Automated Attendance System using Fuzzy Logic and Content based Image Retrieval

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ABSTRACT

The face is the identity of a person. The methods to exploit this physical feature have seen a great change since the advent of image processing techniques. The accurate recognition of a person is the sole aim of a face recognition system and this identification maybe used for further processing. Traditional face recognition systems employ methods to identify a face from the given input but the results are not usually accurate and precise as desired. The system described in this paper aims to deviate from such traditional systems and introduce a new approach to identify a person using a face recognition system i.e. the generation of a 3D Facial Model. This paper describes the working of the face recognition system that will be deployed as an Automated Attendance System in a classroom environment. The techniques and algorithms used along with the constraints and practical difficulties will be highlighted in this paper. The use of Fuzzy Logic and the concepts of Content Based Image Retrieval (CBIR) will be the main aspect of the proposed automated system.

General Terms

Face recognition, techniques, algorithms, constraints

Keywords

3D Facial Model, Automated Attendance System, Fuzzy Logic, Content Based Image Retrieval

1. INTRODUCTION

The purpose of recognition and identification has gone past the mere need for security. The use of face recognition software has been recently used to ease mundane tasks. The age of automation has given rise to such exploitation and it has been remarkable. The techniques that surround face recognition and identification are the basic concepts of Image Processing. The use of optimized algorithms to refine the results and produce a better and quick result has been a goal that has been achieved in most of the implementations. The idea of using this technique to calculate the attendance has been the heart of our entire project. The implementation of this project will be done in a classroom environment of our institution for the sole purpose to automate the procedure of marking the students' attendance [1]. The noteworthy difference in this project and traditional systems would be the use of a 3 Dimensional face model of the student. The task can be explained in three phases:

1) Construction of the image and text database including a 3D model of each face

2) Gathering the input from the environment (classroom) and pre processing

3) Performing image retrieval and marking the attendance

During a lecture in a classroom, well positioned cameras will capture a snapshot of the class with the students. The camera will just retrieve the face and ignore the background pixels. So now, the faces are ready to be used for comparison with the database.

These faces are forwarded into a CBIR system that will check these images with those in the existing database. The generated 3D model will assist the recognition since the face positioned may not be in the expected angle [2]. On checking the images with the database, the corresponding student's attendance will be marked for the lecture. The accuracy of the retrieval is the main concern in the project.

2. AUTOMATED ATTENDANCE SYSTEM

In the case of every organization, institutional or business, there exists the need to maintain a regular log of attendance. It is of utmost importance that such data is consistent, regularly updated, secure from manipulation and also accurate to the second. Practically, there have been many instances where such data is not in its desired form. The causes may vary but the end result is ultimately inaccurate. This gave rise to automated systems to record attendance which was, and in

most places, still is a manually executed task. The rate of error rises with the manual working and hence the automation is the need of the hour. Biometrics has a major role in creating these systems. The extraction of physical features for identification as well as authentication has been the new trend that has proven to be much error free and convenient as compared to a manual approach. Systems like iris scanners, retina scanners, hand-geometry recognition system and even fingerprint recognition systems are the commonly deployed biometric systems. These systems have proved to provide satisfactory and accurate results and are very rarely prone to error or manipulation [2].

Such automation could also be envisioned in the classroom scenario. The faculty taking the particular lecture manually takes the students' attendance. Such a method involves visually matching the student and updating the entry in the log. On the other hand, the student may sign-in his/her log at the time of entry into the lecture. Though we are used to these methods, they are error prone. The faculty may not see the student who is seated afar and may not mark the log for that student in the lecture. Moreover, the faculty could mistakenly mark the log for another student though who isn't present in the classroom. The student signing-in the log could, knowingly, mark the attendance for another student along with his. Such a change or manipulation is generally unnoticed and creates a major problem in the overall accuracy of the system. The chances of an error occurring in this method are really high and hence there is a need for improvement.

