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A Survey based on Machine Learning Approaches for Detection of Human Behavioural Lie using physiological sensors and Face Recognition System

Bishan Lal Thakur[1], Divyansh Thakur[2], Payal Pandey[3]

[1] Department of Computer Science and Engineering, Indian Institute of Information Technology, Una, India
[2] Department of Computer Science and Engineering, Indian Institute of Information Technology, Una, India
[3] Department of Computer Science and Engineering, Indian Institute of Information Technology, Una, India

Corresponding Author: divyanshthakur8@gmail.com, Tel.: +91-9418651105

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***Abstract* -** At present there is a huge need of system which uses both physiological and facial data to detect human behavioral lie, thus this survey is based on getting insight for developing a machine learning based technique using facial and physiological data for detection of human behavior. The purpose of this survey is to identify various physiological sensors and their parameters along with sensing data, also to know whether physiological signals are robust and can be controlled by human being or not. It also reviews about various machine learning techniques for face recognition system and presented the most effective face recognition system in our survey. By getting significant understanding of physiological data and facial data with their classification rate it becomes possible to deduce a machine learning based algorithm using facial and physiological data for detection of human behavioral lie. This survey compiled the work done by various author to provide the precise information about the machine learning techniques, physiological sensors, face recognition system for human behavioral lie.

Keywords – Machine learning techniques, Physiological Sensors, Face Recognition, Emotion Recognition, Lie Detection

I. INTRODUCTION

Today's world filled with lots of data generated by human and computer like text, picture, audio and video. Machine learning is helpful in driving meaning from all of that data. Machine learning is time to time changing branch of computational algorithms, which computationally process input data set to provide desired information from it [1]. Machine learning imitates human intelligence by learning from surrounding environment. Machine learning can be classified into various categories based upon input data label like supervised learning, semi supervised learning and unsupervised learning .In supervised learning machine model trained on labeled data set so that it can predict the outcome out of a sample data, classification and regression falls under this category, where as in unsupervised machine learning we have unlabeled dataset and machine algorithm to draw conclusion from it. A combination of both supervised and unsupervised learning coined the term Semi supervised learning. One of the key features of a computational algorithm used in machine learning is its ability to adapt itself in response to training sample. According to [2] Machine learning is a branch of study that gives the computers the capability to gain knowledge without being explicitly taught. There are several fields where the technique of machine learning are used like computer vision, spacecraft engineering, finance, biomedical and medical application like radiotherapy.

Due to rapid advancement in the area of Nano technology, detection technologies, embedded system and wireless communication According to [3] it becomes possible to build automated smart device which is capable of monitoring human body continuously, also it becomes a necessary need in today's world as the population size is increasing continuously so as the diseases .The existence of throat cut competition in each field leads to stress , anxiety and other mental pressure which has adverse impact on human society, thus it is necessary to have a smart automated physiological sensor capable of sensing human body whether the person is in stress, anxiety or other mental pressure which is better for wellness of our human society. Now a days there are several instrument for measuring physiological signals like GSR, EEG, electromyography, EDA and lot more the motive of the review paper is to investigate various physiological sensors along with their parameters and present various advantages and shortcomings of physiological sensor and then present a physiological sensor which is capable of sensing human body correctly upto a great extent with significant accuracy which will be helpful in detecting human behavioral lie.

A person can fake his facial expressions easily or he can also pretend to be someone else which he is not. Thus facial expression can be deceived easily and depends upon lots of factor not just the presence of stimuli like pleasant sceneries, disgustful scene etc. due to this reason we are using physiological signals which is used in most of lie detectors,

polygraph test, because it is difficult to deceive or control physiological signals if sudden high arousal stimuli has given to a person. Thus in order to check whether subject is expressible or not we are going to record human bodily activity along with facial expression in the presence of combination of stimuli like pleasant scene ,disgustful image. Emotions expressed by physiological signals and facial expressions are analyzed using suitable machine learning model to check whether there is a match or mismatch,if there is a mismatch we are concluding that there is a behavioral lie and it is confirmed by further more testing.

