International Journal of Engineering & Technology, 7 (4.38) (2018) 866-870

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Comparative Analysis of Facial Expression Detection Techniques Based on Neural Network

Yogendra Mohan1 ,Vikas Tripathi2

NERIST Deemed to be University ,Itanagar ,Arunachal Pradesh, INDIA
yogendra.mohan@gmail.com
2TCS, Lucknow, INDIA
**Corresponding author E-mail:vikki.tripathi@gmail.com*

Abstract

Face detection is a critical part of vision and a robot needs to identify a human accurately. A human face undergoes several states of facial expression in a day. Many object detection techniques are applied to identify a facial expression from a digital image or a video frame. Each object detection technique has its own benefits. The overall objective of this paper is to explore the benefits and limitation of existing techniques and provide a comparative analysis. Neural network based facial expression detection technique has demonstrated potential benefits over existing facial expression detection techniques.

Keywords: *Object Detection, Robotics, Pattern Recognition, Neural Network, Facial Expression, Computer Vision*

1. Introduction

Object detection problem is an active research area where academician and industrialist are contributing a lot. It has become part of challenging pattern recognition problem. In a digital image, an object can be of any types such as train, plane, road, moon, plant, human face. In a human image, multiple objects are possible like face, hand, leg. Face detection has been an integral part of the bio-metric detection in any office or organization. Generally, facial expression detection involves process of determining the face of the subject from a human image. At a top-down approach, it covers segregating image into two parts; first including face (object) and second including background (clutter).

A human face transitions across 21 expression states in a day. These facial expressions are manifestation of human emotions. Emotions are derived from the muscles under the facial skin. Fundamentally, neural mechanism is the driver for different states of a face. Facial expression comes under category of non-verbal communication. A human communicates around 70% of communication in non-verbal mode. Role of eye is very crucial in facial expression. Facial expressions play a very significant role in sign language. However, interpretation of facial expression may vary from one culture to another culture. Smile is one of the common and important facial expressions in a daily life of a human. Facial expression detection becomes more complicated by varying photometric conditions such as luminance, lighting and noise.

2. 2. Literature Survey

Facial expressions are like a front end application for the emotions of a human. End to end process of face detection covers four major stages; input, pre-process, classifier and output. In first stage, input, image is passed to the system as an input. Attributes of an image like resolution, size, bit format, color format and file type may vary. In second stage, pre-process, background noise is removed. In third stage, classifier, a decision is taken if image contains face or non-face object. In last stage, output, geometrical location of face is indicated in original image. A technique to detect a face has been illustrated in Fig-1 in the form of a block diagram.

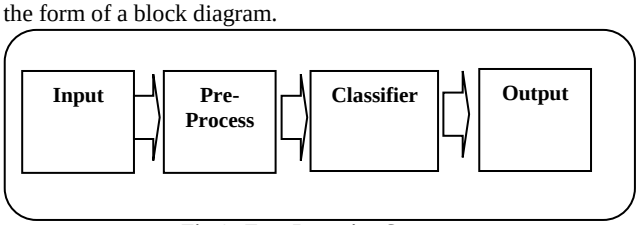


Fig-1. Face Detection System

Numerous papers have been presented to detect facial expressions in day and night scenarios using neural network and thermo grams. List of papers have been classified according to different domains like social networking, teaching, banking and health care.

Michel proposed "Face Detection with Expression Recognition using Artificial Neural Networks" [1]. In this paper, expression of a human face is detected. This paper applies multi-layer perceptron (MLP) with back-propagation to achieve the objective. Various expression states such as happiness, sadness or neutral are detected. Determining the expression of the face takes time.

Copyright © 2018 Authors. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Since computational cost is high and calculation is slow, real time expression detection is not possible with this. keeping in mind the real time face detection, Chenghao came up with a new face detector. He proposed "A Real-Time Face Detector Based on an End-to-End CNN" [2]. In this paper, he suggested single end to end neural network with multi-scale feature. This approach has reduced computational cost. At the same time, it has improved performance. Hence, it is fit for real time face detection and this is helping in the industry.

Jiajun proposed a new variant of real time face detector. He came up with "Research and Implementation on Face Detection Approach Based on Cascaded Convolution Neural Networks " [3]. His detector is based on cascaded convolution neural network framework. In this framework, improved training method and multi-tasking learning network are the main reason for improved result. He has shown that accuracy has been increased and detection time has been reduced.

Use case of facial expression has been extended to security applications. National identifier card like "Aadhaar" has been a prime example of bio-metric based security application. Biometric based systems are being used in forensic analysis as well as collecting attendance in office or college.