Our proposed system plans to overcome the flaws in these methods. This Research and Development project will be implemented in the coming weeks and deployed in the classrooms of our institute. The idea of using a face recognition system in the classroom could eliminate most of the errors that can commonly occur. The 3 phases of the system will work at the time of the lecture and will be initiated by the presiding faculty. The PC in the classroom is the heart of the system and will handle all the computation and storage of the entire system. There will be well positioned cameras in the classroom that will be capable of capturing the digital image of the entire classroom during the lecture that will serve as the input for the further stages of the system. The sole purpose of the project is to reduce the human interaction for such a task and also produce accurate results that can be useful for the entire institution. The system needs to be working at optimum performance at every lecture and maintain the accurate database of the attendance of all the lectures.

The crucial and most important stage of the entire system is the database that needs to be prepared to provide the basis for comparison during the working of the system. The database will be the repository pertaining to the information of a particular class i.e. a database of the students and the schedule of the lectures with the corresponding faculty information as well. Once the database is constructed, the main components of the working should work with the input and produce the results whenever necessary. The highlight of the project is the 3D model which enables the recognition and retrieval of an image that isn't in the position that aligns the front face. The range obtained due to the incorporation of a 3D model is 180 degrees (90 degrees each on the left and right side view of the face with respect to the front view of the face). The camera will be equipped with face detection software that automatically returns just the faces which eases the comparison. The comparison will be performed and the attendance of all the students (after each individual face is compared) will be marked and stored in a separate attendance database. This database allows the faculty to access the daily or monthly records of the attendance log with ease. Thus, our aim is to provide a convenient system that makes such a task possible without much error and mistakes.

3. WORKING OF THE SYSTEM

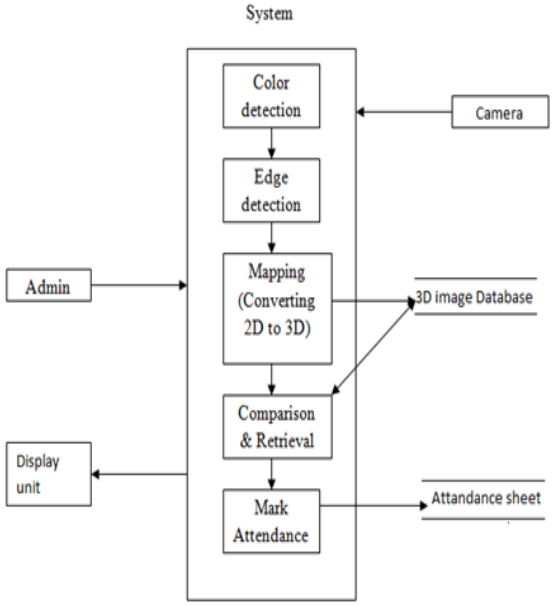


Figure 1: Block Diagram of the System

The system is comprises of 3 main phases:

3.1 Phase 1: Generation of the Database:

The database holds all the data necessary for processing. The database needs to be carefully constructed and the data needs to be gathered and assembled in an organized manner. The procedure of the database generation can be summarized in the following steps:

1. Insert student details in the given GUI format. Insert student name, roll no and class.
2. Give the images of students face i.e. front view, LHS view, RHS view. (Figure 2)
3. Find the edges of the student's face from the given images using Canny edge detection algorithm [3].
4. Store the binary matrix (edges) of the face in the database.
5. Place all the 3 images, both LHS & RHS view orthogonal to front view and parallel to each other.
6. Project all the points in the edges from their respective images to the parallel plane.
7. Find the set of points of intersection of all the projections.
8. For all x, y, z do
    8.1. if front(x, y) && LHS(x, z) exists
        insert x, y, z in the 3D matrix
    8.2. if front(x, y) && RHS(x, z) exists
        insert x, y, z in the 3D matrix
9. Store the 3D matrix in the database.
    10. If new student present goto 1
        else goto 11
    11. STOP