II. PROCESS OF LITERATURE REVIEW

The articles cited in our survey paper were taken from journals having very good impact factor and conferences conducted by IEEE. In this paper more than twenty articles are cited with their references. The main motive of this survey is to find the answer of the following research questions:

- R.Q. 1) what are the various types of sensors or devices used for measuring the human body activity?
- R.Q. 2) which technique of machine learning is adopted by different authors?
- R.Q. 3) what are the various parameters used for measuring the response from human body?

A. Source of information

The important websites and domain name which are used to find and extract research papers or articles related to our problem domain that are

- Google Scholar (https://scholar.google.co.in/)
- IEEE (https://www.ieee.org/)
- ACM (https://dl.acm.org/)
- Springer (https://www.springer.com/in)
- ELSEVIER (https://www.elsevier.com/en-in)
- Taylor & Francis (https://taylorandfrancis.com/journals/)

B. Work Flow of literature review

The fig. 2.Depicts the process of downloading the articles with respect to the keywords that are machine learning, physiological sensors, face recognition system and lie detection system. The whole process of this survey is shown in fig. 2.

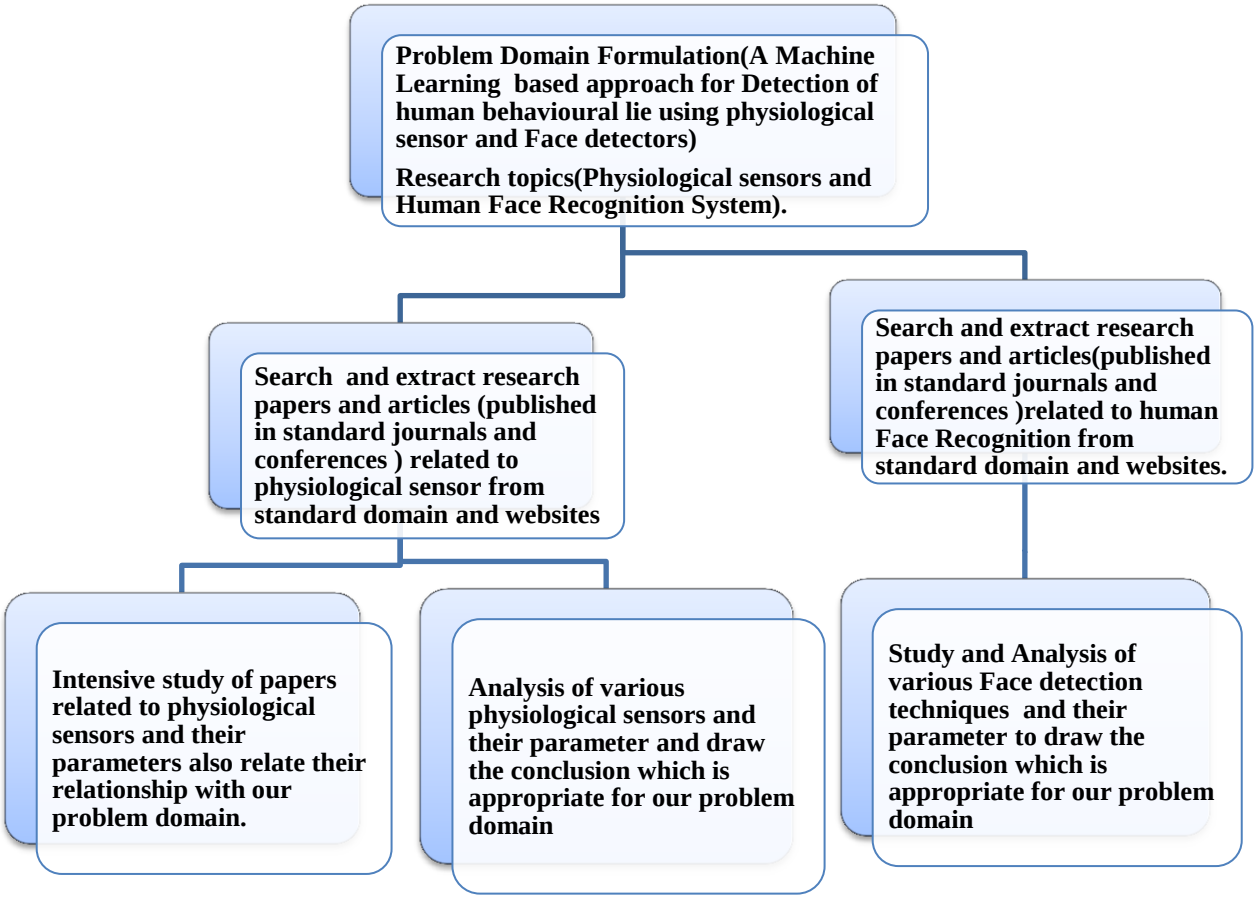

Figure 1: Workflow chart for the selection of articles to be cite in our work

The table 1 gives the detail of articles which are used in our survey paper along with their journal/conference name and publisher

Table 1: Illustrate the presentation of various articles published between 2010-2018 along with their publisher

Sr.No.	Journal/Conference	Publisher	No. of Papers Cited
1.	IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING	IEEE	1
2	Proceedings of the 24th Australian Computer-Human Interaction Conference	ACM	1
3	IEEE 7th International Colloquium on Signal Processing and its Applications	IEEE	1
4	Pattern Recognition	ELSEVIER	1
5	Journal of visual communication and image representation	ELSEVIER	1
