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# IOT based Smart Mirror

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**ABSTRACT:** Our manner of living has made progress to an extent that management of time is the most crucial. But this busy habitual lifestyle incorporates spending a great deal of time in front of a mirror for our daily appearances. Hence, restraining us from our basic minimal activities such as, reading newspaper and weather updates. This issue can be settled by launching of a smart device in a house which assists one to do more in minimal time. We have examined the various possibilities and features that a smart mirror can offer and have represented our outcomes. In this paper, the Haar-cascade and Local Binary Patterns Histogram were examined. The role played by the Facial landmark for the Emotion Recognition was reviewed. The various outcomes and importance of the aforementioned topics were assessed. The system will provide the user with primary benefits such as presentation of weather data, time, date, news feed updates and notifications being fed to the device from the web. Additionally, the device also inculcates a recognition and greeting feature of a user. It also integrates further functionality, like an awareness and security service by mobile contemporizing. Our framework also analyses the Voice Assistance and its implementation in control system in the home appliances. Furthermore, the device also employs the Emotional Recognition feature, which aids to elevate a person's mood based on the emotion detected by the user interface.

**KEY WORDS:** Haar classifiers, Facial Recognition, LPBH, Emotional Recognition.

## I. INTRODUCTION

*"As the Internet of things advances, the very notion of a clear dividing line between reality and virtual reality becomes blurred, sometimes in creative ways." – Geoff Mulgan*

Internet of things is procuring significance is every aspect of the digital world. The progression of this field has reached to the connectivity of every object and machines surrounding us. It has bridged the gap by connecting the unconnected. Smart devices are the pragmatic objects of our lifestyle. Betterment of liveliness, flexibility in usage, increased energy efficiency and upgraded appliance functionality are the pivotal roles performed by these devices.

Internet of Things (IoT) is a technology development in which the devices will authorize us to sense and control the physical world by constructing smarter objects and associating them over an intelligent network [1].The best known advantage of IoT is that it can help to ease the everyday routine. Hence, comes a proposed system called Smart Mirror. This system authorizes users to access information and also manages the lights in the house. We can trace the relevant information such as time, date, warning, weather and location map and traffic. Hence, giving a concept of smart mirror for smart home using Internet of Things [2].

Smart mirrors are a contemporary addition to the family of IoT products that has gained a lot of attention in recent years by each industrial makers and hobbyists. The proposed system is related with the implementation of a voice-controlled wall mirror, indicated to as "Smart Mirror" which uses Machine Learning for the home environment. This mirror displays the real time content as well [3].

This smart mirror can capture and keep tracks of user's faces, it analyses and logs their facial expressions and emotional states. The recommended smart mirror has four distinct modules. In the initial module it operates like a standard mirror. In the next module all the basic functionalities are displayed while behaving as a standard mirror. In the same module user can give voice command to use home automation feature. The third module detects the face from

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captured images, trains it, classifies the preprocessed images into respective name of the recognized person resulting in facial recognition[4].

The smart mirror makes use of the facial expression recognition technology, linked with emotion detection to establish a human-computer interaction system. The smart mirror system is made up of two facets, i.e., facial expression recognition and emotion detection. Facial recognition is done using Haar-Cascade and LBPH classifier and Emotion detection is done using facial landmark and CNN [5].