Initially, psychologist classified six classes for facial expressions which were derived from human emotions. These classes are Happy, Angry, Sad, Surprised, Fearful and Disgusted. All six states of human faces are depicted in Fig-2. Now, cognitive scientist Aleix Martinez came up with updated version of facial expressions. He added three new expressions; Appalled, Hatred and Awed. Along with that he also added 12 compound expressions. Hence, total count has been reached to 21.



Fig-2. States of a Human Face

Smile is the most important expression of a human life. It is imperative to detect smile in a face and capture it. Zhang proposed "Facial Smile Detection Based on Deep Learning Features" [4]. In this paper, extraction of high level features is done by deep convolution network. Recognition and verification signals are used to learn expression features. This method has reduced error rate by 21%.

Xin proposed a new method to detect smile. He came up with "Smile Detection in the Wild Based on Transfer Learning" [5]. In this paper, he proposed a transfer learning based smile detection. This method uses labeled data from face recognition dataset and reduces over fitting on smile detection. This has shown improvement over existing algorithms.

Chi proposed a real time smile detector and came up with "Towards Real-Time Smile Detection Based on Faster Region Convolution Neural Network" [6]. In this paper, a specialized architecture of faster region convolution network (FR-CNN) has improved computational performance of smile detector. Accuracy of this algorithm is in the range of 84.5%.

Health of patient is monitored by decreasing ratio of smile parameter or increasing ratio of pain parameter. Nikolay came up with paper "Pain detection from facial characteristics using supervised descent method"[7]. In this paper, he proposed an algorithm for automatic pain recognition and continuous pain estimation technique. This would be useful for doctors to diagnose patients who are not able to communicate easily like small child, mentally impaired person or mute person.

Weihong went one step ahead and presented a paper "DeepEmo: Real-world facial expression analysis via deep learning"[8] which is based on deep learning architecture. This new architecture is addressing real world expression which is based on multi-labeled classification.

Flat or altered facial activity is the primary use case for schizophrenia patients. This depicts the emotional expressiveness of the patient. Talia suggested a paper "Facial expressions and flat affect in schizophrenia, automatic analysis from depth camera data"[9] for schizophrenia patients.

Facial expression has been used to gauge the understanding level and attentiveness of a student in a class. This is benefitting student and teacher alike. Teacher can modulate his content delivery style and speed to cater the needs of a student. Carla proposed a paper "A methodological approach —Working emotions and learning using facial expressions" [10]. In this paper, a teaching model is demonstrated to improve the teaching-learning process by applying several emotions of a student. Deep learning is used to establish a correlation between facial expression of student and understanding level of student. Complexity and computational cost of this system is high.

"One Size fits all" is not serving the purpose effectively, as culture, age and gender of student is diverse. Gloria came up with "Learning Personalized Models for Facial Expression Analysis and Gesture Recognition"[11]. Personalized learning model is based on two main components; transfer learning and regression framework. Accuracy level has been increased. At the same time, computational has been reduced.

Online education platform are not able to provide live feedback from teacher for queries or reactions from the student during the lecture. Facial expression based model will help in automatic recognition of students engagement levels during e-learning sessions. Aditya came up with "A crowd sourced approach to student engagement recognition in e-learning environments" [12]. This is based on crowd sourced discriminative learning approach. Experimental results have shown 14% improvement against traditional methods.

Social networks have seen exponential growth in the last couple of years. Social networking sites like Facebook , Twitter, Instagram and YouTube have billions of users. These users share photos and videos almost every day. Users of these social networking sites try to make on-line friends. Facial expression can play an important role in making and suggesting on-line friends for a new user. Petr came up with paper "Recommending New Links in Social Networks Using Face Recognition" [13] for the solution of this problem. This algorithm has shown good result in identifying new contact suggestion for a new user. However, it is still behind the text based friend suggestion model.

Use cases and applications of facial expression are limitless. It will be tough to cover all scenarios paper by paper. Typing password for financial transactions has become cumbersome. Financial payment is a new use case of smile detection. Another use case of facial expression is to measure satisfaction level of a customer. This is achieved with the help of smile detection. Even activeness of driver while driving is measured by facial expression. This has helped in reducing the number of road accidents. In addition to that psychologist and physiologist are interpreting facial expression in a different plane.

Face detection in night is a challenging task. On top of that, smile detection in night is even more challenging task. With the application of thermal based face detector and optical based face detector, good results are observed. Thermal based object detector works on the principle of radiation detection from object. Every object radiates infra-red(IR) electromagnetic waves from the spectrum. Image generated from an object is termed as Thermograms. Thermograms are the representation of IR energy transmitted, emitted and reflected by an object.

