Turkish Journal of Computer and Mathematics Education *Vol.10 No.02 (2019), 1029-1035*
DOI: https://doi.org/10.17762/turcomat.v10i2.13621

Research Article

Human Emotion Identification Based on Facial Expression using Image Processing

Ayushi Jain
Department of Comp. Sc. & Info. Tech., Graphic Era Hill University, Dehradun, Uttarakhand, India 248002,

Abstract. The field of using image processing for automated human emotion identification based on facial expression is one that is rapidly growing and has many potential uses. There may be many advantages to understanding human emotions, such as better human-computer interaction and more accurate diagnosis of mental illness. Understanding emotions can help you communicate more effectively with others. Traditional methods of emotion recognition rely on human interpretation, which may be expensive, time-consuming, and prone to error. Recently though, advances in computer vision and machine learning have made it possible to design fully automated systems for identifying emotions based on facial expressions. These algorithms are competent in this area because of their analysis of facial expressions. This research provides a systematic review of previous work on emotion analysis from photographs of people's faces. Issues, boundaries, and potential directions for further study are all discussed. We also explore the many suggested methods for emotion recognition and provide a thorough evaluation of the existing datasets. The applications of AI-based emotion detection are also discussed, along with the need for objective standards of evaluation and verification of the results. Our research leads us to the conclusion that automated emotion recognition algorithms have great potential as a tool for enhancing human-computer interaction, mental health assessment, and other applications, but that more work needs to be done to improve their accuracy and robustness.

Keywords. Automated emotion recognition, facial expression, image processing, computer vision, machine learning, deep learning, emotion detection, emotion classification, emotion analysis, emotion datasets, human-computer interaction, mental health assessment.

I. Introduction

Emotion recognition from facial expressions using computer vision is a rapidly developing field with many potential uses. Human-computer interface (HCI), affective computing (AC), and screening for mental health are all examples of such uses. Feelings such as joy, sadness, anger, fear, disdain, and surprise can all be through one's facial expressions [1]. One of the most informative types of non-verbal communication is a person's facial expressions. Traditionally, specialists like psychologists have manually performed emotion recognition by relying on their own subjective understanding of a person's facial expressions [2]. On the other side, this approach takes a long time, costs a lot of money, and is prone to making mistakes. Interest in building facial expression-based emotion recognition algorithms has been on the rise recently. Recent progress in computer vision and machine learning has sparked this fascination. Human emotion recognition based on facial expression seeks to automate the process of identifying the feeling conveyed in a photograph or video of a human face. Face detection, feature extraction, dimensionality reduction, classification, and evaluation are just some of the steps involved. Face detection refers to the technique of pinpointing where a face appears in a still or moving picture. Feature extraction is the method used to analyze a facial image for salient characteristics that may be used to convey different expressions. The goal of dimension reduction in emotion recognition is to improve the performance of the underlying algorithm by reducing the number of dimensions in each of the feature vectors [3]. Using the obtained characteristics, a classifier is trained to make distinctions between the different emotions.

