Mental Health Monitoring System to Detect Criminal Behaviour using Emotion Recognition and Psychometrics

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Abstract

Mental health refers to the proper functioning of the emotional and psychological factors of the human brain. It shows the ability of coping up to inevitable changes or stress that occurs in a person's lifespan. Difficulties in handling such situations lead to mental illness. Mental illness can be termed as the behavioural disorder that leads to distress and improper functioning of emotional as well as physical quotient. An effective way of handling mental issues is consistent monitoring of emotion transitions. The proposed Mental Health Monitoring System is developed to serve the same. Mental Health Monitoring System is a hybrid design that aims at observing the emotional transitions taking place in the human brain and monitoring them consistently. The human face is an important part of an individual's body and plays an important role in knowing the individual's mood. The face is where a human expresses all his basic emotions. One of the "PEN" personality factors is Neuroticism and it is characterised by a tendency to experience the negative effect. In the existing system, the manual assessment of psychological abnormalities might not be accurate as the psychometrics score cannot predict the emotion of the human user. To overcome this problem and suggest an effective solution for Criminal rehabilitation, we propose a hybrid architecture invoking facial based emotion sequence, PEN test and IQ test. By consistent monitoring of a human's emotion and subjecting to PEN and IQ test, the human's mental state is routed. Combination of the above three techniques provides promising results for Criminal rehabilitation and self-control.

I. INTRODUCTION

According to World Health Organization, India is the country which holds the maximum mental health issues. National Care Of Medical Health survey conducted by WHO found that minimum 6.5 percent of Indian population suffers from mental disorders. This leads to suicide at such rate that it has increased by 18% in ten years and occurs among the people below the age of 44 years. Currently it is 7.5% of Indians who undergo serious mental health problems which are sometimes known and unknown that requires expert intervention according to WHO.

Outward appearances can be considered not just as the most normal type of showing human feelings yet additionally as a key non-verbal correspondence system. In the event that effective strategies can be realized to consequently perceive these outward appearances, striking upgrades can be accomplished in the region of human and technology collaboration.

This paper analyses different transitions of emotions taking place inside a human brain using facial expression detection through the camera. Thus this data is used to extract the parameters required to classify the mental illness of the human being. Hence the project revolves around data mining as the main domain. Further data analytics is performed using python for obtaining the necessary classification of mental health.

Psychometrics is an important field of the study of psychology. It is a standardised method that analyses the different attitudes and personality traits of a human.

This paper conducts a psychometric analysis that consists of an IQ test and personality test. Thus, the output of the psychometric analysis is used to study Neuroticism that interprets the criminal potential of the person based on the PEN model.Three major personality traits in this model are Neuroticism, Psychoticism and Extraversion. [1]

Psychoticism is connected with the accountability to have a psychotic abnormality along with aggression. As defined by Eysenck, a person who has psychoticism is prone to take risks, impulsiveness or anti-social behaviour.   Extraversion is one of the basic personality traits. a person who scores high on an extraversion scale is predicted to be an outgoing person and a person with low extraversion is more comfortable working with himself and less outgoing. Neuroticism is a personality trait that includes anxious and nervous behaviour and a frequent feeling of fear or worry.

The capacity to perceive feelings can be profitable in face acknowledgement applications also. Psychometrics and Emotion together can be used in rehabilitation and mental health center for effective treatment.

II. LITERATURE SURVEY

Due to increasing rates of crimes caused by mental instability, the need of the hour is an effective mental health monitoring system that would efficiently detect and monitor the criminal potential in a person. There are several works being developed to improve the same.

