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Conceptual Model for Proficient Automated Attendance System based on Face Recognition and Gender Classification using Haar-Cascade, LBPH Algorithm along with LDA Model

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Abstract

With the technically and digitally advancing era, a crucial role is played by the technology of face recognition, which is the process of detecting faces and verifying their identification by using image processing techniques in computer vision. Automation of attendance system using face recognition eliminates most of the drawbacks that the manual attendance systems pose, including wastage of productive class time, easy manipulation of attendance records, proxy-attendances, and insecure system. This paper proposes a sound and secure system for automation of attendance system by the integration of the face recognition technology by using Haar-cascade classifiers to detect faces and Linear Binary Pattern Histogram machine learning algorithm for face identification. The attendance is automatically updated in an attendance log in the attendance record database. The proposed system in this paper also tackles issues that arise in building face recognition system, some of which are information retrieval time, image properties such as size, quality and intensity settings, and orientations of faces, by using a sufficient and accurate training dataset, pre-processing techniques and Haar-cascade classifiers. Another issue with face recognition systems arises during recognition of two faces with similar features where the probability of occurrence of false result is relatively high. The problem is solved by the proposed system by integrating a gender classification module using Linear Discrimination Analysis (LDA) model, which outputs the gender of the students present in the classroom to enable verification of the result of the face recognition module. The proposed system of this paper has been made economic and portable by using Raspberry Pi 3, and also highly reliable aided by the gender classification module. The system provides technically and economically sound solutions for overcoming many challenges posed by manual attendance systems and face recognition technologies.

Keywords: Raspberry pi3, OpenCV, Pi camera, Haar-cascade, Viola-Jones, Linear Binary Pattern Histogram, Linear Discrimination Analysis

INTRODUCTION

Education is the main concern of our society and attendance is one of the major aspects of education system. Since the past few decades, the attendance system adopted by most classes involves teacher-student interaction where recording of attendance is done through pen and paper. Such manual attendance system leads to wastage of valuable teaching time as well as increases resource costing of the class, it also involves the overhead of marking and consolidation of attendance by teachers, and errors due to human fault and student transgression are also made. To overcome these drawbacks of the manual system, with the advancement of digital technology, biometric attendance systems have majorly

started finding use in classes since a few years now. Biometric systems scan physiological characteristics of the human body. The first biometric system for scanning finger print was done by Alvarez and Galton in 1982 for criminal identification. [1] Various physiological biometric systems that have found use in attendance systems are fingerprint matching, retina or eyeball matching, signature matching, hand geometry, and face identification of individual students. The biometric information of students is stored in a database to enable their identification during the attendance process. These systems require physical displacement of each and every student to individually go to the device that captures the intended physical features for attendance marking, which leads to disorder in class. This does save more time than the manual attendance systems and prevents errors such as human error and student transgression (proxy-attendance), which is a major advantage over manual systems; but still it consumes a reasonable amount of time in attendance recording. Moreover, due to the presence of human interfacing involved during the registration of biometric features, some other errors may be caused in biometric attendance systems such as incorrect placement of finger for multiple times on a fingerprint sensor, or unidentified eyeball by an eyeball detector due to blinking of eye or improper eye direction. Hence, the avoidance of all human interfacing during the process of attendance registering was necessary not just too efficiently conserve time and human effort, but also for maintaining a rigid attendance recording system for the purpose of strengthening the security system for the students and for enhanced accountability of staff. Negligence of attendance recording issues may lead to serious consequences wherein the staff members or the educational institute might have to face penalties or lawsuits. Therefore, to meet these challenges, automated attendance system with face recognition mechanism was developed.