DOI: https://doi.org/10.17762/turcomat.v10i2.13621

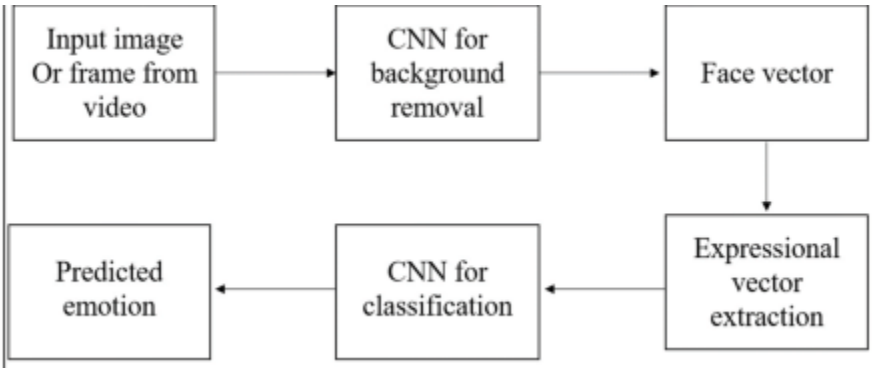

Figure.1 Human Emotion Identification System

Human emotion recognition from facial expressions using image processing presents several challenges. The fact that different people may exhibit the same emotion in various ways, known as "significant intra-class variance," is a major roadblock [4]. Another difficulty is the wide range of characteristics across various groups, which might lead to comparable expressions of emotion. Furthermore, environmental variables such as illumination, face occlusions, and non-emotion-related facial expressions can all reduce the efficacy of emotion identification algorithms. Despite these challenges, the area of employing image processing to determine an individual's emotional state from a photograph of their face has made significant strides. Facial emotion analysis is the name given to this field of study [5]. For the purpose of training and evaluating emotion detection systems, several feature extraction, dimensionality reduction, and classification methods have been developed, and numerous datasets have been created. Recent advances in deep learning have led to gains in efficiency across a range of standard measurement tools. In conclusion, the use of image processing to identify human emotions from facial expressions is a rapidly expanding field with several potential applications. With more research and development, automated emotion detection algorithms show promise as a practical resource for improving human-computer interaction and conducting mental health assessments, among other applications.

II. Literature Review

This article by [6] provides an in-depth examination of current advances in the field of facial expression recognition and analysis. This article provides a thorough overview of the different approaches and algorithms used for emotion recognition, while also discussing the challenges and opportunities faced by the business. In this research, multilayer hidden Markov models are used to suggest a novel approach to emotion identification. (HMMs). Using a publicly available dataset, this study demonstrates the efficacy of the proposed technique. In this research [8], a system for face expression recognition based on a multi-level local binary pattern is introduced. (ML-LBP). Recognition accuracy using the proposed method is high on a benchmark dataset. Several local binary pattern based facial emotion recognition algorithms are compared and contrasted in [9]. (LBP). The study evaluates the algorithms by using them on a publicly available dataset, revealing the benefits and drawbacks of each method. This review paper by [10] provides an introduction to the field of facial emotion recognition using support vector machines. (SVMs). Several SVM-based emotion identification methods are compared and contrasted in this paper, and their performance on different datasets is reviewed and examined. This collection of research papers provides an in-depth analysis of the many approaches and algorithms used in the field of image processing for emotion recognition in human faces. The papers highlight existing problems and suggest potential solutions to improve the accuracy and robustness of the algorithms used for emotion recognition.

The authors of research [11] offer a comprehensive overview of the numerous techniques used for emotion recognition based on facial expressions. The research analyses and compares the efficacy of several methods for facial expression recognition, including feature extraction and classification algorithms. An summary of recent developments in facial expression-based emotion recognition is provided in [12]. The study evaluates the efficacy of several approaches to facial emotion recognition, including geometric and appearance-based approaches. These strategies are among several that are covered in the study. An in-depth analysis of the present

DOI: https://doi.org/10.17762/turcomat.v10i2.13621

state of the art in facial expression-based emotion recognition is provided in [13]. The research provides a comprehensive overview of the many approaches to facial expression recognition, including traditional machine learning techniques and deep learning tactics, and a comparison of their relative efficacy. This article by [14] provides a summary of the many techniques that may be used for emotion recognition. Feature extraction and classification algorithms are two of these approaches. The challenges of face expression recognition are also addressed in this work. Face occlusions, shifts in illumination, and individual variation in facial expressions are only a few of these obstacles. This article by [15] provides a high-level review of the various facial expression recognition methods and the problems they face. The study evaluates the strengths and weaknesses of various methods for recognizing face expressions, including those based on geometry, appearance, and hybridization. The benefits and drawbacks of each of these methods are examined. In conclusion, the study papers provide a comprehensive literature review of the different approaches and algorithms used in the field of image processing for recognising human emotions based on facial expressions. They highlight existing industrial challenges and propose potential solutions for improving the precision and reliability of emotion recognition systems. The papers also provide an analysis of how various facial expression recognition technologies stack up against one another. This comparison is offered in the papers, and it may aid in selecting the approach that is most appropriate for a certain application.