Samira came up with "Random sparse representation for thermal to visible face recognition"[14]. This paper proposes an idea of ensemble classifier which is based on random subspace. As per experimental result, this has demonstrated significant performance improvement. Accuracy of the result is in the range of 89.33 percent.

Siti proposed paper "Temperature determining method from motion detection using thermal images"[15]. Face detection is based on motion. This is using visual and thermal image to create "heat picture" of the object. Thermal camera is used to identify a pointer for hottest area of the object. Accuracy is a challenge for this.

Chule proposed paper "Organ-Based Facial Verification Using Thermal Camera"[16]. In this paper, facial verification is performed by using thermal data from various features of human face. This is almost independent of illumination variation. It has worked in dark place. It has shown verification rate of 91.26 percent.

3. Neural Network

Over the past couple of decades, many approaches for facial expression detection have been proposed. However, artificial neural network (ANN) based model provided better result compared to other models. The main reason for using ANN in facial expression detection is that these models can simulate the neuron behaviors how it works in human brain. Neuron is the basic component of the human brain. As human learns by example, ANN also learns by example. One of the key points of a neural network is its ability to learn. A neural network can easily extract meaningful information from complex or incomplete data. An ANN performs such tasks successfully and easily with the help of inbuilt perceptron model which is being trained by training data set.

Perceptron is the basic building block of an ANN and it is shown in Fig-3. It can be termed as a computational model for a single neuron. A
perceptron consists of one or more weighted input, a processor and a single output. A perceptron follows the "feed-forward" model. In feed forward model, data moves in only one direction. The sum of the products of the weights and the input is calculated. If this value is above the threshold, it is activated and neuron is fired. If this value is below the threshold, it is not activated and neuron is not fired. General activation function is the threshold step function. However, other activation functions such as Sigmoid, Piecewise linear and Gaussian are also used.

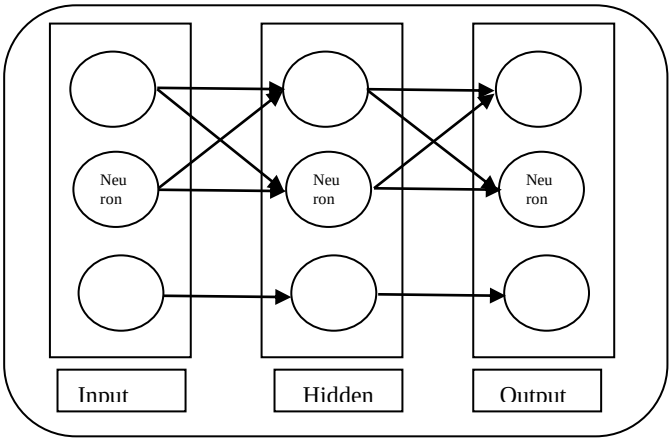


Fig-3: Perceptron

Rosenblatt Frank developed the first perceptron using weighted input. This is also called as single layer perceptron (SLP). Multilayered Perceptron (MLP) can be called as network of many neurons. Architecture of MLP consists of three stages; input layer, hidden layer and output layer. The first stage is called as input layer of the network. Second stage is called as hidden layer. Input layer passes information to hidden layer. This hidden layer consists of several neurons like units. Neurons present in hidden layers are neither connected to input nor output directly. Last stage is called as output layer. Output layer is responsible for delivering the result. Solution to optimize weights of a MLP is known as back propagation. Back propagation is a general method of training an ANN.. It is a supervised learning method and helps in finalizing the objective function. Successful detection of human facial expression by this model is in the range of 94% to 98%.