An automated attendance system based on face recognition is a biometric system where typically, it registers the attendance of each and every student present in class by detecting and identifying all of their faces, and then this recorded information is ideally transmitted to a server device which may compute the attendance of each student and store and update the corresponding data in database. Automated attendance systems are more reliable, rigid and efficient than the traditional attendance systems and other biometric attendance systems, leading to better productivity and output of both the teachers and students, as well as better consumption of time. [2] The issues that may be involved in implementing an automated attendance system based on face recognition are how to detect faces of each and every student in class without any undue utilization of system and external resources, how to enhance the efficiency of the face recognition algorithms used in the system to extract accurate results and minimize the rate of failure, what methods are to be employed to ensure reliability of the attendance recording system, and which data retrieval mechanism is to be employed to enable error-free matching of the facial features. The techniques and mechanisms proposed by this paper deal with these issues with high accuracy and efficiency.

LITERATURE REVIEW

In the authors have proposed an automated attendance management System based On Face Recognition Algorithm which automatically detects the student when he make an entrance in the classroom and captures an image of the student(s) using a camera, and the system approaches to detect faces in the image by using the algorithm of Viola-Jones detection that uses multiple classifiers of Haar-cascade which uses AdaBoost learning algorithm. The extracted faces are subjected to Histogram Equalization to improve and enhance image quality in terms of intensity and contrast. Using the data of enrolled students initially recorded and stored in the database under various lighting conditions, the extraction of features is done by the Principal Component Analyser (PCA) which functions as a face detector, the result of which is outputted for face recognition carried out by the classifier algorithms- LDA (Linear Discriminant Analysis) & LBPH (Linear Binary Pattern Histogram)algorithms. Lastly the names of all the present students are announced using text to speech conversion. This technique is to be use in order to handle the threats like bluffing and human error. [3]

In this system, OpenCV library installed in raspberry pi is used for face identification. The camera captures a video frame of whole class, out of which any one frame is used in identification of the student whose attendance is intended to be marked. Face detection is performed using OpenCV library whose result is pre-processed using Histogram Equalization and further images of individual students taken initially to extract features of each student is pre-processed and updated in the database required for later pattern matching. The system require the feature of extractors combined with classifiers are compared in various real world scenarios such as lighting conditions, Unintentional facial feature changes , Expressions. The extraction is done using Principal Component Analyser (PCA) which uses a set of correlated variables to extract a smaller set of meaningful dimensions out of data which are high dimensional. PCA algorithm finally gives an output of faces recognized whose data is updated into a MySQL database. The authors of this paper have used LBPH algorithm which gives less false positive results even after capturing an image from a height of 4 feet to 7 feet for database of training sets. [4]

This system proposes to build an automated attendance system using face recognition based on image processing. It proceeds by initially creating a database of the facial features of all the enrolled students and storing the templates. Various sets of data are used in order to train the attendance system for pattern matching and recognition. The OpenCV linear binary face recognizer is trained for face recognition. Conduction of attendance takes place through a camera installed in the classroom in form of a still image captured of all students at once and further is used for face detection. By converting captured image to gray scale, it is processed using Haar classifier to detect the faces of each and every student in the image. Linear Binary Pattern Histogram (LBPH) algorithm is used for the comparison along with recognition of each student's face detected, using the trained dataset stored in the database. Finally, the attendance of all the students present is marked in the database. The authors have proposed to use Raspberry Pi for the processing of data. [5]

According to this, parallel examination of two algorithms i.e. Haar- Cascade & Kanade-Lucas-Tomasi is performed. System has captured the image of the entity while the entity is moving and the camera is placed as a surveillance camera. The captured image has been categorized as: a) facing in the front; b) left to the shoulder; c) right to the shoulder; d) up to the ground; and e) down to the ground. The first three categories were further divided into four subcategories - bright, very bright, dark and very dark. Haar-cascade detected 87% of the total outcome whereas Kanade-Lucas-Tomasi detected only 45%. It was observed that Haar-cascade was capable of successfully detecting faces that the Kanade-Lucas-Tomasi algorithm couldn't in five images over and above all the faces that Kanade-Lucas-Tomasi algorithm could detect in other images. So it is proved that the Haar-cascade algorithm work in every scenario. [6]