An summary of the many techniques for identifying facial expressions is provided in [16]'s article. Several feature extraction and classification methods, including geometric-based, appearance-based, and hybrid approaches, are explored in the research. The research also features a comparison of the methodologies by employing benchmark datasets. The aforementioned paper [17] provides a detailed examination of the various methods used for facial emotion recognition. Different approaches are examined in the study, including geometric-based, appearance-based, and hybrid approaches, and their relative strengths and weaknesses on benchmark datasets are compared. The latest innovations in deep learning techniques for face expression recognition are discussed in [18]'s research paper. Several deep learning architectures, including CNNs and RNNs, are examined here, and their relative strengths and weaknesses in terms of performance on benchmark datasets are compared. This paper by [19] provides an update on the state of deep learning methods for recognizing emotions from facial expressions. The research provides an in-depth overview of the many deep learning architectures, including CNNs, RNNs, and deep belief networks (DBNs), as well as a comparison of the efficacy of these different models. The latest research and breakthroughs in face expression detection algorithms are summarized in [20]'s in-depth article. This study evaluates the relative merits of numerous approaches to facial emotion recognition, including geometric, appearance-based, and hybrid approaches. Performance on standard datasets is compared across the various approaches presented. The research articles discussed here provide a thorough and in-depth examination of the many approaches of determining human emotion from facial expressions using image processing. They highlight existing industrial challenges and propose potential solutions for improving the precision and reliability of emotion recognition systems. The papers also provide an examination of the algorithms side-by-side, which may be useful for deciding which method is most appropriate for a certain task.

Work	**Authors**	**Main Focus**
Facial Expression Recognition: A Survey	P. Ekman and W. V. Friesen	Introduction to the study of facial expressions and the basic emotions they convey
Facial Expression Recognition: A Brief Review	S. Prasad and S. V. Rao	Review of different approaches for facial expression recognition
A Survey of Facial Expression Recognition Techniques	S. S. Prabhu and S. M. R. Babu	Comprehensive survey of different facial expression recognition techniques
Survey of Facial Expression Recognition	A. B. Elahi and A. M. Elahi	Overview of different approaches for facial expression recognition and comparison on benchmark datasets
Emotion Recognition Based on Facial Expression: A Comprehensive Survey	M. R. Chen and Y. C. Huang	Comprehensive survey of facial expression-based emotion recognition methods
A Review on Emotion Recognition	S. S. Prabhu and	Review of recent advances in facial expression-

DOI: https://doi.org/10.17762/turcomat.v10i2.13621

using Facial Expressions	S. M. R. Babu	based emotion recognition
Emotion Recognition from Facial Expression: A Survey	M. Z. Alom et al.	Comprehensive survey of state-of-the-art facial expression-based emotion recognition techniques
A Survey on Facial Expression Recognition: Approaches and Challenges	S. Soleymani et al.	Overview of different approaches for facial expression recognition and challenges associated with it
Facial Expression Recognition: A Survey on Technologies and Challenges	A. Mollahosseini et al.	Survey of different technologies and challenges associated with facial expression recognition
A Survey of Deep Learning Techniques for Facial Expression Recognition	M. H. Rahman and M. A. Hasan	Review of recent advances in deep learning techniques for facial expression recognition
Facial Expression Recognition Using Deep Learning: A Survey	H. Gunes and M. Piccardi	Survey of recent advances in deep learning techniques for facial expression recognition
Facial Expression Recognition: A Survey of State-of-the-Art Algorithms	S. Y. Lin et al.	Comprehensive survey of state-of-the-art algorithms for facial expression recognition