Taxonomy

Table-1: Taxonomy

S.N.	Title	Merit	Demerit
1	"Face Detection with Expression Recognition using Artificial Neural Networks" [1]	1.Suitable for several expression detection of face	1.Unsuitable for real time expression detection
2	"A Real-Time Face Detector Based on an End-to-End CNN" [2]	1.Suitable for real time face detection 2.Computational cost has been reduced	1.Unsuitable for non-labeled data set 2.Unsuitable for night
3	"Research and Implementation on Face Detection Approach Based on Cascaded Convolution Neural Networks " [3]	1. Accuracy has been improved. 2.Detection time has been reduced	1.Longer training time for data set 2.Unsuitable for night
4	"Facial Smile Detection Based on Deep Learning Features" [4]	1.Well trained training model 2.Supervised based learning 3.Mid-level error reduction	1.Longer training time 2.Unsuitable for real time detection
5	"Smile Detection in the Wild Based on Transfer Learning" [5]	1.Well trained training model 2.Suitable for labeled dataset	1.Longer training time 2.Unsuitable for non-labeled dataset
6	"Towards Real-Time Smile Detection Based on Faster Region Convolution Neural Network" [6]	1.Improved computational performance 2.Lesser training time for dataset 3.Mid-level accuracy	1.Only for labeled dataset 2.For fine level smile, high level accuracy required
7	"Pain detection from facial characteristics using supervised descent method"[7]	1.Suitable for small child or mentally impaired person 2.Faster diagnosis	1.High Cost
8	"DeepEmo: Real-world facial expression analysis via deep learning"[8]	1.Suitable for real-world facial expression 2.High level of accuracy	1.Higher Computational cost
9	"Facial expressions and flat affect in schizophrenia, automatic analysis from depth camera data"[9]	1.Quick Diagnosis 2.Easy identification of neutral/flat face 3.Accuracy level 85%	1.High Complexity
10	"A methodological approach — Working emotions and learning using facial expressions"[10]	1.Based on instant emotion of a student 2.Improved teaching- learning process	1.High computational cost
11	"Learning Personal-	1.Personalized	1.High Complex-

	ized Models for Facial Expression Analysis and Gesture Recognition"[11]	learning model for a student 2.Low Computational cost	ity
12	"A crowdsourced approach to student engagement recognition in e-learning environments"[12]	1.Modulated content delivery for a student 2.Improved learning of the student	1.Less control in handling of multiple students
13	Recommending New Links in Social Networks Using Face Recognition [13]	1.New way of online friend suggestion model 2.Easy for a new user	1.Low Accuracy
14	"Random sparse representation for thermal to visible face recognition"	1.Hybrid based detection 2.Mid range accuracy 3.Suitable for night	1.Complexity is high
15	"Temperature determining method from motion detection using thermal images"	1.Motion based detection 2.Suitable for dark place	1.High computational cost
16	"Organ-Based Facial Verification Using Thermal Camera"	1.Illumination free 2.Suitable for night 3.Less complex	1.Low accuracy

4. Research

Application of facial expression detection technique has been embraced by several sectors like health, banking and social networking. Fig-4 presents graphical view of all relevant sectors. Accuracy of facial expression detection technique was compared between ANN and non ANN. It was found that accuracy of ANN based technique was significant and this information is presented in Fig-5. Another interesting point was observed that computation time was higher with high accuracy. Fig-6 signifies about computational time.

