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Driver Emotional Status Recognition Using Fuzzy Logic in ADAS: An Indian Perspective

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Abstract--- In the recent years there is a lot of increase in purchasing power of the people towards two and four wheelers which resulted in uncontrolled traffic and number of accidents, due to this driving became very dangerous task inoureverydaylives. Government has taken some steps to develop road infrastructure. Developing the road infrastructure is not only sufficient to reduce the number of accidents. Statistics show that over the past couple of decades the majority of the accidents are not only due to the bad road conditions and poor vehicle technical conditions, but also due to the driver's inattentiveness. The major cause for the inattentiveness includes aspects such as drowsiness (sleepy), fatigue (lack of energy) and emotions (for example sad, angry, joy, pleasure, despair and irritation).As we cannot rectify the human error we opt for advancements in Driver Assistance Systems. These methods strive to provide assistance to the driver and play key role in reducing number of accidents. Advanced Driver Assistance Systems (ADAS) also improve transportation safety and to enhance productivity through the use of advanced technologies. The goal of this project is to apply soft computing methods like cellular neural networks , support vector machines and fuzzy logic for the image processing applications and further how that can be useful in detecting the driver's inattentiveness.

Keywords--- ADAS, Fuzzy logic, Feature extraction, Feature classification, Support vector machine.

I. INTRODUCTION AND RELATED WORK

Driving is a dangerous task. In our day to day life most of the people lost their life and having many injuries due to road accidents. There are several reasons for road accidents like bad road conditions, poor technical condition of a vehicle etc. Literature studies say Driver inattentiveness is the main reason for most of the accidents.

India has sharp rise in the sales of vehicles, unfortunately there is also hike in the road accidents. World Health Organization in its report on "Decade of Action for Road Safety 2011-2020" declared that around 1,05,000 die every year in road mishaps. There is a alarming increase in accidental deaths on Indian roads[1] In India traffic on rural highways are heterogeneous and includes fast moving vehicles like cars, buses, trucks, scooters and slow moving traffic members like bicycle, cart, cattle, and pedestrians. Around 1, 34000 persons were killed in India in 2010[2].The reasons for this are rash driving, driving by consuming alcohol & driving with fatigue.

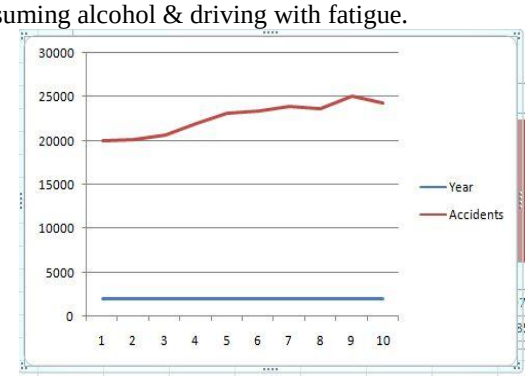


Figure1. Number of accidents per year

Figure1 shows the number of major road accidents per year Indian. Blue line indicates year and brown line indicates accidents

The U.S. National Highway Traffic Safety Administration (NHTSA) estimates that between 2 and 23% of all vehicle crashes can be attributed to driver fatigue. Every year, around 100,000 traffic accidents and 71,000 injuries related to driver drowsiness are reported in the United States, out of which more than 1,300 are fatal [3]. In fact fatigue is the number one cause of heavy-truck crashes. For these reasons, over the past ten years there has been an increased interest in techniques, procedures and technologies for monitoring or reducing driver fatigue. The development of these technologies has taken place primarily in the USA, with Europe, Australia and Asia tending to lag behind [4].

Accidents, tragically, are not often due to ignorance, but are due to carelessness, thoughtlessness and over confidence [5]. One of the major reasons for traffic accidents is the driver's lack of attention due to fatigue or sleepiness. On the one hand the class of systems will aid the driver's detection and assessment of road and traffic hazards, On the other they will provide guidance on the driver's ability to deal with specific hazards [6] ADAS has considerable history. ADASs are safety-critical systems that require a high level of dependability, a term covering reliability, safety, and fault-tolerance. Hazard and risk analyses are therefore performed to identify the safety requirements, usually in terms of the rate of false alarms and missed detections [7]. Ying et al. [8] applied a back-propagation NN to identify the mouth and eye states, which is a basis for recognizing the driver's level of Fatigue. Deriving an effective facial representation from original face images is a vital step for successful facial expression recognition. There are two common approaches to extract facial features: geometric feature-based methods and appearance-based methods [9].