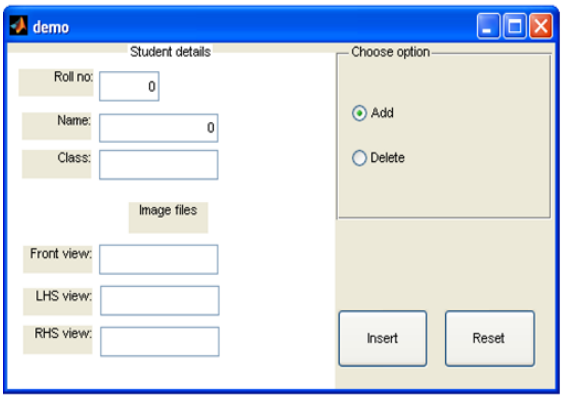


Figure 2: User GUI: Add Student Details in the Database

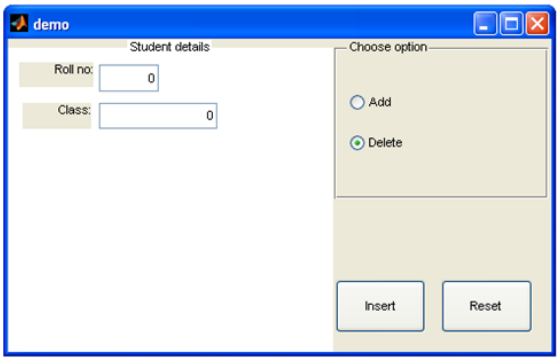
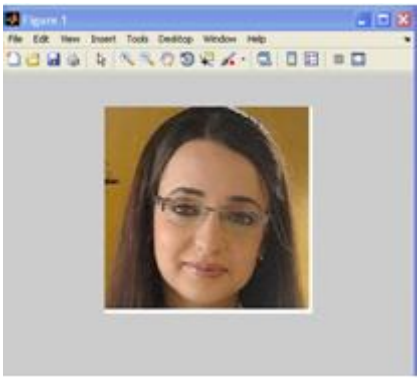


Figure 3: Add/Delete Student Record



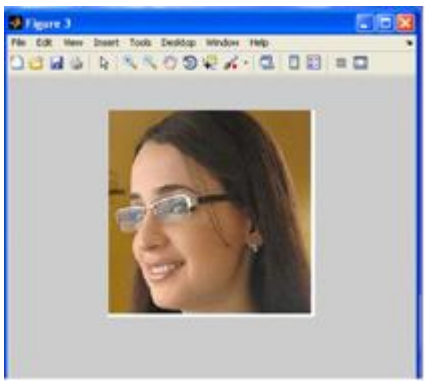


Figure 4: Test Images

The first 2 steps request the administrator to input the text and image details pertaining to a student. The text data includes the student name, roll no and class. It needs to be inserted properly and each entry must correspond to the correct student. Now the image inputs need to be given to the database. These include the images of the FRONT, LEFT and RIGHT side views of the students preferably with a white background. The database image and the camera input image resolution should be fixed at a particular value to ease comparison. If the input isn't in the desired resolution, the image must be resized prior to processing. The Canny edge detection algorithm is applied to detect the strong and weak edges in the images (all 3 views). The working of this edge detector can be generalized in the following steps:

1. The original image in the RGB format is given as an input [4].

2. The colored image is first converted to grayscale image by eliminating hue and saturation information while retaining luminance.

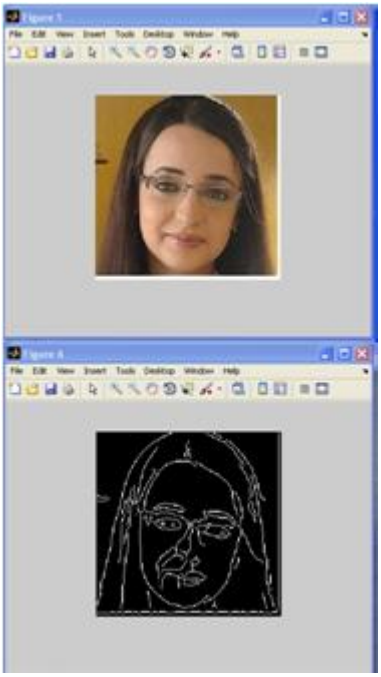
3. Then the gradient of the given image is calculated using the derivative of a Gaussian filter.