## II. RELATED WORK

This section will analyze the associated work that is relevant to our paper. The smart mirror is one such system which has been enhanced and revised over by innovation. The modern man's comforts are highly advanced and can be satisfied through such upgraded devices. Most of the researches are centered around the analysis of providing a sophisticated lifestyle by allowing the mirror to show basic functionalities. One such reference is provided wherein; a system permits the users to access the information and in addition allows the control of lights in the house. Primary display of information such as time, date and weather are displayed in the interface [2].
The system has been reformed to include three distinct parts, one of the being the facial recognition module. The technology adopts an image which matches the identity of the individuals through which the recognition occurs. The Automatic Speech Recognition is accomplished by applying the Google Cloud speech-to-text API. The CNN based object detection is prepared using the Margin Object Detection loss which is made use for the face detection[4]. The study could however focus on the enhancement of the speech recognition module.
However, the speech recognition has raised its specification by automating several tasks that generally require human interaction. This module is made efficient by increasing accuracy and will enhance the control over the devices in a more reformed and adequately.
Distinct spoken commands to turn on the lights and shut the door are implemented along with a speech activated music player.
The commands are provided at a convenient distance by the user[1]. The lack of providing the fundamental features in this system is a disadvantage.
Implementation of the speech and the facial recognition modules into a single system is the advancement found in this reference. Displaying of the real time contents such as time, date and weather also add up to the performance making it a convenient device for the usage. This scheme will employ a design wherein all the calculations will be performed by the raspberry pi. It is also necessary that the techniques exploited will not be irrelevantly high in computational expenses[3]. The limitation lies in the fact that a series of user experiments could have been concluded for evaluating the usability.
Another reference constitutes two modules related to the face image acquisition and the expression recognition. The expression recognition is the advanced venture through which the emotion of the user can be detected formed on the user interface. The images of the user are captured and pre-processed using the face detection based on which the emotions will be classified
A multiclass classifier ELM is utilized for emotion recognition. The images are processed by making use of the face detection and subdivision. The facial images are segmented into three parts namely, nose, eyes and mouth since these parts are the highlight features for facial emotion. The 2D Gabor filter is employed for withdrawing expressions of the face. Also, a uniform LBP operator is adopted[5]. The system however doesn't employ the deployment of standard features and a beneficial purpose of the expression classification.
An improved feature for security and vigilance is adopted in this reference which consists of an input module and intrusion detection module. The object detection is employed for the identifying of intrusion of human. The confirmation of the intrusion leads to the alert E-mail along with the captured image of the intruder to the owner [6]. Synchronizing of the input, intrusion, speech, emotional detection and basic features modules is lacking. Thus, limiting the capability of the system.

The combination of the various modules embedded into a single system is a visible challenge encountered by the various references. Most of the systems employed the basic functionalities of displaying information on the interface which later upgraded to either facial, emotional or speech recognition modules and infrequently integrating two of the mentioned modules.
However, our proposed system affirms to assimilate the mentioned modules collectively.

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## III. PROPOSED FRAMEWORK

### A. System Model

The system architecture is the conceptual model representing our system. It gives a brief description on the structure and relevant behavior of the various aspects of the model.

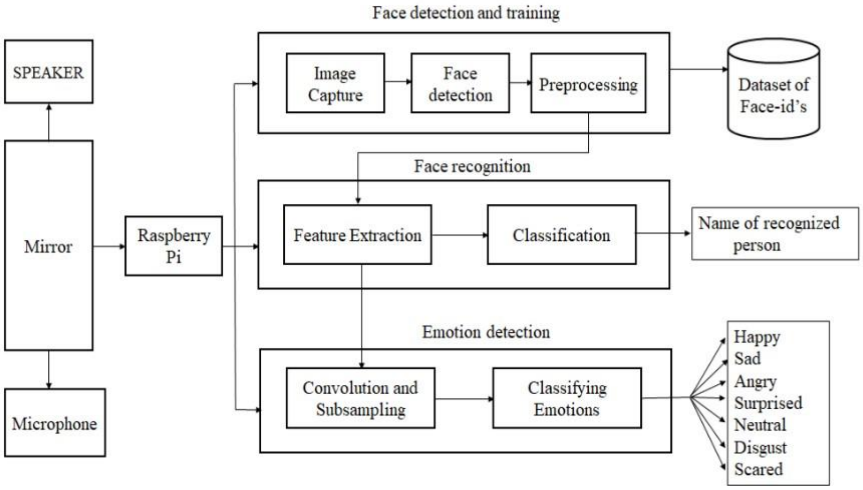


Fig. 1 System Architecture of the smart mirror

There are primarily four important hardware components:

1. Raspberry Pi: Raspberry Pi 3 has been employed for it operates as a mini computer. It performs all the assigned work that a desktop is presumed to do. It possesses a 64-bit quad core processor along with a 1.4 GHz processor.
2. Two-way mirror: It is reflective on one side while being transparent on the other side. Mostly, it is used as an output device acting as a user interface by displaying all the relevant output.
3. Microphone: Used as an input device, it is a transducer converting sound to an electrical signal.
4. Speaker: Device used as an output to play music to the user.

There are three software components:

1. Face detection and training: This unit identifies the face from the captured image and processes it.
2. Face Recognition: This component obtains the facial features from the pre-processed image and allocates it to the respective name of the identified person.
3. Emotion Detection: The emotions obtained are detected by the efficient use of facial landmark. Further, the CNN subsampling classifies the expression to the definitive emotion positioned on the probability computed.

## IV. SIGNIFICANCE OF THE SYSTEM

The paper primarily focuses on how the artificial intelligent techniques, various algorithms and libraries can be adapted in the field of facial and emotional recognition by training the suitable data. The review of each algorithm is conferred in section IV, and section V comprises the applicational areas of the study.