Facial representation based on Local Binary Pattern (LBP) features for person-independent facial expression recognition Examine different machine learning methods, including template matching, Support Vector Machine (SVM), Linear Discriminant Analysis (LDA) and the linear programming technique, to perform facial expression recognition using LBP features. The Local Binary Patterns is a nonparametric and computationally simple descriptor which describes the local spatial structure of an image and recently LBP is introduced into facial image analysis research such face recognition and facial expression recognition [10].Obviously low-resolution images in real world environments make real-life expression recognition much more difficult. Recently Tian et al. [11] made a first attempt to recognize facial expressions at low resolutions. The most important property of LBP features is their tolerance against illumination changes and their computational simplicity. In recent years, LBP has been successfully applied as a local feature extraction method in facial expression recognition [12]. Facial image analysis is an active research topic in computer vision, with a wide range of important applications, e.g., image retrieval, wide baseline matching, object recognition, texture recognition, and robot localization [13].

The KNN algorithm is simple but computationally intensive. When the size of train data set and test data set are both very large, the execution time may be the bottleneck of the application [14]. The k-NN algorithm can also be adapted for regression that is for estimating continuous variables. One such algorithm uses a weighted average of the k-nearest neighbours, weighted by the inverse of their distance Classification of objects is an important area of research and of practical applications in a variety of fields including pattern recognition and artificial intelligence, statistics, cognitive psychology, vision analysis and medicine [15].

The principles of SVM have been developed by Vapnik[16] and they are well founded in the statistical theory. number of vectors divided into two groups, and we must find the optimal decision frontier to separate the sets. The frontier chosen may be anyone that divides the sets but only one of them is the optimal election. The optimal election will be the one that maximizes the distance of the frontier to the two dimensional case where the frontier is a line, in a multidimensional space the frontier will be a hyper plane [17]. Support vector machines are a core machine learning technology. They have strong theoretical foundations and excellent empirical successes [18]. They have been applied to tasks such as handwritten digit recognition, object recognition, and text classification.

Fuzzy Rule-based expert systems have played an important role in modern intelligent systems and their applications in strategic goal setting, planning, design, scheduling, fault monitoring, diagnosis and so on[19].New challenges, both regarding automated learning of knowledge bases involving these rules and potential new fields of application in a number of areas, are also described[20].

The rest of the paper is organised as fallows section II describes emotional data base, in III proposed method and finally IVdescribes experimental results and observations.

II. EMOTIONAL DATABASE

Table1. Description of Emotion database for Indian faces

PROPERTIES	DESCRIPTION
Name	Emotion Database
Source	Student pictures in V. R. Siddhartha college
Number of classes	3
Expression type	Fatigue, Partial Fatigue, Non fatigue.
Total Images	150

Figure2. Sample images from database with different expressions

Generally input images are a set of databases. To apply facial expression recognition, we have introduced VR.Siddhartha Engineering college Face data base. It is build by capturing student images in our college. Expression types considered are Fatigue, Partial Fatigue, Non Fatigue. The complete description of data base is shown in table 1.
All types of expressions like Fatigue, Partial Fatigue, Non Fatigue sample images data base is shown in figure 2.

III. PROPOSED METHOD

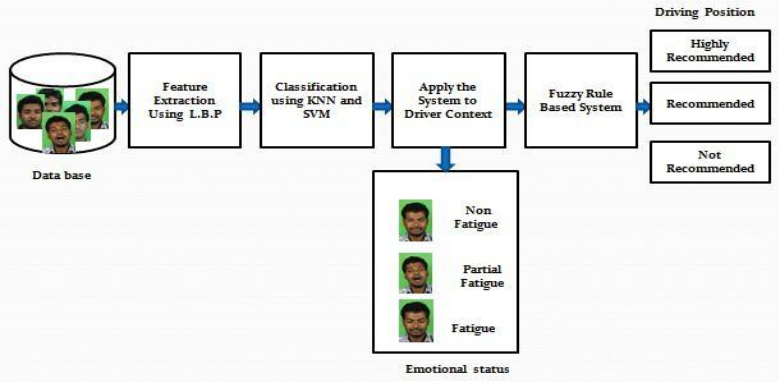


Figure3. Flow chart of the proposed system for fatigue detection

3.1 Local binary patters

Local binary patterns (LBP) are a type of feature used for classification in computer vision. Creation of feature vector is important thing. To create feature vector, the fallowing steps have to be done.

