

Tracking Suspicious Behaviour Using Facial Expression Recognition Techniques: A Survey

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Abstract - Nowadays, facial expression detection and expression recognition has become one of the most important topics in research field. Facial expressions may be used to identify criminals. In today's scenario, the crime rate is increasing day-by-day and criminals are set free due to lack of evidence. Investigators often express confidence in their potential to spot a lie. But identifying a criminal who is lying is very difficult task. This paper aims at listing the steps of the lie detection of criminals using facial expression recognition technique and various algorithms that are used at each step.

Keywords - Classification, Expression Recognition, Facial Expression Detection, Face Detection, Face Tracking, Feature Extraction.

1. Introduction

Communication is the process of exchanging thoughts between two or more person. It may be of two types verbal and non-verbal. Facial expression, which is a type of non-verbal communication, is one of the powerful tools for human communication process. Face of a person reveals a lot of things about a person. To identify a lie of a person, lie detectors are available. But a lie detector test conducted by certified professionals typical costs \$200-\$2000. Length of the test plays an important role to determine price. Longer the session, higher is the cost. Typically two-hour session costs \$200-\$800. Polygraph evidence could even be counter-productive that is, even if a person is guilty, he may be set free. And a polygraph test is also considered to be very slow and time consuming. This kind of test also requires many experts. The objective is to study various techniques and use best methods of tracking and detection, feature extraction and feature comparing and classification, to study facial

expressions of criminals and spot a liar and hence improving the security of society and to track suspicious behavior of a person. A liars expression includes eyebrows raised and pulled together, raised upper lids, tensed lower lids, lips slightly stretched horizontally back to ears, slight up-turn of mouth, right eye more open, slight squint of left eye, down-turn of lips, etc.

Face detection is the process of finding faces in an image or video. Then it returns the location of the face if found. Otherwise it says no face found.

Facial feature extraction is the process of translating the input data into some set of features^[1]. There are many feature points on face like nose, eyes, mouth which are extracted and then used as input data to system^[1]. Use of feature extraction can help reduce huge amount of data to a relatively small set which is computationally faster^[1].

2. Literature Survey

In the process of facial expression recognition and classification, there are mainly three steps involved-detection of face and tracking, facial feature extraction which is also called feature compression and facial feature classification. There are various techniques associated with each step.

Face detection separates the face and background. The background is to be eliminated. Classification also plays an important role in face detection. If the face is found it is classified in face class otherwise as non-face class^[2]. Ming-Hsuan Yang *et al.*^[3] classified the face detection methods into four categories. They include template

matching methods and appearance based methods knowledge-based methods, feature invariant methods. Knowledge-based methods are based on rules. Rules are developed according to the knowledge about human face. For example, if the shape is oval, then it is a face or if there are two eyes then it is a face. Advantage is that it is easy to create IF-THEN rules. Limitations include, difficulty in translating human knowledge into rules. Face may not be detected even if it is present if all the rules are not passed. This is the case if the rules written are too strict. But if the rules are too general, false positive results may be obtained. It is difficult to consider and write all possible combination of cases. In this case, it may happen that the face is not detected even if it is present.

Knowledge- based methods cannot detect faces if the face rotates. Hence they are depended on rotation. In ^[3], the authors told that the face can be detected using facial features, texture and skin color. Faces are detected even in light variations and different poses. Limitation is that the image feature can severely be corrupted due to illumination, noise, occlusion and shadow. Feature based face detection is more accurate, low execution time and high learning time ^[4].

In template matching, there are pre-defined templates. The image or the parts of an image is matched with this template to detect the face. This method is easy to implement. But if there are any variations in shape and pose, face detection fails ^[3]. Appearance-based method learns from examples in image ^[3]. These methods show superior performance.

Neha S. Sakure. *et al.*^[5] compared CAM-Shift and Kanade Lucas Tomasi (KLT) algorithms. CAM shift is widely used as mean shift algorithm. This algorithm is simple and fast to process. CamShift gives more accurate result than mean shift. CAM-shift is good for real time tracking and is also computationally efficient. It gives proper results even if some transformations like scaling and rotation is made. CAMShift fails to track face in outdoor environment but KLT can track face properly. One of the major flaws in KLT and CAM-Shift is that if the face is not detected in the first frame then it cannot detect the face in the entire video ^[6]. CamShift and the Kalman filter is superior in terms of precision, reliability and execution time ^[7].

Sonia Mittal *et al.* ^[8], compared two algorithms of face tracking and detection- Viola-Jones and CAM Shift algorithms. Advantages of Viola-Jones are fast features

are computed very quickly. Feature selection is efficient. Disadvantages include, only frontal faces are detected. The face should not be turned to 45 degrees in order to get the face detected. It is sensitive to lighting conditions. There may be problem of multiple object detection. These objects are detected as face. Faces are tracked using hue channel data by CAM-Shift. The Hue channel is based on HSV color model. After the CAM Shift algorithm has fetched color information, this algorithm works faster and requires less memory.