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## V.ALGORITHMS

### A. Haar-Cascade Classifier

Haar-Cascade is a machine learning algorithm that performs object detection which is used to recognize the objects in an image or video. In this approach a cascade function is trained from various positive and negative images. Later, it is used to identify the corresponding objects in other images.

The algorithm is recognized for its ability to detect faces as well as body parts in an image, but can also be trained to recognizealmost any object. Now, let's consider face detection for an example. At first, the algorithm requires a number of positive images having faces and negative images devoid of faces to train the classifier. Later, we need to derive features from it. Initial step is to obtain the Haar-Features that analyses adjacent rectangular regions at a certain location in a disclosure window, adds up the pixel intensities in each specific region and computes the difference of these sums.

Using of the Integral Images speeds up this process. Nevertheless, most of the images that are calculated will be largely irrelevant. This drawback feature can be made right by the usage of the Adaboost.Adaboost is one such concept that selects the significant features and improves the classifiers that utilize them as follows. Throughout the detection phase, a window of the required size is relocated over the input image, while calculating the Haar features. This obtained difference is now compared to an accomplished threshold which segregates non-objects from objects. Subsequently, the cascade classifier comprises various stages, wherein each stage is equipped with a technique called boosting. The present location of the sliding window is labelled to as positive or negative by the classifier. If the label is found to be positive then it implies that the object was found and vice versa. Further, the next stage is identified if the label is positive and the next region is detected if the label is found to be negative. For each stage to work effectively the cascade must contain a low and false negative rate. However, the Cascade classifier training demands a vast set comprising of positive and negative images for appropriate results.

### B .Local Binary Patter Histograms

Local Binary Pattern (LBP) being a fundamental operator is advocative in texture operation. It results in a binary number by labelling of the pixels of an image, thresholding the neighborhood of the same. Four decisive specifications are present.

Circular binary shapes are built utilizing the radius parameter which represents the radius about the cardinal pixel. This value is basically set to 1. To establish a circular local binary pattern a set of sample points is essential called Neighbors. More the number of sample points, larger will be the computational cost. Here, the corresponding value is set to 8. The next set of parameters considered are the Grid X and Grid Y, both set to the value 8. They represent the number of cells in either the horizontal or vertical direction. Correspondingly, the higher dimensionality is acquired through more cells and a finer grid in both the parameters.
Next section of the concept belongs to training of the algorithm. A dataset having facial images of the person to be recognized is taken into consideration. A unique id must be provided for every image of a particular person. Utilizing this information, an input image is recognized and gives the resulting output. It should be ensured that images must provide same ID for the same person. Following the training comes the computational steps of the algorithm, wherein we apply the LBP operation. Initial step of the computation holds that an intermediate image be created which is more reformed than the original image in facial characteristics. To obtain the desired result the algorithm utilizes a concept called sliding window, which depends on the radius and neighbors‟ specifications. The following image depicts the above strategy:

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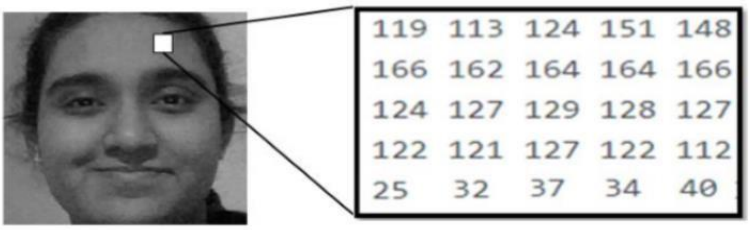


Fig 2. LBPH Operation

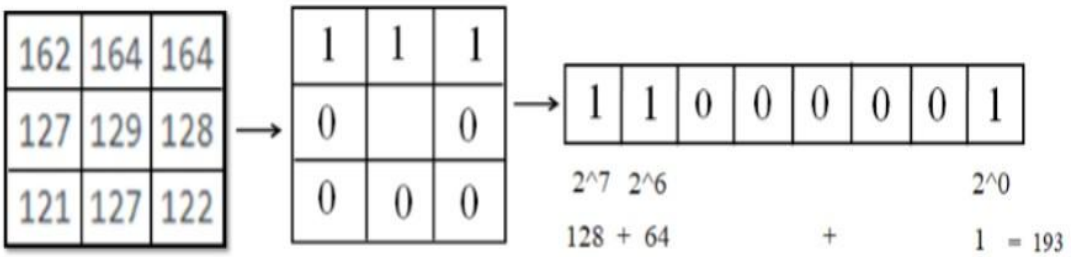


Fig 3. Taking the 8-bit binary neighborhood of the center pixel and converting it into a decimal representation