6	IEEE International Conference on In Automatic Face & Gesture Recognition	IEEE	1
7	IEEE TRANSACTIONS ON AFFECTIVE COMPUTING	IEEE	1
8	IEEE International Conference on Multimedia and Expo	IEEE	1
9	The 6th International Conference on Human System Interaction (HSI)	IEEE	1
10	IEEE Conference onComputer Vision and Pattern Recognition.	IEEE	1
11	IEEE 17th International Conference on Image Processing	IEEE	1
12	IETE Technical Review	Taylor & Francis	1
13	International Conference on Smart City and Systems Engineering	IEEE	1
14	Digital Signal Processing	ELSEVIER	1
15	IEEE International Conference on Data Mining	IEEE	1
16	Computer methods and program in biomedicine	ELSEVIER	1
17	IEEE transactions on pattern analysis and machine intelligence	IEEE	3
18	IEEE International Conference on Automatic Face and Gesture Recognition	IEEE Xplore	1

III. LITERATURE REVIEW

The literature review is partitioned into two categories that are

- Physiological sensors
- Facial Expression recognition and Face Identification

The need behind this literature review is to find the answers of following research questions mentioned in section 2. And to get aware of various trending techniques and terms used for finding out human behavior.

A. Physiological sensors

To measure various parameters of sensors and processing methods for recognizing stress in human body, Sharma et al., [4] done a survey. The following survey include primary measure taken for stress investigation that are physical stress and physiological stress, keywords used in physical stress measure under the survey are eye gaze, voice, hand movement, pupil diameter and for physiological stress are EEG,EMG,HRV,GSR,BVP. From this survey it is concluded that stress alone cannot be directly identified from primary measure. For measuring stress level in human body, Bakker et al., [5] used GSR sensors. In the proposed work, by using sensor data stream the problem of stress finding in human body and categorization of stress is resolved. Moreover, authors mainly focused on serious problems arise while dealing with data obtained through