Neha Bhardwaj *et al.*^[9] described various approaches of feature extraction. The PCA is used for feature extraction. This reduces dimensionality of original data. This is used in feature selection also. PCA has some drawbacks like poor discriminating power within the class and it has large computation also. Linear Discriminant Analysis overcomes the drawback of PCA of poor discriminating power. The main advantage of LDA is to reduce the number of features to a manageable amount before classification. Gabor Wavelet can extract features that are aligned at particular angles called orientation. The Gabor Wavelet extracts the local features. Gabor wavelet is time consuming. The Discrete cosine transform is used to extract the global features. DCT is sensitive to changes in the light direction is the disadvantage.

Jyoti Rani.*et al.*^[10] reviewed the techniques like PCA(Principle component analysis), LDA(Linear discriminant analysis), ICA(Independent component analysis) which are used for expression recognition. These techniques cannot be used for color images. PCA gives better performance if lighting and viewpoint is not be varied ^[10]. LDA and ICA performs better than PCA. But PCA requires less computation as compared to ICA.

Saumil Srivastava ^[11], used a novel method for real time facial expression. First frame extraction is done. In face detection phase, the author used HAAR classifiers and interleaved HAAR classifiers to process each frame followed by skin detection algorithm for further processing. Then facial feature point extraction is done followed by emotion classification. The author used SVM for classification. The advantages of this model are that it generated result directly proportional to intensity of the amount of training provided. The result is robust to pose variations, light intensity changes, possess person independent property and also robust to background changes. Flaws of the model is facial expression recognition process depends upon the webcam and the user. The effect of the distance is to be minimized and also training database is not much extensive for optimum classification results.

Support Vector Machines (SVM) is the popular technique in classification problems. The SVM classifier is advantageous than traditional neural network in the sense that SVMs can achieve better generalization performance [12].

Neha Bhardwaj *et al.* [8], reviewed various classification techniques. Naïve Classifier has shown very good classification results for many real datasets. The Radial Basis Function-RBF has fast learning speed. MLP falls in the category of feed forward neural network. It maps input set to output set. MLP- Multilayer perceptron is a supervised learning technique. Network architecture

should be defined before training. MLP works well if the architecture chosen is good. MLP neural network is by a trial and error procedure. Try to use other algorithm which, during its training phase, builds the neural network architecture [9].

Set of support vectors are used to classify data by minimizing structural risk. Therefore, average error is reduced between target vectors and input [13]. SVM can be used for two-class problem. The summary of the literature survey is shown below in a tabular format.

Table 1: Literature Survey Summary

Sr. no	Paper Title	Algorithms/ Methods	Work done	Parameters	Advantages	Limitations
1.	Detecting Faces in Images: A survey [3]	Knowledge based, feature based, template based, appearance based	Classified face detection into four categories- Knowledge-based, Feature based, template matching and appearance based. Also listed advantages and limitations of each	Face detection rate in different cases and conditions	Knowledge-based: It is easy to form IF-THEN rules	Difficulty in translating human knowledge into rules. -Face may not be detected even if it is present if all the rules are not passed. -False positive results may be obtained if rules are too general -It is not possible to consider and write all possible cases
					Feature based: -Use face feature to detect faces -Face can be detected in different poses and variation in light	Image feature can severely be corrupted due to illumination, noise, occlusion and shadow
					Template matching: It is relatively easy to implement	It is inadequate for face detection because it cannot effectively deal with variation in scale pose and shape
					Appearance based: Show superior performance	
2.	Comparative Analysis Of Face Tracking [5]	Face detection, face tracking	Comparative analysis of CAM-Shift and Kanade Lucas Tomasi	Processing time, Scaling and invariance, accuracy	CAM Shift: -Is simple and fast to process and converge.	-Has problems with multi hue object