In paper [2], we evaluate and examine on how the neuro enhancements of self-control can possibly increase the capacity responsibility of the convicts' to check if the special features of the inmates create a difference in the results of the analysis. As increasing self-control by neuro interventions appear feasible, then we ask whether could be a justified measure in court rulings. We deduce that, if there are any occurrences in which neuro intercessions were justified in the conditions of the stated objective of the criminal court, i.e.,

The key element of many decision support systems is the knowledge base. In this paper, we discuss the implemented knowledge base in Copernicus system - a tool for computer-assisted diagnosis of mental disorders rooted on data received from psychometric tests, coming from the Minnesota Multiphasic Personality Inventory (MMPI) test. This tool utilizes a diverse amount of classification methods for differential inter-profile diagnosis. Thus, the knowledge base incorporated in this is of a different character. [3]

Evaluation of neurocognitive functioning is a reproving work in clinical settings. In most disorders, behavioural symptoms' onset is preceded by the cognitive impairment, and a major factor contributing to functional disability would be cognitive decline. The motive of the current study was to assess the executive functions by comparing the evaluated results obtained using a neuropsychological battery with the one obtained using the virtual reality version of the Multiple Errands Test (V-MET). The study population included three groups: 10 patients affected by Obsessive Compulsive Disorder (OCD); 10 Schizophrenic patients; 10 healthy Controls. The results identify executive problems in clinical samples. [4]

In this paper, we present a hybrid model to monitor the emotions effectively by detecting the emotional patterns that might occur if there are any psychological abnormality, with regard to three main factors additional to their emotions , that would be their IQ level , Psychology level and personality type. The final added advantage would be an accurate percentage of the criminal behaviour that could be exhibited by the individual.

III. PROPOSED SYSTEM

Mental Illness has a profound impact on people's functioning, health and quality of life. Detecting early warnings of depression or any other mental illness is challenging. The proposed system aims at analyzing the emotional behavior of the human being by monitoring the facial expressions using the camera. It pulls real-time data from the input detected to identify the emotion of the person. The emotions are continuously monitored based on which the information for the classification of mental illness of the person is obtained. Thus, data mining is done dynamically in the proposed system. Further, using the information obtained, it conducts a psychology test to diagnose the severity of the mental condition. It combines these outputs with a psychometric study which consists of an IQ test and a Personality test. The output from a combination of three parameters is classified to determine the probabilities of criminal potential a person can hold.

Advantages of Proposed System

Data is mined from the biometric that provides accuracy.

The data mining is performed dynamically which reduces the storage requirements.

Performing data analytics python libraries makes the application more time efficient.

Can be used to determine the mood of physically challenged & mentally challenged people.

The project gives the future prediction of criminal capabilities in a person.

The use of psychometric study gives an accurate analysis of different psychological behaviour.
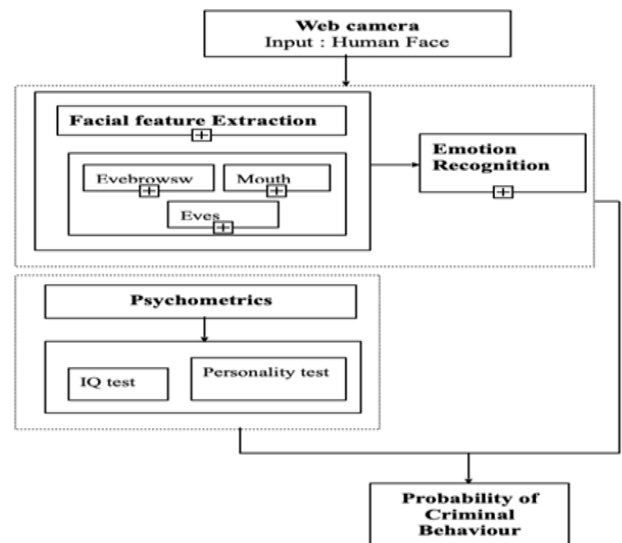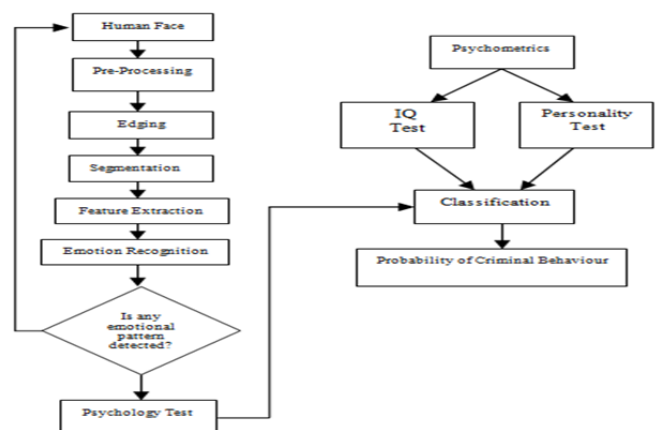

Fig 1. Architecture Diagram

Fig 2. System Design

IV. FACIAL EMOTION RECOGNITION

1) Face Recognition

The input image to the system can be captured using a webcam or can be acquired from the hard disk. This image undergoes image improvement, where tone mapping is applied to images with low contrast to restore the original contrast of the image.