GSR. To recognize human emotions, Jerrita et al., [6] used physiological signals. The various keywords described for human emotion recognition in the implemented work are Physiological signals, Inducement Stimuli, Signal Processing Techniques, and Emotions. It is observed that categorization of elementary emotion is still challenging also there is requirement of large amount of physiological data for reliable and robust emotion recognition systems. Moreover at presently most of the systems for human emotion recognition are user dependent and those which are user independent lacks in accuracy. For long-term and continuous evaluation of electrodermal action, Poh et al., [7] developed a sensor which is wrist-worn and easy wearable. Proposed sensor have ability to execute relaxed long-term measurement of EDA and thus providing opportunities that were previously practically not possible. Key terms explained in the propose work are sweat, forearm, conductance of skin, sympathetic nervous system and wearable sensor, It is wrapped as a result that palmar electrode when subjected to pressure and continuous motion get lost easily however implemented sensor under the research paper does not affect from all these problems and has extraordinary ability to execute relaxed long-term assessment of EDA which distinguish it from all other sensor. To recognize human emotions, Liu et al., [8] introduced a method using mechanically selected GSR signals feature and SVM. The implemented work adopted covariance based feature selection approach in order to have optimized feature gain and will lead to high recognition rate with the help of SVM for which input is optimized feature. At the end it is determined that proposed method has better result and it can recognize emotions of human with correctness level more than 66.67%..The main attributes explained in the paper includes Human emotion, GSR signal, Covariance, SVM. In order to recognize human emotion by using physiological signals, Wioleta et al., [14] done a survey under which it is stated that physiological signals are extemporaneous and cannot be controlled and strongly interrelated with peoples emotional state. It is also concluded that at present there is no system having capability to recognize all human emotions. Main terms explained under the surveys that are emotion recognition, physiological signals and affective computing. For cognitive load measurement**,** Nourbakhsh et al., [15] used GSR. The proposed work include Measurement of GSR data taken form two different experiments that are by means of arithmetic task and text reading tasks each having numerous cognitive load level. From the work done it is observed that when the frequency analyzation is done within range 5Hz to 1Hz or below 1Hz segmented signals have more significant results in both experiments. An investigation done by Wagner et al., [16]on methods used for features extraction and classification under physiological signals and emotions. Under the investigation K-nearest neighbor, linear discriminate function and multilayer perception method have been tested .It is concluded that three classifiers have recognition rate about 80% and results can be improved to 92% while applying feature reduction. To investigate human emotions using physiological signals, Koelstra et al., **[**17**]** constructed a database which includes Electroencephalogram (EEG) and physiological signals of 32 subjects. With frontal face video of 32 subjects. It is found that there is significant connect between EEG signals and subject rating and have significantly better performance than random classification.

B. Facial Expression recognition and Face Identification

For facial expression recognition, Jabid et al., [9] proposed LDP after examining the various shortcomings of local binary pattern (LBP).The proposed work use SVM and template matching the two machine learning techniques to evaluate performance of LDP feature. It is obtained that LDP feature can categorize diverse expression with higher correctness due to the fact that LDP descriptor is invulnerable to non-monotonic illumination variations and noise. For human face identification, Lu Can-Yi et al., [10] proposed WSRC based classification method after reviewing various technique for face recognition that are falls under SRC based classification like NFCS, NN, NFP, NFL. It is observed that based on experimental result WSRC is more effective than SRC particularly in lower dimensional subspace. To recognize human facial expression, Zhao et al., [11] designed an algorithm centered on deep learning. Suggested method is a combination of Deep belief networks (DBNs) and multi-layer perception (MLP) and hence contains benefits of both learning techniques. It is stated that the proposed method have recognition accuracy of 88.57% for (16*16) image 89.05% for (32*32) image and 90.95% for (64*64) image. The important Keyword in this work is Deep belief network. To identify human face, Cao et al., [12] stated a new method based on pose-adaptive equivalent Learning-based Descriptor.