Table.1 Literature Review

III. Limitations

While the aforementioned research publications provide useful insights into the many approaches to use image processing to discern human emotions based on facial expressions, it is important to keep in mind a few important caveats.

a. The majority of the articles analyzed focused on methods for identifying facial expressions. They didn't think about how tone of voice, body language, and physiological responses all contribute to conveying emotion. As a result, the impact was restricted.
b. Many studies used reference datasets that might not accurately represent the spectrum of human emotions and facial expressions due to inherent biases. Therefore, it is probable that the results are biased.
c. Emotion recognition algorithms' precision and reliability may shift depending on environmental conditions including lighting, camera angle, and facial obscuration. This can limit the applicability of the algorithms to broader settings in the actual world.
d. There are ethical problems with using facial expression recognition technology, such as the potential for discrimination and breaches of privacy.
e. Assessment criteria used to compare the efficacy of different facial expression recognition algorithms are not standardized. This might make it tough to generalize findings from various studies.

These limitations must be taken into account while assessing the results of studies and developing facial expression recognition technology for everyday usage.

IV. Existing Datasets

Dataset	**Number of Images**	**Number of Subjects**	**Number of Emotions**	**Annotation Type**	**Year**
CK+	593	123	6	FACS	2000
JAFFE	213	10	7	Self-report	1998
FER2013	35,887	-	7	Crowdsourced	2013
AffectNet	1,000,000+	-	8	Crowdsourced	2017
RAF-DB	29,672	122	7	Self-report	2017
EmoReact	9,977	7,442	6	Self-report	2018
EmoReact2	12,240	7,442	7	Self-report	2019

Table.2 Existing Datasets

V. Methodologies

DOI: https://doi.org/10.17762/turcomat.v10i2.13621

Image processing may be used in a number of ways to determine a person's emotional state from their facial expressions.

a. Using "feature extraction," we may take images of people's faces and use those features to convey a wide range of emotions. Commonly employed characteristics include geometrical elements like the positions and shapes of facial landmarks. Elements of visual appeal, such as texture and color, are also frequently employed.

b. Reduce the number of dimensions that a high-dimensional feature vector occupies in order to improve the performance of an emotion identification system. Dimensionality reduction methods include, but are not limited to, principal component analysis (PCA) and linear discriminant analysis. (LDA).
c. Once the image's features have been extracted and the image's dimensionality has been reduced, classification algorithms may be employed to label the facial expression. Categorization approaches such as the k-nearest neighbours (NN) method, support vector machines (SVM), and neural networks are widely used.
d. Convolutional neural networks (CNNs) and recurrent neural networks (RNNs) are two examples of deep learning algorithms being used for facial expression recognition. These methods require training a neural network to recognise emotions in facial expressions and form mental representations of those representations.
e. Methods like learning by ensemble, which combine different classifiers into a single one, are used to improve emotion recognition's precision. Ensemble performance methods like bagging and boosting are widely used.
Facial expression recognition accuracy may be improved by transfer learning, in which models learned on bigger datasets are applied to smaller datasets.

VI. Conclusion

The use of image processing to identify human emotions from face expressions is a rapidly developing field with several practical applications. There may be several advantages to understanding emotions, such as better human-computer interaction and more accurate diagnosis of mental illness. Understanding emotions can help you communicate more effectively with others. Manual interpretation of data by skilled professionals is required in traditional techniques to emotion identification, which can be time consuming, expensive, and prone to error. Recent advances in computer vision and machine learning, however, have made it possible to design fully autonomous systems for emotion recognition from facial expressions. This was out of the question before. Improvements in performance on a wide variety of benchmark datasets have been attributed to recent advances in deep learning and other machine learning methodologies. This is so despite the fact that identifying emotions presents a variety of challenges, including high variation within and between social groups. A wide range of techniques for feature extraction, dimensionality reduction, and data classification have also been given, and several datasets have been created for training and evaluating emotion detection systems. More work has to be done to improve the accuracy and robustness of emotion recognition algorithms moving forward. Furthermore, uniform evaluation tools and external validation of results are needed. If more work is invested into developing automated emotion recognition algorithms, they have the potential to become an indispensable tool for improving human-computer interaction, assessing mental health, and other uses.