This paper has approached the attendance recording in four steps, image acquisition, preprocessing, detection and extraction, and matching. The preprocessed images are subjected to the algorithm for the face detection process. The detected faces are then cropped and stored in a folder later to be used for testing. The features are then extracted from the set of cropped faces and stored using Principal Component Analysis (PCA) for the set of training images. Training set contains individual face images of students taken with variations like with/without spectacles, these are used for comparison during face recognition phase. The limitation of this system is that it is not possible to identify faces having similar facial features. [7]

The part of the human face below the nose, the chin and mouth, contains structural information such as roughness or smoothness of skin, and amount of facial hair present on the skin, using which it can be determined whether the gender of the person is male or female. The system proposed by the authors of this paper uses this information to build a gender classification system which works by dividing the system into four steps.

1. The system uses a grayscale image and the first step of the system involves the extraction of the concerned face parts, i.e. chin and mouth using a model which is based on geometric approach where area containing the lower face parts is cropped below the nostril. Histogram approach is employed to detect the row of pixels below the nostril, and also to crop out the non-face pixels of the image vertically.
2. Next, for analyzing information about the texture of the skin GLCM, i.e. Gary Scale Level Co-occurrence Matrix is constructed
3. The GLCM is used to calculate features of dissimilarity of image, contrast in intensity of adjacent pixels in the image, and the feature of variance.
4. Finally, gender classification is done using these features using Support Vector Machine, i.e. SVM and Probabilistic Neural Network, i.e. PNN; both are standard classifiers that perform pattern matching or pattern classification using training data and vectors. [8]

The paper uses gender classification in an automated attendance system using the measure of facial distance. Initially an image of the frontal view of the face is captured and processed for various visual features by improvising the quality of the image. Color conversion is performed for better feature extraction, noise reduction is performed for better image quality, and detection of edge of the face is done to detect the facial area in the image. Extraction of facial features is performed on pre-processing result using mathematical operations with the use of Mat lab. Local features that are geometric based, are extracted using an algorithm that divides the image of the face into four parts and locates and calculates the distances between eyes, mouth and nose, length and width of the face, thickness of eyebrow, by using the centroids of each of the four parts of the image, and then uses this data to calculate ratios of inter-ocular distance, lip to nose, nose to eyes, and lips to eyes. Finally gender classification using these ratios based on the threshold values set for each ratio. [9]

PROPOSED ALGORITHM

The system proposed in our paper of Automation of Attendance System using Face recognition and Gender Classification performs recording and analyzing of attendance in a class of students very efficiently with high rigidity and reliability, using multiple algorithms in an orderly fashion and stores the data of attendance of students present and absent in a class in a database.

