Application of Face Recognition and Location-Based System for Locating Culprit in the Philippines

Vincent S. Rivera
Gima B. Montecillo

University of Perpetual Help System Dalta Calamba
Colegio de San Juan de Letran Calamba

vincent.s.rivera@gmail.com
gsbatinggal@yahoo.com.ph

Abstract

The Philippine National Police (PNP) keep pace on the current developments in IT to enhance their administrations in locating the culprits [10]. However, a timely identification of culprits by the police force is critical to the wellbeing and security of offices and overall population.

Face recognition can be utilized to compare face images for a particular reason like coordinating reports of the sighted individual to a culprit. Consequently, this study would like to propose a Face Recognition (FR) with Location-Based System (LBS) to speed up the process of recognizing and finding whereabouts of the culprit.

The study will test the (1) "false acceptance rate" (FAR) and "false rejection rate" (FRR) at varying distances and face angles, (2) speed of face recognition, (3) correctness of recognizing the location of the reported person, and (4) capability of the system to inform the reporter about the percentage of similarity of the face.

Keywords: *Mobile application; Global Positioning System; Luxand FaceSDK; False Acceptance Rate; False Rejection Rate*

1. Introduction

In the Philippines, since 2008, the PNP maintains on their website the photos, profiles and rewards of the most wanted criminals in the country [10].

According to the PNP, in the event that the culprit does not have a mug shot, the witness will have to describe the facial feature of the culprit using the Facial Composite application. This application resembles in an automated pencil portraying 1000 sorts of eyes, nose, ears and mouths [3].

Another technology utilized by the PNP is the closed-circuit television also called CCTV. The use of this technology for finding and recognizing a culprit is very constrained since the number of places with CCTV is very limited [9].
At present, people could report the location of an alleged culprit via call, text and or a mobile application called "Itaga Mo Sa Bato". To report using this app, the reporter should send the following information: suspect's name, whereabouts, and kind of crime; reporter's age, and gender; and picture with description. The PNP verifies the identity of the reported person through "mug shots", "background investigation" and "affirmation of the complainant or witness" [10].

Without a doubt, PNP keep pace on the current developments in IT to enhance their administrations in locating the culprits [10]. However, a timely identification of culprits by the police force is critical to the wellbeing and security of offices and overall population. Consequently, this study would like to propose a Face Recognition (FR) with Location-Based System (LBS) to speed up the process of recognizing and finding whereabouts of the culprit.

The study will test the (1) "false acceptance rate" (FAR) and "false rejection rate" (FRR) at varying distances and face angles, (2) speed of face recognition, (3) correctness of recognizing the location of the reported person, and (4) capability of the system to inform the reporter about the percentage of similarity of the face. This study hopes to provide additional knowledge and information on how FRS with LBS can be more effective specially when use as a tool in searching for person-at-large.

2. Literature Review

2.1 Structure of FRS

Face detection by computer is the process of determining if each pixel in the 2-dimensional or 3-dimensional image is part of the face and which are not [11].

Pre-processing is use to improve face recognition rate. The process starts by converting the detected face into gray image. Using suitable cropping schemes, the face image is cropped. Then, to meet the required size of the image, the nearest neighbor interpolation method is used. Since the image with uncontrolled environment contains non-uniform contrast or intensity/gray level, the histogram equalization technique is used. Often, images have noise because of variations in illumination. In order to de-noise the image, the pixel-based filtering technique is used [4].

Once face is detected, the next step is to locate the facial features, like eyes, nose and lips. Then last phase is the face recognition also called face classification. The main idea behind this phase is to minimize errors between the test image and the gallery of face images [6].

Figure 1 shows the phases of FRS.

Figure 1. Steps of FRS [5]

2.2 Luxand FaceSDK

Luxand FaceSDK 6.3.1 is a face detection and recognition library. Some of its capabilities are: strong frontal face detection; can detect 70 facial features points (eyes, eyebrows, mouth, nose, face contour); can detect several faces in the photo; can support head rotation with -300 to 300 degrees in plane and out of plane rotation; can detect images with 0.0034556 sec to 0.020 sec depending on the webcam resolution; can detect images from 0.07471 sec to 0.642 sec depending on the digital camera's resolution; face detection parameters can easily be configured; has the ability to returned information for each detected face; the size of the template is 13 kb; has the capability to returned facial similarity index; and can identify gender, age and face expressions [7].

