the face recognition: A meta-analytic review	2013	The effects were not significantly different from one another (p=47), suggesting that the magnitude of females' own-gender bias does not vary depending on the degree of facial familiarity	257	IEEE transactions on image processing
Rifai, et al. [50]	Disentangling Factors of Variation for Facial Expression Recognition	2012	Analysis showed that show how the features recovered by the CDA scheme were invariant to factors such as subject identity and pose while remaining sensitive to changes in facial expression.	240	Imaging Science Journal
Ashu, et al. [51]	Face detection techniques: a review	2019	Result of calculating the distance from face space in principle component analysis was higher than the other methods	236	Artificial Intelligence Review

Martineez, et al. [52]	A Model of the Perception of Facial Expressions of Emotion by Humans: Research Overview and Perspectives	2012	Results suggested that there could be three groups of expressions of emotion. The first group was intended for conveying emotions to observers. These expressions have evolved a facial construct (i.e., facial muscle positions) that was distinctive	235	Journal of Machine Learning Research
Calvo, et al. [53]	Perceptual and affective mechanisms in facial expression recognition: An integrative review	2015	Analysis suggested that frequency of occurrence contributes significantly to recognition and accounts for the recognition differences among facial expressions.	232	Cognition and Emotion
Eleftheriadis, et al. [54]	Discriminative Shared Gaussian Processes for Multiview and View-Invariant Facial Expression Recognition	2015	Gaussian process latent variable model outperformed the state-of-the-art methods for multi-view and view-invariant facial expression classification and several state-of-the-art methods for multi-view learning and feature fusion	225	IEEE transactions on image processing
Huang, et al. [55]	Spontaneous facial micro-expression analysis using Spatio temporal Completed Local Quantized Patterns	2016	Spatiotemporal Completed Local Quantized Patterns achieved a substantial improvement in analyzing facial micro-expressions	212	Neuro computing
D.K.Jain, et al. [56]	Extended Deep Neural Network for Facial Emotion Recognition	2019	Analysis shows that, the DNN model can outperform the recent state-of-the-art approaches for emotion recognition	190	Pattern Recognition Letters
Gillis, et al. [57]	Sparse and Unique Nonnegative Matrix Factorization Through Data Preprocessing	2012	Nonnegative matrix factorization is effectively achieved in facial expression recognition when compared with other facial expression techniques	169	Journal of Machine Learning Research
Khan, et al. [58]	Framework for reliable, real-time facial expression recognition for low-resolution images	2013	FG-NET facial expressions and emotions database framework exceeds state-of-the-art methods for expression recognition on low-resolution images.	158	Pattern Recognition Letters

Nakisa, et al. [59]	Evolutionary Computation Algorithms for Feature Selection of EEG-based Emotion Recognition using Mobile Sensors	2017	Findings were significant for informing future development of EEG-based emotion classification because low-cost mobile EEG sensors with fewer electrodes are becoming popular for many new applications	158	Expert Systems With Applications
Yuan, et al. [60]	Adaptively Learning Facial Expression Representation via C-F Labels and Distillation	2021	knowledgeable teacher network (KTN) achieved better performance when compared with the other frameworks	138	IEEE transactions on image processing

From table 4, it is shown that Anil K. Jain had the highest number of citations (624) from the year 2015 and it belongs to the journal of Pattern Recognition Letters. 2nd position was attained by Adin Ramirez with a number of citations 569 from the journal of IEEE transactions on image processing. 3rd position was achieved by the author John Atkinson with a number of citations 538 from the journal of Expert Systems with applications. Among these top 25 authors, the least cited (138) author was Hangyu Li.

4. Conclusion:

There were many research topics of papers available for facial expression recognition by different techniques and many literature reviews had been published. In this paper, a bibliographic survey was conducted on the topic of facial expression recognition by different techniques from the Scopus database. In spite of the presence of many other databases in the public domain, the Scopus database remains undeniably the most widely used and popular database among all in order to explore, compare and track several citations. Initially visualizing all the journals of facial expression recognition research, 50 journals were filtered and it was considered for the research. Metrics of journals such as SJR, SNIP, publishing frequency, publisher and impact factor had been analyzed from the database. Countries of author and their published work under different journal country for the research also had been analyzed. This bibliographic review focusing on each domain of the process would be a promising avenue for future work.

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