Proposed method used unsupervised learning procedures to learn an encoder from the teaching sample. It is

Concluded that implanted method have ability to attain 84.45% recognition rate. To recognize emotions of human face, Dahmane et al., [5] used dynamic grid-based HOG Features. HOG is a technique useful for digging the arrival features of human body by collecting the gradient magnitudes for a set of alignments. In the proposed work, methods used are replica of the “baseline method” and “machine learning techniques” that are statistical. By using these methods it is concluded that proposed method used under the research paper is far better than LBP implementation. In order to identify human face, Mohammed et al., [13] designed an algorithm centered B2DPCA and extreme learning machine. From experimental results it is observed that proposed method accomplishes better recognition at a considerably faster amount than present techniques also implemented work is autonomous from the number of models used for training.For identifying

skin color in face recognition system, M. Jose et al., [18] did a color space study in order to find which color model is the best choice to build an effective face detector. The ten most common colour model considered under the study that are RGB, YpbPr, CMY, CIE-XYZ ,YUV, YIQ, YcgCr, YdbDr, HSV—or HSI—and YcbCr, and 15 truth images are used having distinct face color as compare to rest of the images. For each color space after comparing different results it is concluded that the most suitable color spaces for skin color identification is HSV model. For human face identification, Guo et al., [19] used SVM along with binary tree classification approach. Standard face database taken for experimentation and comparison under the research paper is Cambridge ORL. Results of the experiments shows SVMs algorithms can be trained effectively as compare to NCC methods for human face recognition. To describe human face, Ahonen et al ., [20] suggested LBP based techniques for human face representation. He at el., [21] proposed Laplacian faces method for human face recognition by means of LPP. Standard approaches that are chosen for comparison are Fisher face and Eigen Face and databases that are MSRA, Yale and PIE. It is determined that suggested approach provides better recognition rate with lower error rate. To recognize human face under ideal as well non –deal condition**,** Gao et al., [22] proposed LEM face feature approach .The implemented work includes comparison with popular Eigen face approach .It is determined that LEM is effective than the edge map method and having efficiency equivalent to Eigen face technique for human face identification.

The Table 2. Provides the brief information about the work done by various authors. In this table work done, various tools/techniques and keywords are shown.

Table 2 The following table depicts the Work Done and Tools/Techniques

Author	**Work Done**	**Tools/ Techniques**	**Keywords/ Parameters**
Sharma et al., [3]	Did a survey which includes measurement of various parameter of sensor and processing method.	• Bayesian classification. • Artificial neural network. • Decision tree. • Support Vector Machine. • Markov chains and Hidden Markov chain model • Fuzzy technique.	• EEG • EMG • HRV • GSR • BVP • Eye Gaze • voice • Hand movement • Pupil diameter.
Bakker et al., [4]	Used GSR sensor to measure stress level in human body.	• GSR • Stress Factor • ADWIN	ADWIN is used for changing data which is relying on raw data using adaptive window.
Dahmane et al., [5]	Use of dynamic grid-based HOG Features to recognize emotion of human face.	• dynamic dense appearance descriptors • Statistical machine learning techniques.	• SVM • LBP • RBF • SVM • GEMEP-FERA • FACS.
S Jerrita et al., [6]	Use of physiological signal to recognize human emotion.	• Inducement Stimuli • Physiological signals • Various techniques for processing of signal	• Inducement Stimuli • Physiological signals • Signal Processing Techniques.
Poh et al., [7]	Development of wrist worn easy to wear sensor for long term and continuous evaluation of electrodermal action in human body.	• EDA sensor waveform • Distributions of correlation coefficients between EDA measurements	• EDA • Forearm • Galvanic skin response. • Skin conductance. • sympathetic nervous system • Wearable sensors, wrist.
Liu et al., [8]	To recognizing human	• Recognition of facial expressions • AUDN	By using AUDN facial expression is recognized.