2) Binarization

All RGB and grey scale images are converted into a

binary image. This preprocessed image is loaded into the face detection module. Figure 2 shows the image before and after binarization.

Fig 3.Binarization

Fig 4. Segmentation

3) Segmentation

A bounding box is formed over every feature of the face that contributes to an emotion. Each bounding box is derived using face coordinates. These boxes are thus segmented and studied further to derive an emotion. Figure 3 shows the bounding box formed around the features of the face.

4) Feature extraction

The face detected in the window frame forms the input needed for feature extraction stage. In order to obtain accurate real time values under reduced time complexity, only eyes and mouth are considered. These two features are combined to convey emotions accurately. Figure 5 shows the different facial expressions and Figure 6 shows the confusion matrix that is used for predicting the emotions.

Finally, a corner purpose detection algorithmic rule

is employed to get the desired corner points from the feature regions.

EMOTIONS DERIVED	FACIAL FEATURES
ANGER	• wrinkled and staring eyes • Gnashing teeth and lips tightened • Eyebrows shrunk
FEAR	• Inner brow raised up • outer brow projecting down • Mouth open and jaw dropped
SAD	• Eyebrow edges slightly pulled down • Shrunk or closed eyes • Lips and mouth projecting downwards
DISGUST	• Eyebrows downwards with shrunk or closed eyes • Lips wrinkled and pulled down
SURPRISE	• Wide opened eyes • Eyebrows completely raised up • Mouth open and jaw drop
HAPPY	• Wide opened eyes with wrinkled edges • Mouth open and expanded upwards • Cheeks slightly raised

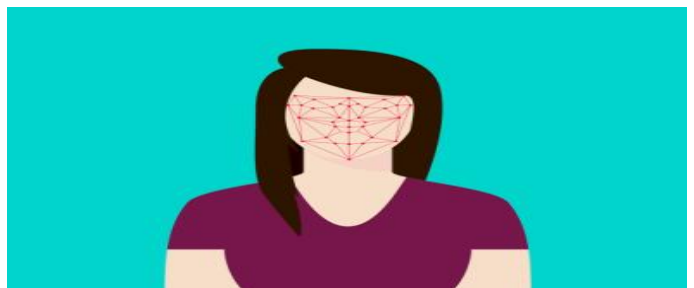**Table 1. Classification of Emotions**

Fig 5. Feature extraction

5) Emotion Recognition

An emotion matrix is constructed with discrete set of values. The rows and columns represent the extent of each motion in the person. These values set a range that determines the permutations of different emotions.
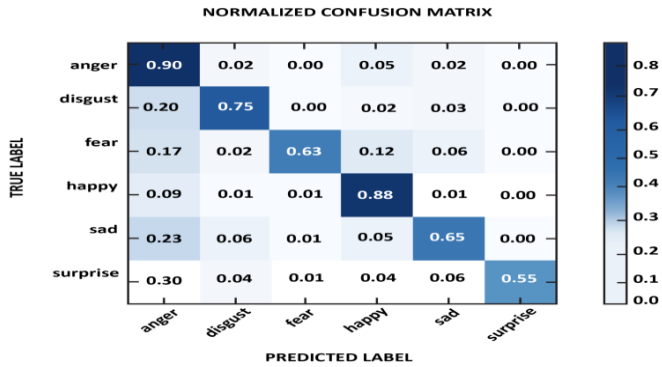

Fig 6. Emotion recognition[6]

NORMALIZED CONFUSION MATRIX

Fig 7. Confusion matrix [7]

Convolutional neural network (CNN):