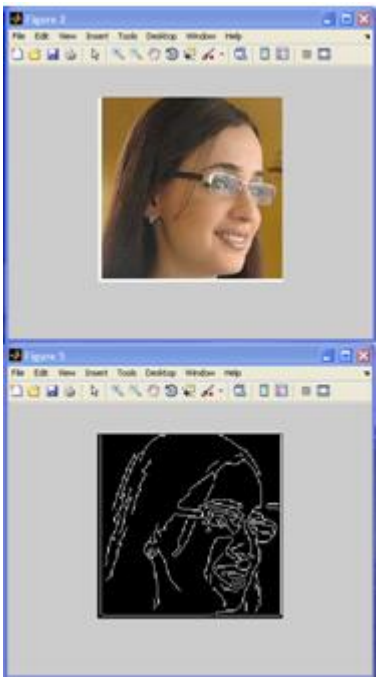
4. Now, the local maxima are found for the edge detection in the given image.

5. Here, two thresholds for the edge are taken into consideration.

6. One threshold is used for the detection of strong edges and the other threshold is to detect weak edges only if it is present near the strong edge

7. The standard deviation used for the canny edge detection algorithm is 1 for the Gaussian filter.





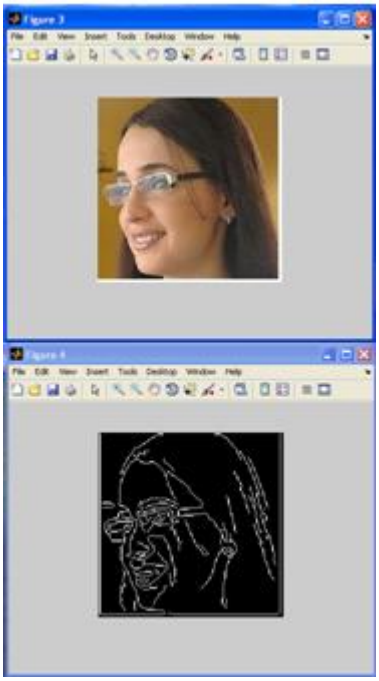


Figure 5: Canny Algorithm Results on the Test Images

This edge detected Image is stored in database.

Fuzzy Logic is a form of many-valued logic; it deals with reasoning that is approximate rather than fixed and exact. Fuzzy Logic has been extended to handle the concept of partial truth, where the truth value may range between completely true and completely false. Furthermore, when linguistic variables are used, these degrees maybe managed by specific functions. The 3D model of a particular face needs to be generated and stored as part of the attributes for that student. The algorithm of the 3D model generation method employs the use of Fuzzy Logic. The 3 views will be orthogonally placed and the points will be projected along the opposite direction (negative axis). The intersection of these points will generate an entire set of intersections that need to be used for the 3D Model. The Front View will have common feature points with the Left and Right Views. These points are checked and added to the 3D representation points only after the condition is satisfied. Figure 6 shows the projection of the model on the 3 co-ordinate axes. The table of Fuzzy Rules with the true and false values [1]:

X	**Y**	**Z**	**P= X^Y**	**Q=X^Z**	**Output (P^Q)**
T	T	T	T	T	T
T	T	F	T	F	F
T	F	T	F	T	F
T	F	F	F	F	F
F	T	T	F	F	F

F	T	F	F	F	F
F	F	T	F	F	F
F	F	F	F	F	F

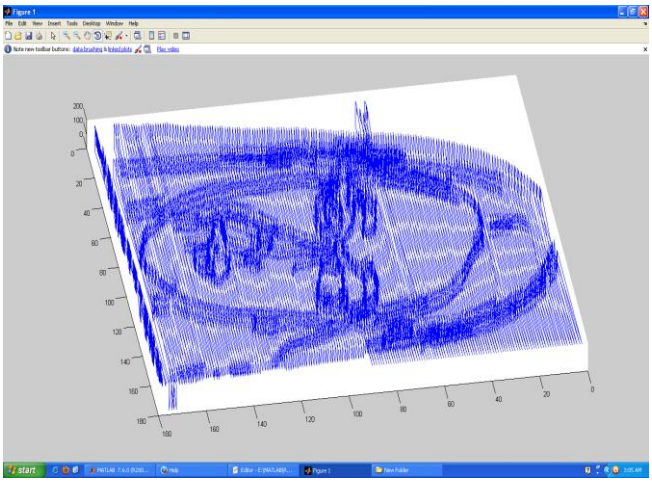


Figure 6: 3D Projection

The database maintains a feature vector of each image as its attribute and it is used for comparison in the final stage.

3.2 Phase 2: Input to the system:

After the first phase, the database is ready for the system. Now the real time input needs to be extracted from the classroom environment. The cameras have been placed within the classroom. The faculty begins the working of the system by initiating the image capture of the camera through the computer. The cameras will now capture images of the classroom and begin the process of eliminating background and noisy pixel values. Each camera will return just the faces of the students after this preprocessing phase. The interface between the camera and the computer must provide proper synchronization to ensure no delay occurs. The captured faces are now sent to the computer where they are taken in an array of images. This array is to be checked with the existing database to retrieve the appropriate student and provide this detail to the next phase.

3.3 Phase 3: Comparison and Retrieval

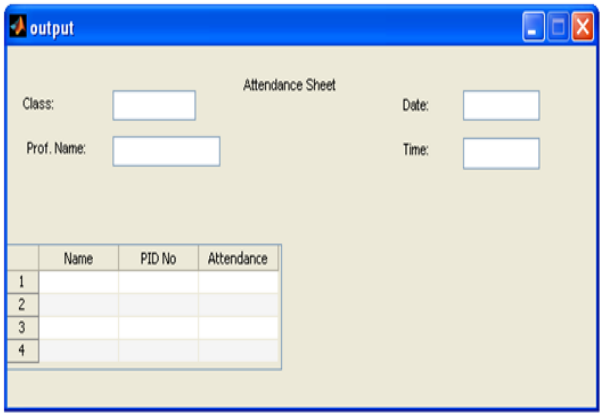
This phase is very crucial for the working of the system. The main aim of this phase is to check the captured facial images with the existing database and retrieve the exact image that corresponds to the current student's face. The task of comparison is very time consuming and in our case we have to deal with 70 student faces that individually need to be compared with the entire database. The result of this one-to-many comparison is the excess time consumption that will delay the system's results and may prove the system to become useless. The concept of CBIR is employed here. We aim to use the edge, color and texture content of the image to for the retrieval. So the comparison phase follows the following steps [4][5][6][7]:

1) Resize the image according to the predefined size.
2) Color Detection:
   1. Once the image of the user is provided to the system, as it is a colored image it poses a wide range of color intensity in the RGB format.
   2. System will use this wide range and will separate the higher intensity pixel from the lower intensity pixel depending on the threshold decided and thus using Colormap the color of the image is detected as a feature vector. This color detection is also performed during the database creation and a feature vector of color is stored in the database. This vector is compared with the newly generated vector and the number of images now left to compare the input has been shortened to 45-50 by the color detection. [9]
3) Edge Detection:
   Again the Canny Algorithm is employed here. The results of this algorithm are compared with the ones in the database to further shorten the number of images [3][11].
4) Kekre's Transform is applied:
   The following algorithm is applied on the image:
   1. The image is split into its 3 RGB planes.
   2. Now the feature extraction process begins. There are 2 different approaches applied.
   3. Approach 1:
      1) Calculate the row and column mean vectors.
      2) Apply Kekre's Transform.
      3) Compare the generated feature vector with database feature vector by querying the latter from the database.
      4) Apply the Similarity measure: Euclidean distance.
      5) Select the images less than the predefined threshold and retrieve from the database.
   4. Approach 2:
      1) Calculate the row and column variance vectors.
      2) Apply Kekre's Transform.
      3) Compare the generated feature vector with database feature vector by querying the latter from the database.
      4) Apply the Similarity measure: Euclidean distance
      5) Select the images less than the predefined threshold and retrieve from the database.