	emotion used mechanically selected Galvanic Skin response signal feature and support Vector machine.		
Jabid et al., [9]	Used local Directional pattern to recognize human facial expression.	• SVM • Template matching machine learning	• Image representation, • Facial expression recognition • Local directional pattern • Feature extraction.
Lu Can-Yi et al., [10]	Proposed weighted sparse representation based classification method to recognize human face.	• WSRC	• Face recognition • Weighted Sparse Representation • Nearest Feature Classifiers • Sparse Representation Classification • Local representation.
Zhao X et al., [11]	Deep learning based method to recognize human facial expression.	• Combination of DBNs with MLP.	• Deep belief networks • Deep learning, • Facial expression recognition, • Feature learning, Multi-layer.
Cao et al., [12]	Human face recognition by using learning based descriptor and pose-adaptive matching.	• Unsupervised learning • PCA pose-adaptive matching method.	• Learning-based (LE) descriptor • Labeled Face in Wild (LFW) • PCA • SVM classifiers • Multi-PIE.
Mohammed et al., [13]	Introduction of an algorithm to recognize human face.	• Bidirectional two dimensional principal component analysis (B2DPCA) • Extreme learning machine (ELM).	• PCA • LDA • AVR • B2DPCA • ELM • FERET • KNN • JAFFE
Wioleta et al., [14]	Presented a review paper to recognize human emotion using physiological sensor.	• SVM • k-Nearest Neighbor (KNN) • Discriminate Function Analysis (DFA) • The Least Significant Difference (LSD) test • Linear Discriminant Analysis (LDA) • Classification And Regression Tree (CART) • Self-Organizing Map of Neural Network • Naïve Bayes.	• Emotion recognition • physiological signals • Affective computing.

Nourbakhsh et al., [15]	used galvanic skin response for cognitive load measurement.	• ANOVA test • GSR data.	• cognitive load • physiological signals • galvanic skin • response, temporal analysis • spectral analysis. information interfaces and presentation User • interfaces - Evaluation/methodology.
Wagner et al., [16]	An investigation on methods used for feature extraction and classification under physiological signals and emotions.	• music induction method • Four-channel biosensors • linear discriminant function • K-nearestneighbour and multilayer perceptron.	• Electromyogram (EMG) • Electrocardiogram • (ECG) • Skin conductivity (SC) and respiration change • (RSP).Analysis of Variance • (ANOVA) • component analysis • PCA.
Koelstra et al., [17]	Constructed a database to investigate human emotion using physiological sensors.	• Electroencephalogram (EEG) • Physiological signals.	• Classification of Emotions • Electroencephalogram • Signals for physical activities. • Processing of Signals pattern classification
M. Jose et al., [18]	Did a color space study to identify face skin color in face recognition system.	• The Ten most common color model and 15 truth images are used having distinct face color.	• RGB • CMY • YUV • YIQ • YPbPr • YCbCr • YCgCr • YDbDr • HSV—or HIS • CIE-XYZ
Guo et al., [19]	Introduced SVM along with binary tree classification approach.	• SVM • NCC.	• Binary tree, Eigenface, principal • Component analysis. • Face recognition, support vector machines, • optimal separating hyperplane.
Ahonen et al., [20]	Used LBP based technique to recognize human face .	• LBP.	• LBP, component based • Face recognition • Texture features • Facial image representation • Face misalignment.
He at el., [21]	Implemented Laplacianfaces approach to identify human face.	• Laplacianfaces • LPP.	• PCA • LDA • LPP • Face recognition

			• Face manifold • Subspace learning.
Gao et al., [22]	LEM face features approach to identify human face.	• LEM • Eigen face method.	• LHD • LEM • Structural information..

IV. CONCLUSION

The main motive of this survey is to find the solution of the research questions which are described in section 2. .However, we also investigated the various reported face detection technique and algorithm.

The promising solutions or the answer for the designed research questions are

R.Q. 1) what are the various types of sensors or devices used for measuring the human body activity?