CNNs[8][9] is developed with depths variably for the evaluation of performance by these model's facial expression recognition. One of the representative network structures is the in-depth learning is the Convolution neural network and has become a hotspot in the field of speech analysis and image recognition. ConVnets process the data of the form of multiple arrays. The input of the CNN would be a raw image, to avoid the feature extraction and data reconstruction procedure in the standard learning algorithms. Its weight sharing structure of the network makes it similar to the biological neural network, reduces the complexity of the network model and reduces the number of weights. Convolution Neural Networks are invariant to various forms of deformation like translational, scale, tilt. The important idea frame of convolution neural is the local area perception; CNN architecture mainly comprises of three layers viz., Pooling Layers, Convolutional Layers and Fully Connected Layers. The output of the convolutional layer is given to pooling layer and so on[10]. The convolution layer extracts the features and then combines to form a more abstract feature, finally, forming the description of the image object characteristics.

V. ALGORITHM

Phase I : Conventional Phase

All weights and biases of the CNN are initialized to a small value.Learning rate Ω is set   such that

$0<\Omega<1$. When m is in the interval 1 to M , the pattern xm is propogated through the network . While k is the interval of 1 to the number of neurons in the output layer , the error is found. For layers L-1 to 1 and for maps J = 1 to J , the error factor to be propagated is found. Whereas in the loop , i= 1 to L and j=1 to J , Δw is found for all the weights of the map and updates respectively in weights and biases.

W(new)= w(old)+ Δw

Mean square error (MSEI) is evaluated until MSEI $<\varepsilon$ or

n > maximum bounds.

Phase II. Transfer Knowledge phase

When tk is from 1 to TK (number of training samples), the pattern xtk is propagated through the network . In the loop , z= 1 to the number of neurons in the last convolutional layer (Z) ,the output of Oz of last layer of the convolutional layer is found.

$$Oz = (O1,O2,O3,……………….....Oz)$$

The Oztk if evaluated using TSL framework .

Phase III   Update learning phase for transfer learning phase

When tk is in the interval 1 to TK, the feed forward layers (Layers after last convolutional layer) are being trained using Oztk available in Phase II .

Now , MSE2 is calculated , until MSEI $<\varepsilon$ and n>maximum bounds
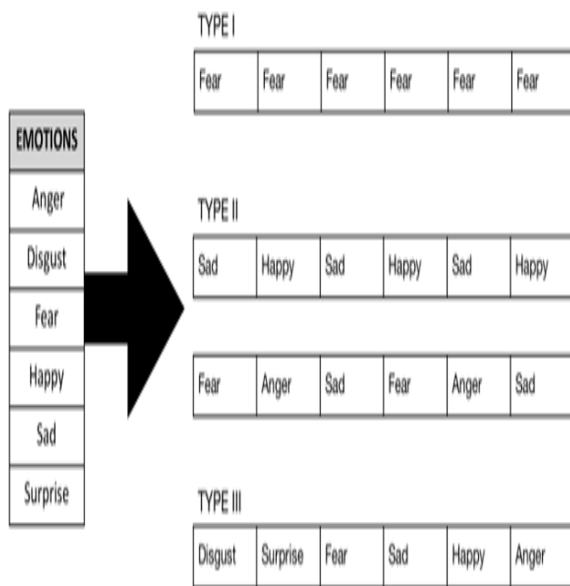
6) Mental State Detection

Fig 8. Types of Emotion Patterns

The emotions recognized are stored in a data frame and monitored over a period of time. Depending on the persistence and repetition of the emotions, mental state of the person is detected. Further a psychology test is taken up to evaluate the severity of the clinical condition. Figure 7 shows the types of emotion patterns that can predict psychological abnormality.

B. Evaluation of Psychometrics

The term psychometrics refers to the look and interpretation of tests that evaluate psychological values like-ability, temperament, memory, happiness and intelligence. These tests are designed for and given in mental state, education and employment settings.

In this project, we measure the IQ value and the personality traits of the person. Hans Eysenck's personality test is used to measure personality based on three dimensions psychoticism, extraversion and neuroticism (PEN)

IQ TEST	
Result	**Inference**
High/Normal	Less prone to Criminal Behaviour
Low	More to Criminal Behaviour

Table 2. IQ test results & inference.