- Divide the examined window into cells (e.g. 16x16 pixels for each cell).
- For each pixel in a cell, compare the pixel to each of its 8 neighbours (on its left-top, left-middle, left-bottom, right-top, etc.). Follow the pixels along a circle, i.e. clockwise or counter-clockwise, which is shown in figure 4.
- Where the centre pixel's value is greater than the neighbour's value, write "1". Otherwise, write "0". This gives an 8-digit binary number (which is usually converted to decimal for convenience).The binary number is 11010011, having decimal value 211 which is shown in figure 4. The corresponding decimal value of the generated binary number is then used for labelling the given pixel. The derived binary numbers are referred to be the LBPs or LBP codes. Here LBP code is 211.
- Compute the histogram, over the cell, of the frequency of each "number" occurring (i.e., each combination of which pixels are smaller and which are greater than the centre).
- Optionally normalize the histogram.
- Concatenate (normalized) histograms of all cells. This gives the feature vector for the window.

The feature vector can now be processed using the support vector machine or some other machine-learning algorithm to classify images

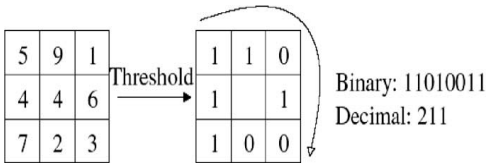


Figure4: Example of the basic LBP operator.

3.2 K-nearest neighbors algorithm

In pattern recognition, the k-nearest neighbour algorithm (k-NN) is a non-parametric method for classifying objects based on closest training examples in the feature space.

K-NN is a type of instance-based learning, or lazy learning where the function is only approximated locally and all computation is deferred until classification. The k-nearest neighbour algorithm is amongst the simplest of all machine learning algorithms: an object is classified by a majority vote of its neighbours, with the object being assigned to the class most common amongst its k nearest neighbours (k is a positive integer, typically small). If k = 1, then the object is simply assigned to the class of that single nearest neighbour.

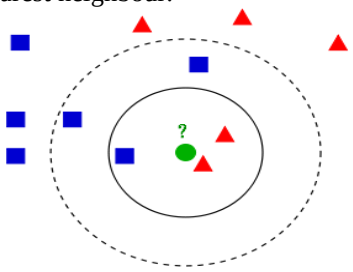


Figure5: Example of k-NN classification

The test sample (green circle) should be classified either to the first class of blue squares or to the second class of red triangles. If k = 3 (solid line circle) it is assigned to the second class because there are 2 triangles and only 1 square inside the inner circle. If k = 5 (dashed line circle) it is assigned to the first class (3 squares vs. 2 triangles inside the outer circle).

3.3 Support vector machine

There are several ways to classify, Bayesian decision, neural networks or support vector machines, for example. In this work the SVM classifier is the best option to be chosen since the number of training examples is required to be little. The SVM tool gives us a simple way to obtain good classification results with a reduced knowledge of the problem.

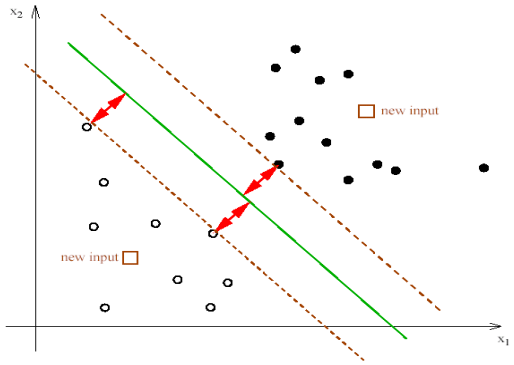


Figure6: Support vector machine

The main concept is Maximize the minimum distanceThe goal of SVM modeling is to find the optimal hyper plane that separates clusters of vector in such a way that cases with one category of the target variable are on one side of the plane and cases with the other category are on the other side of the plane. The vectors near the hyper plane are the support vectors. The figure below presents an overview of the SVM process.

3.4 Fuzzy rules

Fuzzy logic has two different meanings. In a narrow sense, fuzzy logic is a logical system, which is an extension of multi valued logic. However, in a wider sense fuzzy logic (FL) is almost synonymous with the theory of fuzzy sets, a theory which relates to classes of objects with un sharp boundaries in which membership is a matter of degree. Fuzzy logic is the codification of common sense — use common sense when you implement it and you will probably make the right decision.

A fuzzy rule is defined as a conditional statement in the form:

IF x is A THEN y is B

Where x and y are linguistic variables; A and B are linguistic values determined by fuzzy sets on the universe of discourse X and Y, respectively.

Consider an example age then, linguistic variables are young, old, very old. Similarly another example height short, medium and tall are the linguistic variables.

A membership function (MF) is a curve that defines how each point in the input space is mapped to a membership value (or degree of membership) between 0 and 1. Membership functions are μyoung,μold. In our project fatigue, frame, driving time are the linguistic variables.

Fatigue is determined by the two factors, frame factor and time factor. Rules based up on frame factors,1) If frame is normal then fatigue is less. 2) If frame is partial fatigue then fatigue is average.3) If frame is fatigue then fatigue is high. Rules based up on time factors,1) If driving time is minimum then the fatigue is less.2) If driving time is more then the fatigue is high.