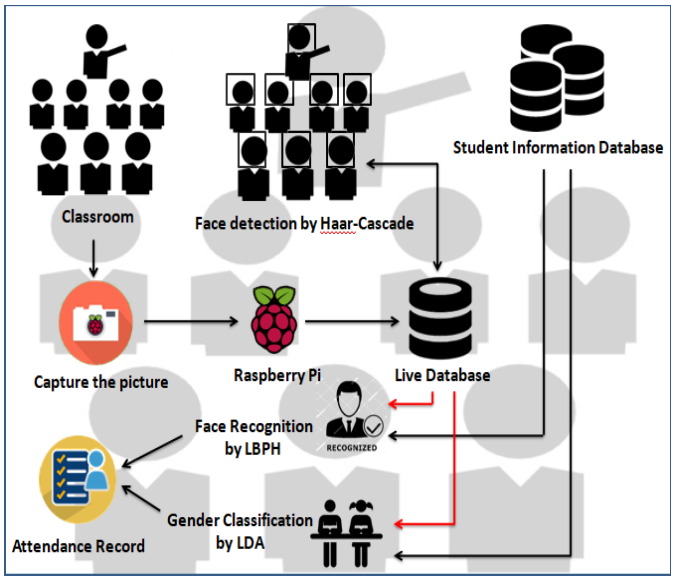

Figure 1. Block diagram of the proposed system

- *Stage I –*

The first phase of the system involves the acquisition of image using a camera. For our system we are using Pi camera which has a fixed focussing lens of 1.3 megapixels. We have chosen Pi camera over a USB web camera since it has the ability of utilizing the capability of graphics processing of Broadcom CPU used by Raspberry Pi in a more efficient manner. The Pi camera used is connected to Raspberry Pi 3, which is a small computer of single-board. It has a processor

speed of up to 1.4 GB. [10] We have used Raspberry Pi 3 in our system as the processor because of its small size which enables its easy installation and portability, and also because of its cost effectiveness which reduces the overall cost of our system with respect to a classroom.

Once the image has been captured, the image is forwarded for pre-processing which involves conversion of the image into gray scale, which is necessary to be performed on the image for face detection as it decreases the colour complexity of the image which also aids in faster processing of it. Gray scaling is done by using the cvtColor method provided by OpenCV, i.e. Open source Computer Vision library, which is a library of built-in programming functions that aim to perform computer vision operations in real-time. The cvtColor method of OpenCV does gray scale conversion by performing averaging of the most prominent colours and the least prominent colours. The luminosity method under cvtColor method calculates a weighted average for RGB image to gray scale. The formula used for luminosity is as follows, where R, G, B are colour components namely, red, green, and blue: [11]

$$Y = 0.299R + 0.578G + 0.114B$$

- *Stage II –*

The next phase of our proposed system involves detection of faces from the pre-processed image. We have used Haar-cascade classifiers to perform face detection as it performs detection of faces with high efficiency and high accuracy even with different orientations of the faces to be detected under different lighting conditions. Under the face detection system proposed by Viola and Jones [12], the system is designed by giving input of faces and non-faces. The images containing faces are called as positive images and the images not containing any faces are called negative images. This is used to train the classifier for differentiating a face from a non-face and thereby, identifying positive images. Haar features are analogous to convolution kernels in terms of their use in the detection of the presence of the concerned feature in any given image. When each type of Haar features is applied on a given image, the output given is the highlighted regions of the image where that Haar feature is present.

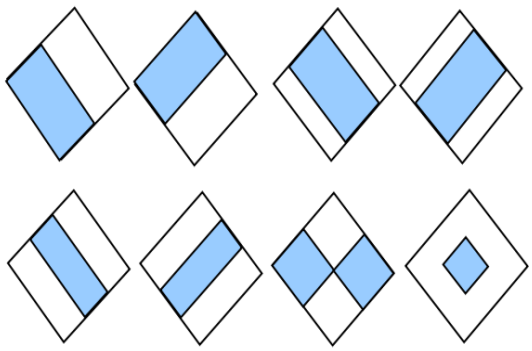

Figure 2. Some types of Haar features used in Viola-Jones

The difference between the sums of the number of pixels under the rectangles that are white (representing a light region) from those that are black (representing a dark region) results in a single value which represents each ααfeature. To make the calculations faster, the image is represented using an integral image wherein only the corner pixel values of each black or white rectangle present in the image are used to represent the whole rectangle. Then to eliminate redundant and irrelevant features of the face with respect to face detection, AdaBoost is used, which is a machine learning algorithm. AdaBoost does so by selecting some features that are relevant for detecting a face, which are known as weak classifiers. Then it constructs what is known as a strong classifier which is used to successfully differentiate a face from a non-face. A strong classifier, F(x) is constructed by forming a linear combination of the weak classifiers, f1(x), f2(x), f3(x) and so on, with the assignment of weights, α1, α2, α3 and so on to each weak classifier, as follows:

$$F(x) = \alpha 1 f1(x) + \alpha 2 f2(x) + \alpha 3 f3(x) + \ldots$$

If the result of the strong classifier is positive then the face is detected, else the face is not detected.