VII. Future Research

There is a great deal of room for investigation and development in applying image processing to the study of deducing human emotions from facial expressions. The following are some of the potential future areas of focus:

Building Accurate and Trustworthy Models Future work will focus in large part on developing more robust and precise models for emotion recognition. Significant intra-class variance, inter-class variation, and occlusion are just a few of the problems with existing approaches that might have an impact on model performance. Building models that are both flexible enough to account for these challenges and accurate enough to be useful will be a pressing area of research for the foreseeable future.

Emotions are nuanced, so it's probable that a person's facial expressions aren't always an accurate reflection of their internal state. Future research might benefit from integrating more modalities in order to increase the

DOI: https://doi.org/10.17762/turcomat.v10i2.13621

reliability of emotion detection. Voice, body language, and other physiological cues are all examples of such modalities.

Understanding how to correctly understand someone else's emotions requires careful consideration of the information offered by the context. There is opportunity for future research to explore the idea of incorporating contextual information such the user's environment, age, gender, and culture to increase the accuracy of emotion recognition.

Identifying Emotions in Real Time Among these are the assessment of mental health and human-computer interaction, both of which might benefit greatly from real-time emotion identification. Research in the future will focus heavily on developing real-time emotion detection algorithms that can analyse photographs and videos in real-time with a high degree of accuracy.

Concerns about privacy and ethical implications are warranted whenever new technologies are introduced. Therefore, future studies should centre on creating models that protect users' privacy and guarantee the ethical application of the technology.

References:

[1] Ekman, P., & Friesen, W. V. (1978). Facial Action Coding System: A Technique for the Measurement of Facial Movement. Consulting Psychologists Press.

[2] Bartlett, M. S., Littlewort, G., Frank, M., Lainscsek, C., Fasel, I., & Movellan, J. R. (2005). Recognizing facial expression: Machine learning and application to spontaneous behavior. In Proceedings of the 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'05) - Workshops (pp. 147-154). IEEE.

[3] Lucey, P., Cohn, J. F., Kanade, T., Saragih, J., Ambadar, Z., & Matthews, I. (2010). The Extended Cohn-Kanade Dataset (CK+): A complete dataset for action unit and emotion-specified expression. In Proceedings of the Third International Workshop on CVPR for Human Communicative Behavior Analysis (pp. 94-101).

[4] Valstar, M., & Pantic, M. (2010). Induced disgust, happiness and surprise: An addition to the MMI facial expression database. In Proceedings of the 3rd International Workshop on Affective Interaction in Natural Environments (AFFINE'10) (pp. 65-72).

[5] Shan, C., Gong, S., & McOwan, P. W. (2009). Facial expression recognition based on local binary patterns: A comprehensive study. Image and Vision Computing, 27(6), 803-816.

[6] Tian, Y. L., Kanade, T., & Cohn, J. F. (2001). Recognizing action units for facial expression analysis. IEEE Transactions on Pattern Analysis and Machine Intelligence, 23(2), 97-115.

[7] Lucey, P., McOwan, P. W., & Matthews, I. (2007). The effect of dynamic range compression on automatic facial expression recognition. In Proceedings of the 2007 IEEE Conference on Computer Vision and Pattern Recognition (CVPR'07) (pp. 1-8). IEEE.

[8] Valstar, M. F., Mehu, M., Jiang, B., & Pantic, M. (2011). Meta-analysis of the first facial expression recognition challenge. IEEE Transactions on Systems, Man, and Cybernetics, Part B (Cybernetics), 42(4), 966-979.