If we combined both the above rules we can get the rules.

- If frame is normal or driving time is minimum then fatigue is less.
- If frame is partial fatigue, then fatigue is average.
- If frame is fatigue or driving time is more than fatigue is high.

IV. EXPERIMENTAL RESULTS & DISCUSSIONS

Table2.Accuracy (%) of emotion recognition process using LBP over SRC and KNN as a base line results

Feature extraction	Classifier	Accuracy
LBP	SRC	60.00
LBP	KNN	74.00

Table 2 showes the accuracy results of SRC and KNN classifier.for feature extraction LBP is used for classification SRC and KNN are used ,by using KNN we can get more accuracy.

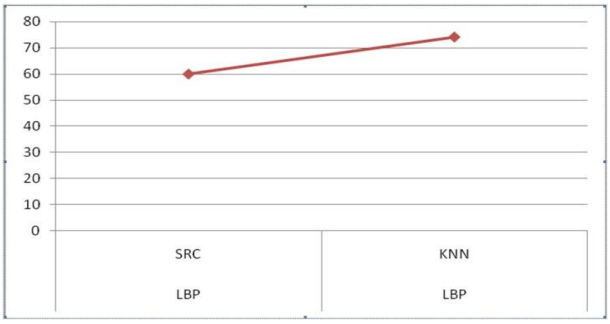


Figure7: Graph for SRC and KNN

Figure 7 shows the results of local binary patterns when consider with the combination of sparse representation classifier (SRC) and k-nearest neighbours (KNN) algorithm.

Table3. deals with three types of kernels like Linear, Quadratic and RBF in SVM. Accuracy (%) along with LBP tabulated here.

Classifier	Kernel type	Accuracy
SVM	Linear	78.54
SVM	Quadratic	81.00
SVM	RBF	90.00

In table 3 classifier SVM is used, here kernels types are linear, quadratic and RBF.By using RBF kernel we can get more accuracy.

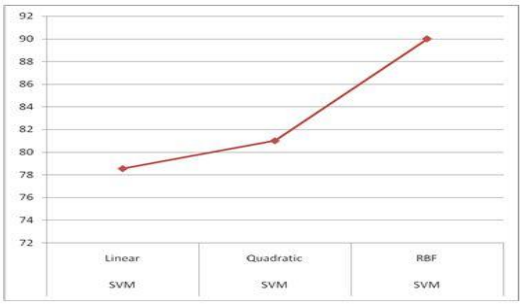
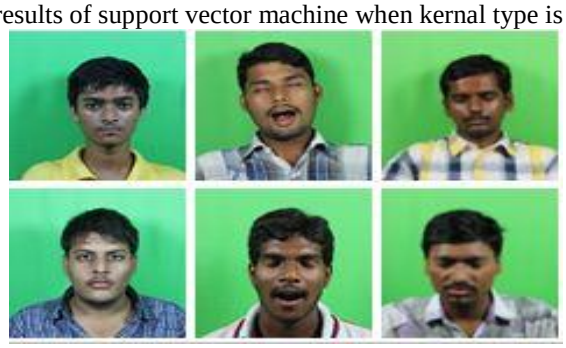


Figure8: Graph for Linear, Quadratic and RBF kernels.

Figure 8 shows the graph results of support vector machine when kernal type is Linear,Quadratic and RBF



a. Non Fatigue b. Partial Fatigue c. Fatigue

Figure9: Expression recognition result that shows the images which are correctly recognized.

a. Fatigue b. Partial Fatigue c. Non Fatigue

Figure10: Expression recognition result that shows the images which are wrongly recognized.

This Paper is said to be success if it reaches up to 90% accurate results, The right results are shown in figure 9. Similarly, it is impossible that no system can give 100% accuracy results some of the time the results which are obtained may be wrong, this wrong results are shown in figure 10.

a.video1. b.video2.

Figure11. Frames of videos

Figure 11 shows the video frames having different expressions, like Normal, Partial Fatigue and Fatigue.
Here we captured two driver videos and extracted the frames at different interval of time with different expressions which are shown in (a)video of one driver (b)video of another driver.

V. CONCLUSION AND FUTURE WORK

The goal of this project is to apply soft computing methods like cellular neural networks, support vector machine and fuzzy logic for the image processing applications and further how that can be useful in detecting the driver's inattentiveness.

In present days advanced driver assistance system is an active research area. Many R&D projects are developing different ADAS In this project we apply local binary patterns and combination of KNN and SVM then finally fuzzy logic is applied for verification of fatigue range. Experiments show that the accuracy of the proposed method for extracting the symptoms of driver fatigue is good

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