   This algorithm shortens the list further to about 10 images. These images are used for the final comparison phase [4].

5) 3D Model Comparison and Retrieval:
   The 3D model generated for each of these shortlisted images is retrieved for comparison. The input image is at an angle or maybe perfectly aligned with the Front View of its respective database counterpart. Nevertheless the angular difference is calculated and accordingly the 3D model will be rotated to that angle. The concept of rotation is matrix rotation accordingly to the calculated angle. Now we have to compare 2D to 2D. So we use Euclidean Distance to find the minimum distance and hence we can arrive at the final accurate image. The threshold is set by trial and comparison to allow only a particular range of Euclidean distance values to be considered. Once the correct image has been retrieved, its corresponding textual data will also be accessible and thus the attendance of the recognized student can be marked and updated in the database for that particular lecture and time [8].

Figure 7 shows the representation of the Output.



4. PROJECT SPECIFICATIONS

Technical Requirements

Hardware Requirements

- A standalone computer needs to be installed in the classroom where the system is to be deployed.
- Multiple Cameras must be positioned in the classroom to obtain the snapshots of the entire classroom. Optimum Resolution: 512 by 512 pixels.
- Secondary memory to store all the images and database

Software requirements

- MATLAB Version 7.6(R2008a) or higher
- Windows XP(Service Pack 2) or higher

Expenditure

The cost of the entire project will depend simply on the expenditure incurred for the hardware requirements. The software requirements can be easily fulfilled without any cost.

Equipment:	Cost:
Standalone PC	Rs. 30000/-
Camera	Rs. 3000 per camera

5. MERITS AND CONSTRAINTS OF THE SYSTEM

5.1 Merits

- The system is activated only when the faculty decides to use it. In the mean time, there is no processing or working done by the system. Thus, there is no need for the system to run continuously and consume unnecessary computer memory.
- The database of the students will hold all the information pertaining to the student. It will also allow the administrator or the faculty to change the details as and when it is necessary.
- Security is a main concern and a necessity in every system. There will be an additional security element in the system that enables only the registered users (faculty of that department pertaining to that classroom). This will prevent the intrusion into the system by any third party who wishes to manipulate the log for his/her benefit.
- The optimizations and the decrease in the time for the one-to-many image comparisons will result in a efficient marking of the log and also maintain the necessary accuracy.
- The system is completely automated and once initiated by the faculty; the system will work till the attendance is updated in the database. It eliminates any room for human error.
- This also has an environmental benefit. Current attendance logs are maintained on paper. With this system, there won't be the need for using paper at all. The attendance database can merely be queried to retrieve any attendance record that is necessary. The use of paper will no longer be necessary for the attendance log procedure.