- *Stage III –*

The face recognition is the facial image already extracted, cropped and resized by the Haar-cascade algorithm then the face recognition algorithm i.e Local Binary Pattern Histogram (LBPH) which is provided by the OpenCV; it is responsible for finding and identifying the characteristics feature of the image. LBPH improves the detection performance on the datasets at a very fast rate and so, it improves the execution of the system. LBPH uses training datasets of student data which we have created along with their facial features from different orientation of the faces which is stored in the student information database. LBPH extracts faces to perform face recognition by comparing pre-processed data (provided by the live database) with training dataset (student information database). Facial feature extraction is done by the image generator; to do so it create an intermediated image from the live image so that it can define the original image in a conceptual way by highlighting the facial feature of the image. For this concept we have used sliding window which represents the image in the matrix form wherein each pixel of the image in the matrix is represented under the terms of the neighbouring pixels within a specific radius around it, giving an output of a matrix represented in binary values which generates the intermediate image. Using this intermediate image, histogram of the image is created that represents the face in terms of its extracted facial features. The created histogram is compared with the histograms of faces stored in the training database to return the face with the closest histogram match, which is the output of the face recognition method and is stored and recorded in the attendance database.

- *Stage IV –*

Our proposed system contains an additional module of gender classification which improves the reliability of the attendance record by verifying the gender of the students available in the

student information database. Our system has implemented the gender classification system using Fisherfaces algorithm provided by OpenCV based on Linear Discrimination Analysis (LDA) which performs classification.

Pre-processing is necessary before classification of the image containing the face. The images are cropped, rotated and aligned at the same levels, i.e. the eyes of all the faces are aligned and all faces are cropped for uniformity in their sizes and dimensions. Normalization of data is a good practice in order to perform LDA for classification.

Figure 3. Pre-processed images of faces for gender classification with alignment at eye level

For classification of the images containing faces, Linear Discriminant Analysis (LDA) is used, which is a machine learning algorithm that learns the features of each class using the training data provided to it. In this case, multiple pre-processed image files containing human faces along with the information about which class each image belongs to- male or female, are fed to the LDA analyser which in turn reads the given data to learn the extracted characteristic details about each class. For example, for each class k, the mean value, m of each input, x is calculated as below:

$$m(k) = (1/n) * sum(x)$$

And the variance across such classes is calculated as follows, where n is the count of instances with k class:

$$Sigma^2 = (1/(n-k)) * sum((x-m)^2) [10]$$

To learn the inter-class differences and intra-class similarities for further application in the classification process, the LDA algorithm calculate two parameters which are measure of intra-class scatter or covariance, and measure of inter-class scatter, using which LDA predicts the class of a given input by calculating the probability of that input belonging to each class and hence the class with the highest probability finally gets outputted as the classification result.

The proposed system successfully delivers automation of a classroom attendance system using face recognition to overcome the drawbacks of manual and biometric attendance systems. It is a portable and relatively cheap system that can be easily installed in classrooms. The proposed system of automated attendance along with gender classification has enhanced reliability and gives results with high efficiency and accuracy, thereby enabling faculty members to utilize time in a purely productive manner without concerning about any misconduct of attendance.

CONCLUSION

Thus, on developing an automated attendance system with recorded output of classroom session by which the lecturer or faculty can record student's attendance with minimum human interface (less human error) or student proxy attendance. The system is reasonably economical due to the use of Raspberry Pi3 & Pi camera. The use of Linear Binary Pattern Histogram (LBPH) and Linear Discrimination Analyser (LDA) together in the system increases its efficiency and reliability toward recognition of faces of the students to provide a secure system.

FUTURE WORK

The use of video in real time can give better outputs for face detection and recognition due to enhanced capturing abilities of favourable face orientations and fault corrections. Modification in this system is required to achieve the detection of faces partially or fully concealed under veils.

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