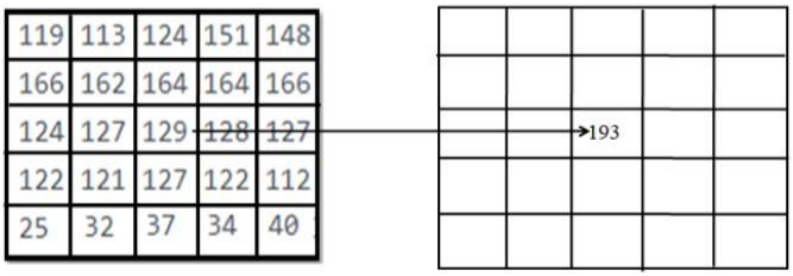


Fig 4: Input Image Fig 5: Output Image

Extracting of the histograms is the next crucial step in the algorithm. Using the parameters Grid X and Grid Y the image is divided into a series of grids. Depending on the images extracted, a histogram can be obtained. For every image in grayscale a histogram will consist of only 256 positions depicting the existence of every pixel intensity. Now integrating of each histogram is performed to obtain a better and new histogram. For instance, if a 10x10 grid is considered, then 25,600 positions are present in the final histogram which represents the functionalities of the actual image.

Final procedure involves performing the face recognition. An input image is taken and the above steps are conducted to form a histogram. Now, to gain the image which matches the input image a comparison of the two is taken and the resulting closest histogram is given as output. Here, we make use of the Euclidean distance formula for the computation:

$$D = \sqrt{\sum_{i=1}^{n}(hist1_i - hist2_i)^2}$$

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The ID of the image having the closest histogram is given as the output. The calculated distance obtained can be used for the "confidence" measurement. The algorithm can be considered as a successful one if the value of confidence is lower than the threshold being defined.

### C. Emotional Recognition using Facial landmark and CNN

The principal intention of this paper holds in classification of the facial expressions to the emotions that are demonstrated by a person. These expressions conceivably are the six fundamental emotions in addition to the neutral emotion. Following the above algorithms, the facial landmark detection and feature abstraction using CNN is performed.

The objective of the concept here is to obtain a Region of Interest (ROI) of the facial features for instance, the eyes. The feature point abstraction can then be applied relative to the eyes. The method employed for the deployment of the above concept uses an equation of a circle having a radius r with a center(a,b) called the Hough Transform. The regarding formula is given by: (x-a)2 +(y-b) 2=r 2.

The resulting ROI windows are procured from the detection windows for the facial features. These are then used to achieve the corner point features. Parameters such as the Euclidean distance calculated above, the corner points for the facial landmarks are taken into consideration. Now that the feature points are abstracted from the input images, the following step will be to determine the feature vectors that should be given to train the neural network. These feature input vectors will be deciding the classification of the final output emotion.

As we know, the MLP neural network comprises of an input layer, followed by two hidden layers and finally an output layer. Concerning the activation functions of the nodes, in an MLP network non-linear activation functions are made use. To conclude the activation function, it is mandatory to consider the objective and the result of the neural network. Hence, a Probability of Emotion (Yi) considering the input image x, where i holds values 0 to 6 relative to the 7 output emotions is given as P(Yi/x). Maximum of the probabilities of the 7 output emotions is taken to be the final emotional classified, which can be represented as max(P(Yi/x)). The final outcomes of the concept are represented in the form of a confusion matrix.

## VI. APPLICATION AREAS

### A. Additional Capability

The mirror has been acknowledged as a primary piece of furniture all through the years, while completely ignoring its effectiveness if it was used as a digitized system. The smart mirror is being reformed moderately to become an accepted device at various households. The system performs additional functionalities at our convenience. While displaying of multimedia data can be considered as the basic outcomes, it's also favorable for various aspects concerning information display.

### B. Personal Digital Assistant

Considering the hectic schedules of our lifestyles an automated digital assistant would provide much help and reliance for our activities. The elementary information essential for our everyday routine can be provided by this system. The device permits the user to contact and cooperate with various contextual information, including weather data and news feed at the user's disposal. This system merges seamlessly in the daily routine acting as a Personal Digital Assistant.

### C.Hospitality

Providing digital hospitality at various restaurants and public places by displaying its features. This leads to the comforts of the user and works as a highlighting feature of the device. Various services cannot be fulfilled manually at the user's comforts, this leads to the help of such automated devices. The accuracy of the results further enhances its necessity at providing sophisticated hospitality.