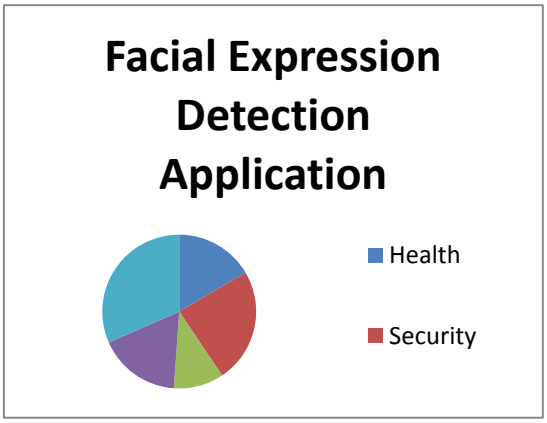


Fig-4. Classification of facial expression in various domains

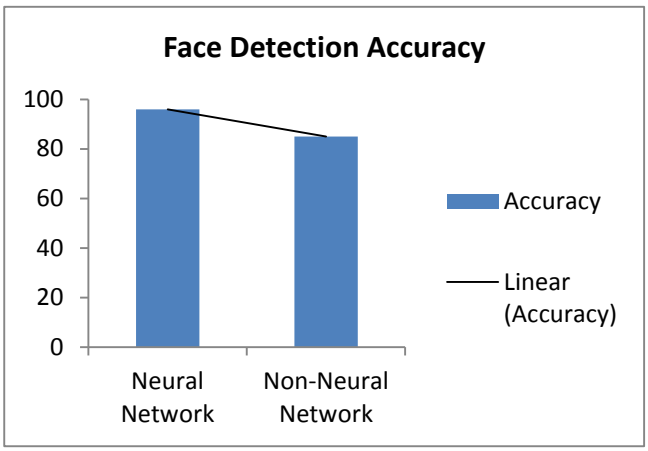


Fig-5. Face Detection Accuracy

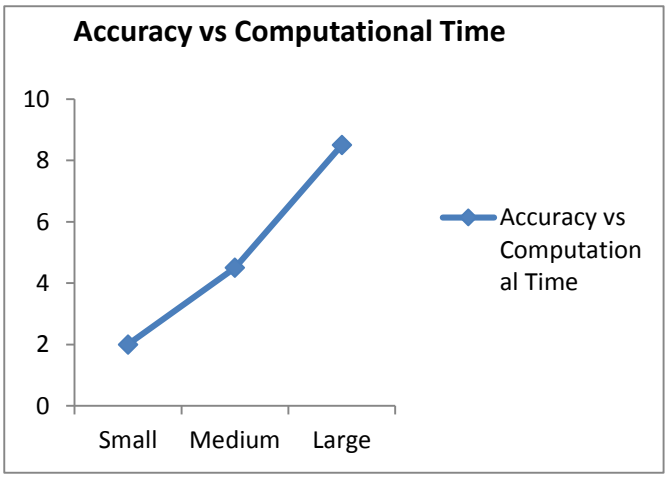


Fig-6. Trend of Neural Network\

5. Conclusion and future work

Many applications are applying facial expression detection feature across different industries. Earlier, it was utilized in computer vision field. Now, robots are becoming more intelligent and using it to identify humans more precisely. Numerous techniques have been proposed to solve this problem. By looking at various papers, it is found that ANN based facial expression detection technique has highest accuracy rate and it is ranging from 94% to 98%. This technique has demonstrated more benefits over existing facial expression detection techniques. However, sometimes ANN is penalized for computational cost.

It is clearly evident that research in facial expression is still an unexplored area and it will keep scientist and engineers busy alike. Smile detection, a special case of facial expression, in night has been a challenging task. Thermogram and neural network based smile detection would be able to resolve this issue. Computational cost and accuracy are going to be the main driver for determining a better facial expression detector. New smile detection technique will be proposed in near future, which has the ability to identify smile in several scenarios and remove different types of noises as well.

References

[1] Michel Owayjan, Roger Achkar and Moussa Iskanda ,"Face Detection with Expression Recognition using Artificial Neural Networks", IEEE, 2016

[2] Chenghao Zheng ,Menglong Yang and Chengpeng Wang, "A Real-Time Face Detector Based on an End-to-End CNN" , IEEE, 2017
[3] Jiajun Wang, Beizhan Wang, Yinhuan Zheng and Weiqiang Liu, "Research and Implementation on Face Detection Approach Based on Cascaded Convolutional Neural Networks', IEEE, 2017
[4] Kaihao Zhang,Yongzhen Huang, Hong Wu and Liang Wang, "Facial smile detection based on deep learning features" , IEEE, 2015
[5] Xin Guo, Luisa Polania and Kenneth Barner , "Smile Detection in the Wild Based on Transfer Learning", IEEE, 2018
[6] Chi Cuong Nguyen, Giang Son Tran, Thi Phuong Nghiem, Nhat Quang Doan, Damien Gratadour, Jean Christophe Burie, Chi Mai Luong, "Towards Real-Time Smile Detection Based on Faster Region Convolutional Neural Network" , IEEE, 2018
[7] Nikolay Neshov and Agata Manolova , "Pain detection from facial characteristics using supervised descent method", IEEE, 2015
[8] Weihong Deng, Jiani Hu, Shuo Zhang and Jun Guo ,"DeepEmo: Real-world facial expression analysis via deep learning", IEEE, 2015
[9] Talia Tron, Abraham Peled, Alexander Grinsphoon and Daphna Weinshall , "Facial expressions and flat affect in schizophrenia, automatic analysis from depth camera data", IEEE, 2016
[10] Carla M. C. Paxiuba and Celson P. Lima, "A methodological approach — Working emotions and learning using facial expressions", IEEE, 2018
[11] Gloria Zen, Lorenzo Porzi, Enver Sangineto, Elisa Ricci and Nicu Sebe, "Learning Personalized Models for Facial Expression Analysis and Gesture Recognition", IEEE, 2016
[12] Aditya Kamath, Aradhya Biswas and Vineeth Balasubramanian, "A crowdsourced approach to student engagement recognition in e-learning environments", IEEE, 2016
[13] Petr aloun, Jakob Stonawski and Ivan Zelinka, "Recommending New Links in Social Networks Using Face Recognition", IEEE, 2013
[14] Samira Reihanian, Ehsan Arbabi and Behrouz Maham, "Random sparse representation for thermal to visible face recognition", IEEE, 2017
[15] Siti Nurhana Abd Wahab, Suzaimah Ramli and Norulzahrah Mohd Zainudin, "Temperature determining method from motion detection using thermal images", IEEE, 2015
[16] Chule Yang, Danwei Wang and Prarinya Siritanawan, "Organ-Based Facial Verification Using Thermal Camera", IEEE, 2016.