Sr. no	Paper Title	Algorithms/ Methods	Work done	Parameters	Advantages	Limitations
			(KLT) algorithms		-Is improvement of mean shift algorithm to make the result more accurate.	-Fails to track face in outdoor environment
					-Is that it is computationally efficient with the performance of real time tracking. -Is invariants to scaling and rotation	
3.	Comparative Study And Analysis Of Face Detection Algorithms [6]	Face detection	Compared KLT and CAM Shift algorithm	Tracking accuracy	KLT: KLT can track the face properly in the outdoor environment	If face is not detected in the first frame, then the face is not detected in the entire video
4.	Face Detection and Tracking: A Comparative study of two algorithms [8]	Face tracking and detection	Compared Viola-Jones and CAM Shift algorithms	CUP resource , time	Viola-Jones: -Feature selection is efficient. - The features are scaled instead of scaling the image -Fast features are computed very quickly CAM Shift: -Objects of variety of colors can be recognized. - After the CAM Shift algorithm has fetched color information, it can track objects faster and consumes very less amount of CPU resources.	- Detector is effective only in the case of frontal images - If the face is turned 45 degrees, it fails to recognize the face. -Sensitive to lighting conditions. -Because of overlapping sub-windows, multiple objects may be detected as face
5.	A Review: Facial Expression Detection with its Technique and Application [9]	Face expression detection	Studied various face detection techniques, reviewed feature extraction methods along with classification techniques. Listed advantages and limitations	Computation, time, feature extraction accuracy, discriminating power	Feature Extraction: -LDA(Linear Discriminant analysis) has no discriminating power. -LDA reduces the features to less number of features so that they are easily manageable.	Principle component analysis has poor discriminating power. -PCA has large computation - Gabor wavelet is time Consuming. - DCT(Discrete cosine

Sr. no	Paper Title	Algorithms/ Methods	Work done	Parameters	Advantages	Limitations
						transform) is sensitive to changes in lighting direction.
6.	Emotion Detection Using Facial Expressions –A Review [9]	Facial expression recognition	Reviewed the techniques for facial expression recognition- PCA, LDA, ICA, 2DPCA, SpE2DPCA, Gabor Filer Bank	Recognition rate, imaging and lighting condition, performance	<p>- Fisher's Linear Discriminant reduces the projected sample scattering and have better performance than PCA^[15]</p> <p>-Independent component analysis (ICA) gives better performance than PCA (Principle component analysis)</p> <p>-SpE2DPCA works with color images</p> <p>-Recognition rate of SpE2DPCA is higher than PCA, 2DPCA, E2DPCA</p>	<p>In PCA, imaging and lighting condition should be constant and should not vary to get better performance.</p> <p>-PCA is computationally expensive than ICA</p> <p>-2DPCA requires more storage than PCA because more coefficients for image representation are needed.</p> <p>-In Gabor filer bank, maximum bandwidth is limited</p>
7.	An Overview of Principal Component Analysis [10]	PCA- Principal component analysis	Used PCA for facial expression recognition	Noise, memory, efficiency	Low noise sensitivity, the less requirements of memory, and increased efficiency given the processes taking place in a smaller dimensions	At times, simple variant may not be captured

3. Facial Expression Recognition System

The system consists of three modules. Input is the video sequence. The first module is face tracking and detection. In this module, the face is to be identified and located if found. The second module is feature extraction. Feature extraction also known as feature reduction plays a major role in detecting lie using facial expression. Facial features like eyes, lips, eyebrows etc. are to be extracted in this phase. After the features are extracted, they are to be compared and matched with the database images which in turn will classify the expression in a pre-defined category. There are two pre-defined categories, one with the liar's expression and other with all the expression that does not correspond to a liar. Following are the sequence of steps:

1. Face detection and tracking
2. Facial feature reduction/ extraction
3. Feature comparing and classification

Step 1: The input to the face tracking and detection phase is the video sequence. The video sequence may contain faces, objects, etc. It may also happen that the video sequence does not contain any faces. The purpose of this phase is to detect faces in the video and track the face in the successive frames. Output is the detected faces.

Step 2: Facial feature reduction/ extraction is the most important step before feature comparing and classification. Faces obtained from step 1 contain many features like eyes, nose, lips, eyebrows, ears, etc. The required features are extracted in this phase.

Step 3: Features obtained from feature extraction phase are compared with the dataset. After comparing they are classified accordingly into pre-defined classes. This helps in lie detection. The features are compared and classified as –“Person is lying” or “person is innocent”.