5.2 Constraints

Hardware constraints

- Camera: Our project needs a high resolution camera. It should be positioned in the classroom in such a way that it captures snapshots of maximum number of occupied benches in a single image. This position should be maintained constantly. The image must then be processed by the camera to eliminate the background and any noise or distortion that can hamper the results of the following stages. This camera must be equipped with the face detection software that returns only the faces of the students that will be used for retrieval.
- Computer: The classroom should be equipped with a processor of 2.8GHz in case of a single core processor or a 2GHz in the case of dual core or core 2 duo processor. The processing should be quick enough to prevent any lag in the system. The computer should be able to communicate with the camera and the latency should be negligible from the time of capture to the arrival of the faces as input to the computer. If there isn't proper synchronization, there will be a delay in the performance of the system.
- Memory for Storage: The computer must be equipped with sufficient memory to store the database content and the processing unit of the system. The images and text data needs to be stored in a fixed directory to ease the comparison. If the memory is insufficient, some of the comparisons may be erroneous and may affect the working of the system.

Environmental constraints:

- Lighting: The lighting in the classroom should be not to bright or even too dim. Light can affect the face detection software and hence it is necessary to resolve any shadow or other light effects on the

face. The camera should be equipped to adjust the light smoothly as the image is captured during the lecture. The operation must be performed immediately and forwarded to the system.

- Lenses of cameras should have proper visibility and not be affected by dust or any other factor. The presence of any unwanted materials on the camera lens will blur or distort the entire image of the classroom. The camera lenses must be clear to obtain a distortion-free snapshot.
- Retrieval of the face: The external background should be ignored and just the face should be forwarded to the retrieval system. The camera should ignore the background pixels and only return the image containing the students' faces. This includes elimination of noise, out-of-focus blur and even improving the contrast of the image.
- Capture Angle: The student's face image should be captured within the range of -90 degrees to 90 degrees with respect to the front side image. This range is possible due to the incorporation of the 3D model. But an image that is captured at an angle beyond this range will not provide an accurate result. So it is necessary to provide the input that lies within the 180 degrees range.

Software Constraints

- Database Content: The images in the database should be at a proper angle in order to generate the 3D model which will be used for retrieval. The three images of each of the student should preferably be taken with a white background image. The content of the database should be correct to ensure the comparison and retrieval is done accurately.
- Consistency of information: Any changes in the classroom should be incorporated in the system. The lecture name, time and even a change in roll number of a student should be updated into the system on time to avoid any discrepancies. Any changes in facial structure can also be updated to improve the accuracy of retrieval. Any inconsistency in the database will cascade into all the results of the further stages. It will be a tedious task to identify and correctly rectify the error made by inconsistent data.

Miscellaneous Constraints

- Change in facial features: In a practical world, there isn't a complete assurance of the accurate results from the face recognition system. The facial features of a person are not always consistent. E.g. facial hair, change in hairstyle, wound on the face, etc. Such changes in the face pertaining to a particular student must be understood by the system. An updating feature must be added to the system that will check and make the necessary changes in the face and store both the old and updated image to increase efficiency.
- Case of identical twins: Considering the images of two identical twins obtained from the multiple face detection system, the system cannot easily differentiate between the two images and extract the information accordingly. The face edges and other features are identical and hence it is a problem to distinguish one image from the other. The feature matching and threshold should be predetermined to provide better results in this situation of comparison.

6. ACKNOWLEDGMENTS

We would like to extend our sincere thanks to all those individuals and organizations for extending their kind support and help in our endeavor.

Firstly, we are highly indebted to our Institute, St. Francis Institute of Technology and the Computer Department for providing us this learning opportunity along with the required resources to accomplish our task.

Secondly, we would like to sincerely thank our project guide Ms. Kavita Sonawane for her guidance and constant supervision as well as for providing necessary information concerning the betterment of the project.

7. CONCLUSION

Our proposed project, "Automated Attendance System" has been envisioned for the purpose of reducing the errors that occur in the traditional (manual) attendance taking system. The aim is to automate and make a system that is useful to the organization such as an institute. The camera plays a crucial role in the working of the system hence the image quality and performance of the camera in real-time scenario must be tested thoroughly before actual implementation. Our approach has 3 main phases.

The database is crucial to the execution of the system and the details of every student must be consistent. The database should also be updated as per the changes that occur in the classroom with respect to the lecture schedule or the faculty.