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### D.Smart Home Appliance

The device can be referred to as a Smart appliance considering the home automation mechanisms it provides. The mirror being a primitive device has found its usefulness by being part of the smart home concept. Supervising of the various devices of the house at the user's convenience has increased its exploitation. The devices can be managed from one convenient place inside the house, thus providing enormous flexibility in its usage.

### E. Digital Therapist

The major complication concerning numerous people of our society is the mental health. At times when help and comfort is needed the users can rely on the system for emotional comfort and assuage. The recognition of the emotions presented acts as the input for the device to gauge the mental state of the user and contribute appropriately. The critical performance displayed by the device involves in its ability to behave as a mood elevator. It enhances the emotional stability of the user by providing soothing and comforting messages.

## VII. RESULTS

### A. Facial Recognition

The results for the facial recognition are represented in the images below. The datasets provided in the image serve as the inputs for the classifier to rightly train the user's face with a unique ID. The trained image is recognized along with name of the person and a welcome greeting with appropriate voice messages. The unknown image of the person is labelled the same with suitable message.

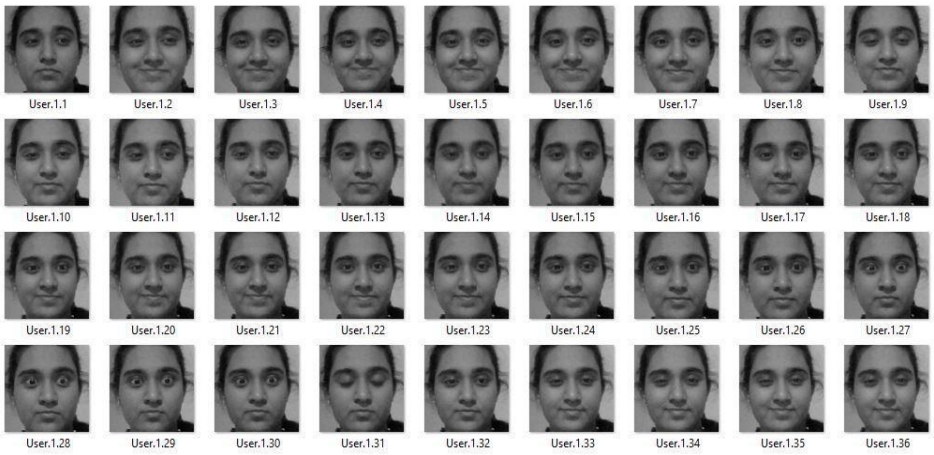


Fig 6. Datasets of captured images for a single person


Fig 7. Face Recognition of a known and an unknown person

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**B. Emotional classification**

The results for the Emotional classification post raining of the neural network are depicted below. The images are presented along with the confusion matrix. It was noticed that the emotions regarding happiness and surprise had a higher positive rate demonstrating that those emotions are more uniform.
Whereas the other facial expressions such as sad, disgust have a moderate positive rate because these kinds of emotions can overlay with other emotions.

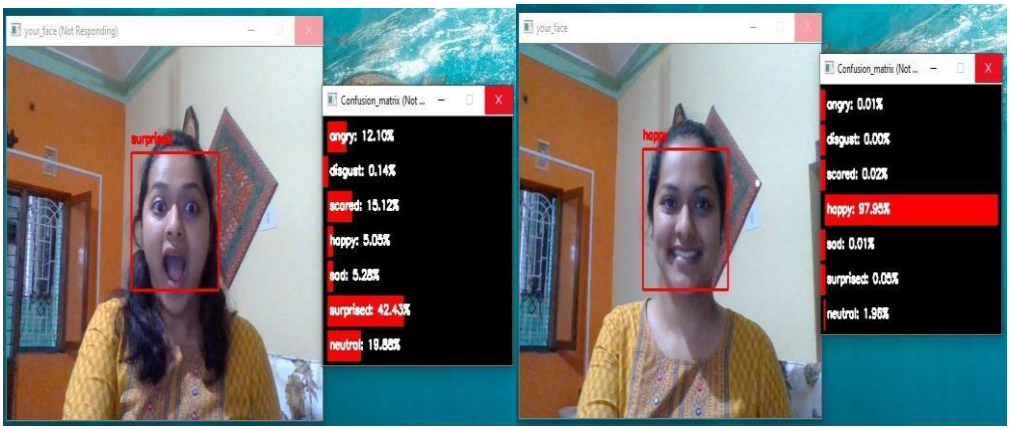


Fig 8. Emotion Classification for surprised and happy

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