Table 3.PEN test results & inference.

PEN PERSONALITY TEST			
Result		**Inference**	
Extraversion	High	impulsive and sociable, dis-inhibition	More prone to criminal behaviour
	Low	introvert, shy, quite	Less prone to criminal behaviour
Neuroticism	High	unstable, unpredictable, aversive	More prone to criminal behaviour
	Low	stable, tolerant, calm	Less prone to criminal behaviour
Psychoticism	High	creative, aggressive, lack a sense of empathy	More prone to criminal behaviour
	Low	unselfish, warm, empathic, and altruistic	Less prone to criminal behaviour

C. Classification of Criminal Behaviour

The last module of this mental health monitoring system is the classification of criminal potential in a person. This is done by combining the estimated outcomes of the above three tests- psychological test and the psychometrics (IQ & Personality Test). A mean value is predicted from the results of all the tests. This mean value is the final output of the system that determines the degree of criminal potential pertaining in the person.

VI.   EXPERIMENTAL RESULTS

A. Emotion Recognition

According to the observations made Convolutional Neural Network (CNN) Algorithm is found to be most suitable for making accurate predictions in face recognition. We compared three different face recognition algorithms, namely K Nearest Neighbor (KNN), Naive Bayes and SVM with CNN using 20 images for calculating accuracy.

Table 4.Outputs corresponding to the different accuracy scores.

Algorithm	No. Of Images	Accurate Answers	% Accuracy
CNN	20	16	0.9733
KNN	20	7	0.46
Naive Bayes	20	9	0.49
SVM	20	13	0.6878

B. Psychometrics

Psychometrics has been widely used to understand the psychological factors of the human being. The PEN test has been proved to show effective results for criminal behaviour compared to Five Factor Model & HEXACO Model. IQ test also helps in determining the factors affecting criminal behaviour. Low IQ level human are prone to criminal activities as they have low self-esteem and therefore have higher frustration levels. High levels of neuroticism and extraversion implies that they have low cortical arousal and seek out to do risky activities.

In Fig 9, we show a Sample IQ test where along with few more questions, we evaluate the IQ score to infer the amount the amount of criminal behaviour.

Fig 9. Sample IQ Test

In Fig 10, we show the IQ results for the previously taken Sample IQ test. Here the results indicate the IQ score and their levels, which are decided with respect to their age and gender.

Fig 10. Results of the Sample IQ Test

Fig 11 shows the personality test taken up based on PEN theory. It has sample questions that evaluate the percentage of each of the three characteristics in the person.

Fig 11. Sample PEN Test

In Fig. 12, we show the results of PEN Personality test for the sample test taken in the above example. The results indicate the level each personality characteristic such as extroversion, neuroticism and psychoticism.
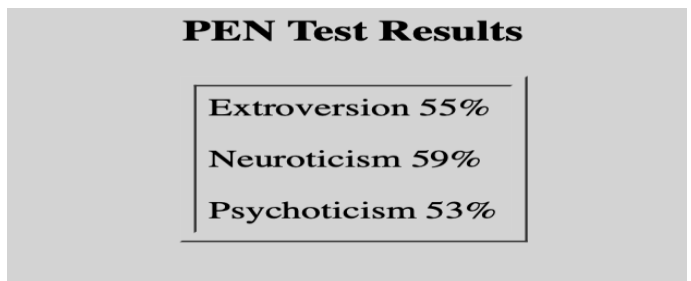
Fig 12. Results of Sample PEN Test

VII. CONCLUSION

Thus in the proposed paper, the basic emotions of a human brain are detected accurately. This is done under a process of eight modules. Based on the persistent observation of emotions, the mental state

of the person is interpreted. Further, this paper fixes the severity of the mental state of the person using a psychology test. The paper proposes a psychometric study that includes an IQ and a personality test. The purpose of the personality test is to categorize the severity of the mental state of the person as psychoticism, neuroticism and extraversion based on PEN THEORY. Hence considering the results of psychology and psychometrics the probability and the kind of criminal potential in the person is interpreted as self-destructive or harmful to the society

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