The image capturing and processing phase is the source of the input to the system. Our trails on differently sized images have provoked the idea for having a fixed size (512X 512 pixels) for each image. This resolution has showed optimum results with respect to time and memory. The improvement on the image is the incorporation of the 3D model of each student. This model: created from the 3 views of the student's face by applying Fuzzy Logic will allow the capturing angle range to between -180 to 180 degrees. Thus, the image angle has a broader range for capture.

The final phase is the retrieval of the corresponding student and marking of the attendance. Our approach includes the features like edge, color and texture as part of the Content Based Image Retrieval procedure. We have implemented the first phase of the system. The database was constructed and each student was added along with the corresponding facial images and 3D model. The Canny edge detection algorithm that we used proved effective since it delivered the apt result and the computational time was less than its counterparts.

The system is expected to work at optimum efficiency and fulfill all the constraints mentioned above. The testing of the system will be crucial and we have begun work on the 2nd phase of the system. The system will be perfectly complete and up and running within 2 months and the results obtained after every iteration will be monitored closely to ensure no inconsistencies exist [10][11][12][13].

8. REFERENCES

[1] Xue Yuan, Jianming Lu, Takashi Yahagi, "A method of 3D face recognition based on principal component analysis algorithm."

[2] Shalini Gupta1, Mia. K. Markey2, Alan C. Bovik, "Advances and Challenges in 3D and 2D+3D Human Face Recognition", Department of Electrical and Computer Engineering, The University of Texas at Austin, TX 78712, USA.

[3] Dr.H.B.Kekre, Sudeep Thepade, Shobhit Wadhwa, "Image Retrieval with Shape Features Extracted using Gradient Operators and Slope Magnitude Technique with BTC", International Journal of Computer Applications (0975 – 8887) Volume 6– No.8, September 2010.

[4] Dr. H.B. Kekre, Kavita Sonawane, "CBIR Using Kekre's Transform over Row Column Mean and Variance Vectors", *International Journal of Computer Science and Engineering* Vol .2, No. 5, pp 1609-1614, July 2010

[5] X. Fu, Y. Li, R. Harrison, S. Belkasim, "Content-based Image Retrieval Using Gabor-Zernike Features", Department of Computer Science and 2Department of Biology, Georgia State University, Atlanta, USA.

[6] Shafin Rahman, Sheikh Motahar Naim, Abdullah Al Farooq and Md. Monirul Islam, "Curvelet Texture Based Face Recognition Using Principal Component Analysis", Department of Computer Science and Engineering, Bangladesh University of Engineering and Technology (BUET), Bangladesh.

[7] Remco C. Veltkamp, Mirela Tanase, "Content-based image retrieval systems:a survey" , Department of Computing Science, Utrecht university

[8] B.S.Manjunath and W.Y. Ma, "Texture features for browsing and retrieval of image data", IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI), vol.18, no.8, pp.837-42, 1996.

[9] Guoping Qiu, "Color Image Indexing Using Btc", IEEE Transactions On Image Processing, Vol. 12, No. 1, January 2003.

[10] Y. Rui, T. Huang, and S. Chang, "Image retrieval: current techniques, promising directions and open issues", J. of Visual Communication and Image Representation, vol. 10, no.4, 39-62, 1999.

[11] Mamta Juneja, Parvinder Singh Sandhu, "Performance Evaluation of Edge Detection Techniques in Spatial Domain", International Journal of Computer Theory and Engineering, Vol. 1, No. 5, December, 2009, 1793-8201.

[12] Mark A. Ruzon, Carlo Tomasi "Color Edge Detection with the Compass Operator", IEEE Conference on Computer Vision and Pattern Recognition '99, Volume 2, pages 160-166, June 1999.

[13] Weilong Yang, Dong Yi, Zhen Lei, Jitao Sang, Stan Z. Li, "2D-3D Face Matching using CCA", Center for Biometrics Security Research & National Laboratory of Pattern Recognition