The typical steps for using the Luxand FaceSDK are the following [7]:

1. Activate the FaceSDK library by calling the "FSDK_ActivateLibrary" function and Luxand key.
2. Initialize the FaceSDK library using "FSDk_Initialize function".
3. Load the face images from a buffer using "FSDK_LoadImageFromFile" and "FSDK_LoadImageFromBuffer" functions or HBITMap handle using "FSDK_LoadImageFromHBitmap function".
4. Use "FSDK_SetFaceDetectionParameters" and "FSDK_SetFAceDetectionThreshold" functions to set face detection parameters.
5. Use "FSDK_DetectFace" function to detect a face, otherwise use "FSDK_DetectMultipleFaces" to detect multiple faces.

6. Then detect facial features using “FSDK_DetectFacialFeatures” and “FSDK_DetectFacialFeatureInRegion” functions.
7. Extract the face feature using “FSDK_GetFaceTemplate”, “FSDK_GetFaceTemplateInRegion” and “FSDK_GetFaceTemplateUsingFetaures” functions.
8. Compare the face feature to get the facial similarity index using “FSDK_MatchFaces” function.
9. Lastly, compare the threshold to the far or FRR rate using “FSDK_GetMatchingThresholdAtFAR” and “FSDK_GetMatchingThresholdAtFRR” functions to determine if the face belongs to the registered face.

2.3 Location-Based System

A LBS utilizes the telephone's GPS coordinates to track one's location. This technology can be used as long as there is a connection to the Internet [1]. By means of a special receiver, a geographic position in space and time can be measured through the reception of satellite signals [2].

2.4 Performance Evaluation

The most common accuracy metric for Face Recognition System is “False Acceptance Rate” (FAR) and “False Rejection Rate” (FRR). FAR is the measurement of the number of times the system wrongly accepts an unregistered person because the criterion of the reference threshold is not met. It falls in the range of registered person. The equation for FAR is [8]:

$$FAR = \frac{\text{wrongly accepted individuals}}{\text{Total Number of Wrong Matching}} \quad (1)$$

While the FRR is the measurement of the number of times the system wrongly rejects the registered face because the criterion of the reference threshold is not met. It falls in the range of impostor person. The equation for FRR is [8]:

$$FRR = \frac{\text{wrongly rejected individuals}}{\text{Total Number of Correct Matching}} \quad (2)$$

Results are presented by stating the FRR and FAR or by graph. The lower FRR and FAR, the better the FRS [8].

3. Methodology

3.1 Context Flow Diagram

Figure 3 shows the step by step process of the prototype. The first step is to record in the FRS the person-at-large details such as name, age, gender, address, description and facial image. Subsequently, when a citizen who is already registered to the system wants to reports a spotted person-at-large, the report should include facial image, limited to -300 to 300 face angles. The location of the person-at-large should also be included via GPS. In order to submit the data, the mobile application should be connected to the Internet. Once the system received the report, the PNP will search for the top 10 matches in the database. Once the top 10 matches were identified, the system will automatically notify the sender of the report about the percentage of similarity. The police in charge must make a report and update the status of the found person-at-large in the database.

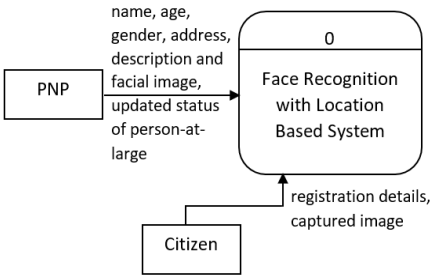

Figure 3. Context Flow Diagram

3.2 Testing Procedures

The testing procedures include the following steps:

1. Secured a signed consent form from 20 persons.
2. Captured the face images of the 20 persons using 13 megapixels mobile phone. Then register those images in the system. Figure 4 shows the sample registered faces in the database. Each person has 0^0 and 30^0 face angle shots. For a total of 40 face images.