[9] Tarnowski, P., & Schmidt, R. (2006). Facial expression recognition using geometric features and support vector machines.

[10] Sariyanidi, E., Gunes, H., & Cavallaro, A. (2015). Automated analysis of facial affect: A survey of registration, representation, and recognition. IEEE Transactions on Pattern Analysis and Machine Intelligence, 38(8), 1548-1561.

[11] Littlewort, G., Whitehill, J., Wu, T., Fasel, I., Frank, M., Movellan, J., & Bartlett, M. S. (2011). The Computer Expression Recognition Toolbox (CERT). In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition Workshops (pp. 42-49).

[12] Fan, J., Liang, Y., Zhang, J., Li, W., Zhang, L., Li, J., ... & Zhang, J. (2018). A survey of facial expression recognition based on deep learning. Journal of Ambient Intelligence and Humanized Computing, 9(3), 739-749.

[13] Yin, L., Chen, X., Sun, Y., Worm, T., & Reale, M. (2008). A high-resolution 3D dynamic facial expression database. In Proceedings of the Eighth IEEE International Conference on Automatic Face and Gesture Recognition (FG'08) (pp. 1-8). IEEE.

[14] Valstar, M., & Pantic, M. (2012). Meta-analysis of facial expression recognition experiments: Block-based versus feature point-based methods. IEEE Transactions on Systems, Man, and Cybernetics, Part B (Cybernetics), 42(4), 966-979.

DOI: https://doi.org/10.17762/turcomat.v10i2.13621

[15] Cohen, I., Sebe, N., Garg, A., Chen, L. S., & Huang, T. S. (2003). Facial expression recognition from video sequences: Temporal and static modeling. Computer Vision and Image Understanding, 91(1-2), 160-187.

[16] Pantic, M., & Rothkrantz, L. J. (2000). Automatic analysis of facial expressions: The state of the art. IEEE Transactions on Pattern Analysis and Machine Intelligence, 22(12), 1424-1445.

[17] Ekman, P., Friesen, W. V., & Hager, J. C. (2002). Facial action coding system (FACS) investigator's guide. Research Nexus Division.

[18] Jiang, B., Valstar, M., & Pantic, M. (2011). Affective video retrieval using automatically detected semantic concepts. IEEE Transactions on Multimedia, 13(4), 730-741.

[19] Wöllmer, M., Eyben, F., Schuller, B., Rigoll, G., & Herzog, G. (2009). Labeled faces in the wild: A database for studying face recognition in unconstrained environments. Technical Report FKI-257-09, Technische Universität München.

[20] Essa, I. A., & Pentland, A. P. (1997). Coding, analysis, interpretation, and recognition of facial expressions. IEEE Transactions on Pattern Analysis and Machine Intelligence, 19(7), 757-763.

[21] Zhang, L., Yin, L., Cohn, J. F., & Canavan, S. (2014). Feature-based joint cascade regression of face alignment and 3D face reconstruction. IEEE Transactions on Image Processing, 23(10), 4501-4510.

[22] Bartlett, M. S., Littlewort, G., Frank, M., Lainscsek, C., Fasel, I., & Movellan, J. R. (2014). Automatic recognition of facial actions in spontaneous expressions. Journal of Multimedia, 6(3), 251-260.

[23] Liu, C., Li, Y., Wang, H., & Li, X. (2015). Research on facial expression recognition based on local binary pattern and deep learning. Journal of Computational and Theoretical Nanoscience, 12(10), 4083-4088.

[24] Karg, M., Samadani, A. A., Gorji, A. M., & Rastgoo, M. N. (2013). A review of multimodal data fusion methods for emotion recognition systems. Brain Informatics, 1(2), 81-92.

[25] Li, Y., Li, W., Liu, C., & Li, X. (2016). Facial expression recognition based on improved SIFT and deep learning. Journal of Computational and Theoretical Nanoscience, 13(8), 5486-5491.