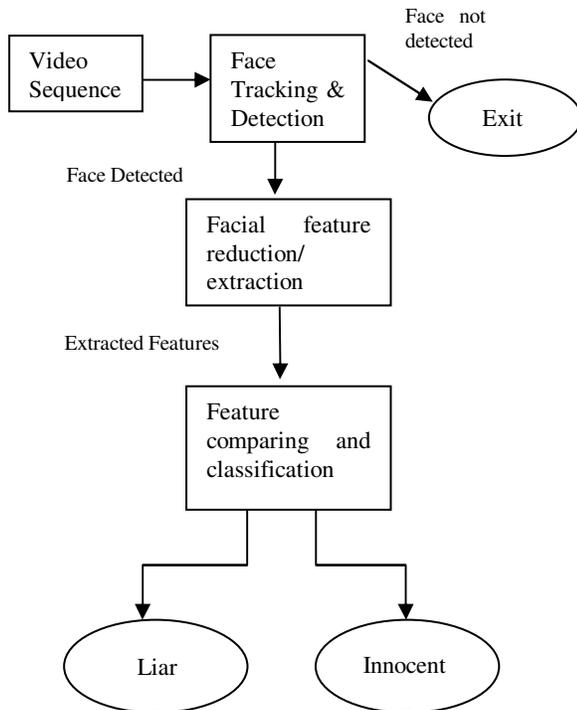


Fig. 1: Lie detection using facial expressions

4. Conclusion

In this paper, various techniques of face tracking and detection, feature extraction, feature comparing and classification are reviewed. The best suited algorithms in each of the modules can be in the system. The steps for facial expression recognition to detect a lie of a person are shown. One can use CAM-Shift algorithm to detect and track faces in a video frame if importance is given on memory requirement and time. It is also invariant to rotation. PCA is good for smaller dimensions, is low noise sensitivity, and less memory requirement. SVM is the most popular method for classification. It is suited for two-class problem. Choosing any algorithm is based on the requirement of your system and it totally depends on the system developer.

5. Future Scope

Live video stream can be supplied as input and real time lie detection can be done. Other parameters like eye blink

rate, hand and arm gestures can be taken into consideration in order to spot a liar.

References

- [1] Nifi C Joy and Dr. Prasad J.C.: Feature Extraction Techniques for Facial Expression Recognition Systems, GRD Journals- Global Research and Development Journal for Engineering | Volume 1 | Issue 2 | January 2016
- [2] Rajkiran Kaur, Rachna Rajput: Face recognition and its various techniques: a review, International Journal of Science, Engineering and Technology Research (IJSETR) Volume 2, Issue 3, March 2013, ISSN: 2278 – 7798
- [3] Ming-Hsuan Yang, David J. Kriegman, Narendra Ahuja: Detecting Faces in Images: A survey, IEEE Transactions on Pattern Analysis And Machine Intelligence, Vol.24, NO.1, January 2002
- [4] Mayank Chauhan, Mukesh Sakle: Study & Analysis of Different Face Detection Techniques, International Journal of Computer Science and Information Technologies, Vol. 5 (2) , 2014, 1615-1618 .
- [5] Neha S. Sakure, Rushikesh T. Bankar, Suresh S. Salankar: Comparative Analysis Of Face Tracking, International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE) Volume 5, Issue 3, March 2016
- [6] Prof. Rushabh Shah, Aalisha Sheth, Biyanta Shah Aayushi Shah, Dr. Priyanka Sharma: Comparative Study And Analysis Of Face Detection Algorithms, International Journal of Advanced Technology in Engineering and Science, Volume No 03, Special Issue No. 01, March 2015
- [7] Afef SALHI and Ameni YENGUI JAMMOUSSI: Object tracking system using Camshift, Meanshift and Kalman filter, International Science Index, Electronics and Communication Engineering Vol:6, No:4, 2012 waset.org/Publication/15036
- [8] Sonia Mittal , Chirag Shivnani: Face Detection and Tracking: A Comparitive study of two algorithms, IJCSC Volume 7,Number 1 sept 2015-March 2016 pp.76-82 DOI:10.090592/IJCSC.2016.011
- [9] Neha Bhardwaj, Manish Dixit: A Review: Facial Expression Detection with its Techniques and Application, International Journal of Signal Processing, Image Processing and Pattern Recognition , Vol.9, No.6 (2016), pp.149-158
- [10] Jyoti Rani, Kanwal Garg: Emotion Detection Using Facial Expressions -A Review, International Journal of Advanced Research in Computer Science and Software Engineering Volume 4, Issue 4, April 2014, ISSN: 2277 128X
- [11] Saumil Srivastava: REAL TIME FACIAL EXPRESSION RECOGNITION USING A NOVEL METHOD, The International Journal of Multimedia & Its Applications (IJMA) Vol.4, No.2, April 2012

- [12] Mohammed Javed, Bhaskar Gupta: Performance Comparison of Various Face Detection Techniques, International Journal of Scientific Research Engineering & Technology (IJSRET) Volume 2 Issue1 pp 019-0027 April 2013
- [13] Sujata G. Bhele, V. H. Mankar: A Review Paper on Face Recognition Techniques, International Journal of Advanced Research in Computer Engineering & Technology (IJARCET) Volume 1, Issue 8, October 2012
- [14] P. Suja, "Emotion recognition from facial Expressions using frequency Domain proceeding of Advances in Intelligent Systems and Computing, vol. 264, (2014).
- [15] P. N. Belhumeur, J. P. Hespanha, and D. J. Kriegman, "Eigenfaces vs. Fisherfaces: recognition using class specific linear projection," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 19, no. 7, Jul. 1997, pp. 711–720
- [16] Sasan Karamizadeh, Shahidan M. Abdullah, Azizah A. Manaf, Mazdak Zamani, Alireza Hooman, "An Overview of Principal Component Analysis", Journal of Signal and Information Processing ,2013, 4, 173-175 Published Online August 2013, doi:10.4236/jsip.2013.43B031

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