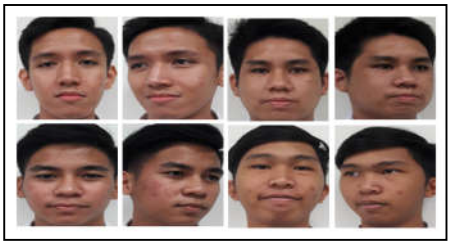

Figure 4. Sample Registered Faces

There were face images of 5 genuine (registered) individuals and 2 impostors (unregistered) that served as the test images. Zoom functionality of the camera was also utilized up to 4x magnification. Figure 5 shows the sample test image which were taken from 1, 3 and 5 meters with 0^0 (tilt up and down) and 30^0 (tilt up and down) face angles. All images have 512 pixels in width and 512 pixels in height. And each shot was repeated for 5 times for a total of 90 shots per person.

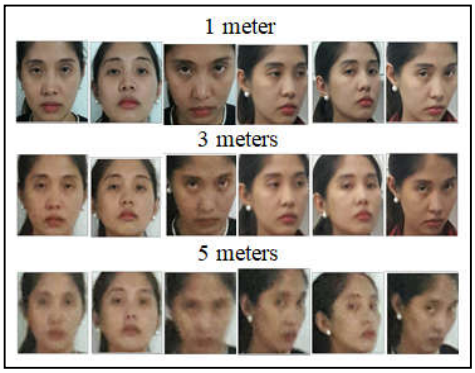

Figure 5. Sample Test Images

3. Reference threshold in the system was also assigned using 0.0 thresholds.
4. Test images in the FRS were executed.

5. The similarity index that was provided by the system was recorded.
6. Count the total number of wrongly accepted individual, wrongly rejected individual and total number of correct and incorrect matching.
7. Computation of the FRR and FAR were executed.
8. Results interpretation.

4. Results and Discussions

Figure 6 shows the performance evaluation of FR using test images with 0^0 face angle captured at varying distances. The FAR and FRR of the system both got 0% at 1 meter and 3 meters distances. Then again, the FRR increment up to 100% and FAR stays at 0% when the test image were taken at 5 meters distance.

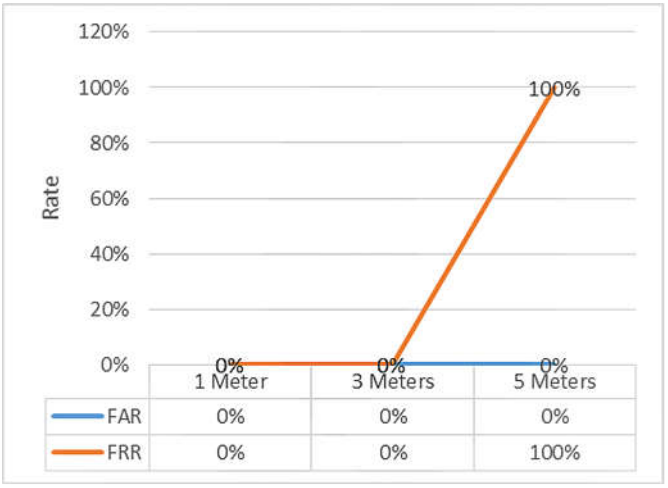

Figure 6. Accuracy of FR Base on Varying Distances

Figure 7 reveals at a distance of 1 meter, the system provides 20% FRR when the test data captured is at 0^0 tilt up and 30^0 tilt down. The FRR keep on increasing up to 40% at 3 meters, particularly in 0^0 tilt down and 30^0 tilt down. While the FRR for 5 meters got 100% rate.