For finding the results on the basis of various human body activities various authors used different tools and sensor for obtaining the result. The mostly used devices and sensors which we get to know about from this survey are EEG,EMG,HRV,GSR,BVP and wrist-worn sensor. We found that for long term continuous assessment of human activity is wrist worm sensor which is easy to wear and to obtain result on the basis of electro dermal activity of human body. It is concluded that physiological signals are the best way to analyses human behavior as they are [14] extemporaneous and cannot be controlled and strongly interrelated with peoples emotional state.

R.Q. 2) which technique of machine learning is adopted by different authors?

As according to the definition of machine learning algorithms there are six categories in which machine learning algorithms are categorized. Supervised learning, unsupervisedlearning, Semi-Supervised learning, Reinforcement learning, Transductive learning and Inductive learning are the categories of machine learning algorithms. By this survey we concluded that supervised learning technique is mostly used. SVM, HOG, LDP, NFCS, NN, NFP, NFL, k-NN . We conclude that WSRC based classification method is more effective thanSRCbased . For facial expression recognition that a deep learning method [11] which is a combination of Deep belief networks(DBNs) and multi-layer perception (MLP) is suitable having recognition accuracy of 88.57% for (16*16) image 89.05% for (32*32) image and 90.95% for (64*64) image for human face skin color detection in face recognition study result [18] suggested HSV model. Now a days a lots of research going on in the field of face detection as there is no system available having capability to detect human face completely.

R.Q. 3) what are the various parameters used for measuring the response from human body?

In this survey paper various parameters on which the human activities are measure to determine the behavior of human body that are Palm, Eye gaze, Voice, Hand movement, Pupil diameter, Heart Rate, Brain, facial expressions and skin color. On the basis of these parameters various author's has implemented there proposed models.

Appendix: 1Acronyms of various terminologies used in this survey.

Abbreviations	Name
AVR	Average recognition rates
AUDN	AU-inspired Deep Networks
B2DPCA	bidirectional two dimensional principal component analysis
BVP	Blood Volume Pulse
CART	Classification And Regression Tree
CMY	Cyan Magenta Yellow
DBN	Dynamic Bayesian network
DFA	Deterministic Finite Automation
EDA	Exploratory data analysis
EEG	Electroencephalography
ELM	Extreme learning machine
EMG	Electromyography
FERET	Face Recognition Technology

GSR	Galvanic Skin Response
HOG	Histogram of oriented gradients
HRV	Heart Rate Variability
i.e	That is
JAFFE	Japanese female facial expression
k-NN	k-nearest neighbors algorithm
LBP	Local binary patterns
LDA	Linear Discriminant Analysis
LDP	Local directional pattern
LEM	Line Edge Map
LHD	Line Segment HausdorffDistance
LE	learning-based (LE) descriptor
LPP	Locality Preserving Projections
LFW	Labelled Faces in the Wild
LSD	Least Significant Difference
ML	Machine Learning
MLP	Multi-layer perceptron
NCC	Nearest Center Classification
ORL	Olivetti Research Lab
PCA	Principle component analysis
RBF-SVM	Radial basis function kernel - Support vector machine
RGB	Red Green Blue
SRC	Sparse Representation based Classification
SVM	Support vector machine
WSRC	Weighted Sparse Representation based Classification
YIQ	Yellow I (orange-blue) and Q (purple-green)
YCbCr	Represents colors in terms of one luminance component/luma (Y), and two chrominance components/Chroma(Cb and Cr).

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Authors Profile

Bishan Lal Thakur, pursuing B.Tech. In computer Science and Engineering from Indian Institute Of Information Technology, Una. The research interest lies in Machine Learning Algorithm and natural Language Processing.

Divyansh Thakur, Currently working at Indian Institute Of Information Technology, Una in department of Computer Science and Engineering. The research areas of the author[2] are Internet of Things, Wireless Sensor Network, Machine Learning, Big Data Analytics, Artificial Intelligence.

I am Payal Pandey, currently pursuing engineering (B.Tech) from IIIT Una. I am a Computer Science undergrad who's interested in data structures and algorithms. I am an avid reader and love memoirs as well as fiction.