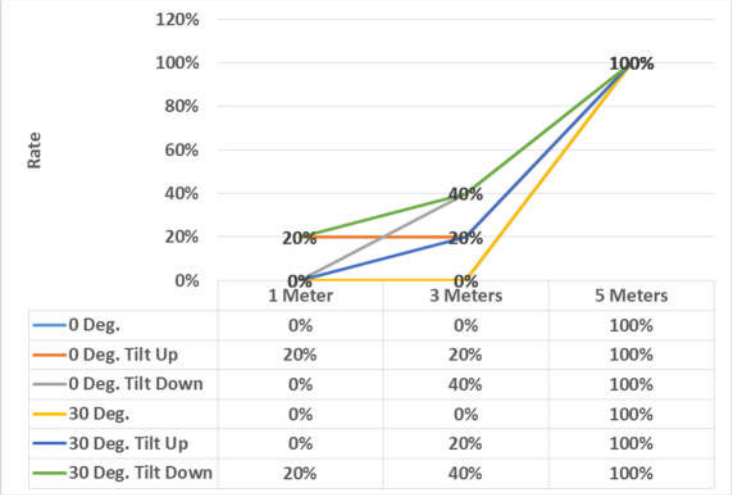

Figure 7. FRR at Varying Distances and Face Angles

Figure 8 demonstrates that the FAR in 1, 3 to 5 meters on all given face angles got 0% rate. As gleaned on the figure, the performance of the face recognition changed when varying angles and varying distances were applied.

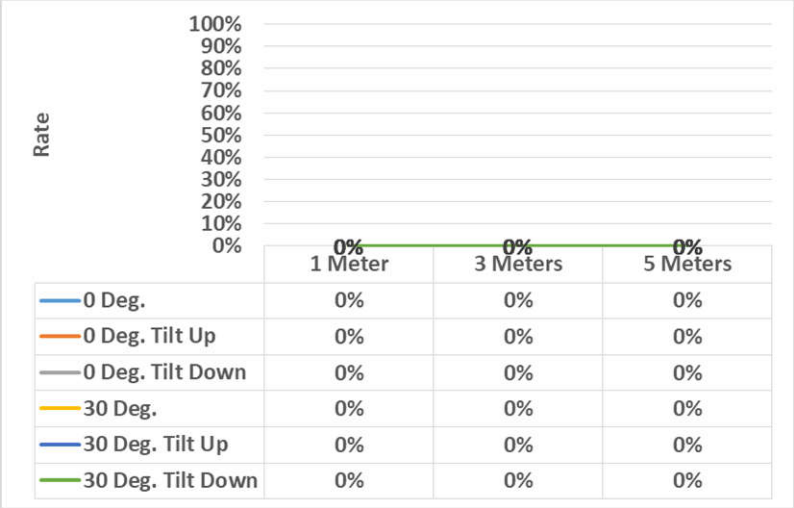

Figure 8. FAR at Varying Distances and Face Angles

Table 1 shows that the average speed of the face recognition is 2 seconds when searching a match from 20 registered individual.

Table 1. Average Speed of Finding a Match

	Speed
Test 1	3 sec.
Test 2	2 sec.
Test 3	1 sec.
Test 4	2 sec.
Test 5	2 sec.
Average	2 sec.

Table 2 shows the system provides correct location of the sighted person-at-large.

Table 2. Accuracy of LBS

	Reported Location	Result
1	Cabuyao	Correct
2	Pansol	Correct
3	Calamba	Correct
4	Parian	Correct
5	Canlubang	Correct

Table 3 shows that the system is capable of notifying the family and the reporter of the sighted person-at-large about the similarity index via SMS.

Table 3. Informing the Reporter about the Similarity Index via SMS

		SMS Notification
1	Message 1	Received
2	Message 2	Received
3	Message 3	Received
4	Message 4	Received
5	Message 5	Received

5. Conclusion

In light of the evaluation result, the False Rejection Rate (FRR) increments as the distance from the camera increments. Consequently, FRR relies upon the nature of the camera, the higher the megapixel of the camera, the lower the FRR.

Likewise, the outcomes demonstrate that the system can perceive a face regardless of whether the point of the test image is not enlisted in the database. In this way, Luxand does not utilize apple to apple matching. However, the study still prescribes capturing the face image with different face angles for higher recognition result.

Moreover, the outcome shows that Luxand recognized a face in an average speed of 2 seconds, the LBS using GPS gives 100% accuracy, and the similarity index of the sighted individual was received by means of SMS.

6. Recommendations for Future Research

1. Further examinations ought to be led by measuring the system's speed from the time of sending a report through the mobile application up to the time of receiving the similarity index by the reporter by means of SMS;
2. A comparative study should be done to compare the accuracy rate dependent on iOS cell phones; and the accuracy rate based on varying megapixels of the camera.

7. References

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