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Short Paper*

RAMY Greeting Feature using HAAR cascade classifier and HOG Algorithm for Asia Pacific College

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Special Issue on International Research Conference on Computer Engineering and Technology Education 2023 (IRCCETE 2023). Guest Associate Editors:* **Dr. Nelson C. Rodelas, PCpE (*Computer Engineering Department, College of Engineering, University of the East-Caloocan City; nelson.rodelas@ue.edu.ph*) and **Engr. Ana Antoniette C. Illahi**, PCpE*(Asst. Professor & Vice Chair, Department of Computer and Electronics Engineering, Gokongwei College of Engineering, De La Salle University, Taft Ave., Manila; ana.illahi@dlsu.edu.ph*).

Abstract

Purpose –A self-maneuvering robot called RAMY will be installed in the lobby of the Asia Pacific College (APC) building. For guests at APC, as well as for professors, students, and visitors, RAMY will act as an information hub. information about the available courses, the cost of tuition, the location of the rooms, etc. The RAMY greeting function is the subject of this study. The welcome features employ facial detection and identification, and they greet the person if they are detected.

Method –The researchers made use of HAAR Cascade for facial detection, HOG algorithm for feature extraction and classification, and pyttsx3 for the text-to-speech greeting.

Results – The results showed that accuracy has a scale of good with 85.16%, reliability has a scale of poor with 87%, and robustness with an excellent with 3.45m. From the results, the greeting feature has a low performance on recognition rates but still works great at far distances.

Conclusion – The researchers conclude that the lighting on the faces has a significant impact on the rate of recognition. To greet someone, however, you don't need to be close to the RAMYbot because the greeting feature works over great distances.

Recommendations – While currently trained datasets are being delivered, training time can be decreased by using an approach that can retain pre-trained models.

Practical Implications – The software will lessen the interactions involving close physical contact for people who need to ask questions.

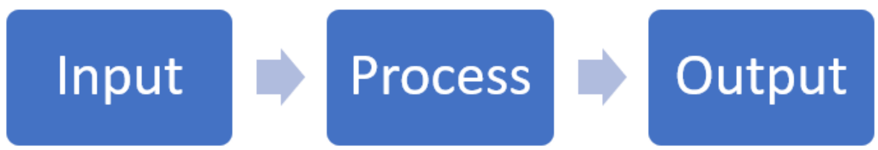
Keywords – Facial detection, facial recognition, text-to-speech, machine learning

INTRODUCTION

Technology has advanced because of ongoing inventions that have simplified our daily lives. One of the major advances in technology was the development of facial recognition in the 1960s, which began with the use of computers to identify faces by manually marking various landmarks on the face, computing the distances between the landmarks, and comparing those distances between photographs (NEC NZ, 2020). As a result of advancements in artificial intelligence, machine learning, and deep learning, facial recognition technology can now capture, analyze, and recognize facial features and match them to images of people in a database that already exists (PXL Vision, 2021). This is done by going through the processes of face detection, face alignment, feature extraction, face recognition, and face verification. Additionally, these technologies (facial detection/recognition) are used in robots, and they are referred to as computer vision employing image processing (Feng et al., 2019)..

Like how human vision processes images obtained from the eye, computer vision analyzes photos taken with a camera. They have now found their way into industrial applications like checking the size of mechanical parts, examining food for quality, conducting forensic investigations, and using computer vision for facial identification in biometrics (Nixon, 2013). Creating models and extracting data and information from images are the goals of computer vision, while image processing carries out computational transformations to images such as sharpening, contrast, etc. (Wiley & Lucas, 2018).

Changes and developments are still occurring now. Innovations and new technology have become essential, especially since the pandemic's beginning, to deal with the lack of human interaction and reduce inter-human contact(Anderson-Bashan, et al., 2018). As a result, organizations like the Asia Pacific College came up with the concept of building a robot for the APC Community called "RAMY." Different establishments suffer from a lack of human resources and are unable to make other arrangements due to the installation of COVID-19 restrictions since the number of individuals allowed outside is restricted to stop the virus from spreading further(Commission on Higher Education, 2021).The implementation of RAMY within the walls of Asia Pacific College was envisioned as a replacement or addition to the lack of human power that can recognize and greet people, respond to questions about Asia Pacific College's basic operations, such as where to look for faculty members, while also achieving a secure and contactless building and facilities for the APC Community. The group's goal is to create a system for the RAMY Robot's greeting feature that focuses only on RAMY's ability to recognize and greet people to prepare for future face-to-face classes at Asia Pacific College (Toquero, 2020). The system will involve facial recognition and will output a speech greeting once a face is detected (Toquero & Talidong, 2020).



▪ Video	▪ Detect human faces in input video ▪ Classify detected faces in input video to faces in dataset ▪ Recognize New Faces	▪ Audio Greeting

Figure 1. Conceptual Framework.

Figure 1 shows the conceptual framework of the study. The system's input is a live stream video from a webcam or camera. Once the video streaming commences, the system will then start looking for human faces. The process of facial recognition starts once a face has been detected, the system will start extracting the facial landmarks of each of the detected faces(Solomon, 2016). Afterward, the extracted landmarks from the input video will be compared to the dataset of extracted landmarks from the dataset.

The system will loop and continue comparing facial landmarks on each face until it finds a match (Batinggal & Niguidula, 2018). After finding the correct match for each face, the system will identify and recognize the faces from the input video. If the system fails to find a match of the detected face to the dataset, the system will register it as a new face.

The system's output is an audio greeting coming from a speaker. Once the face recognition is successful, the system will greet the person by the name that was matched by the system (ISO/IEC, 2018).

METHODOLOGY

Design Concept

Figure 2 shows the Process of the System Block Diagram of Face Recognition to Audio Greeting. Input Video using a webcam which is a video camera and needing for detecting a face afterward its features will be extracted to reduce the amount of data or information from the dataset so that it can easily classify the face of a person and determine or recognize whose face it is. Lastly, once done recognizing a person's face the output will result in an audio Greeting, in which the RAMY Greeting System will greet a person based on their name or as a guest.

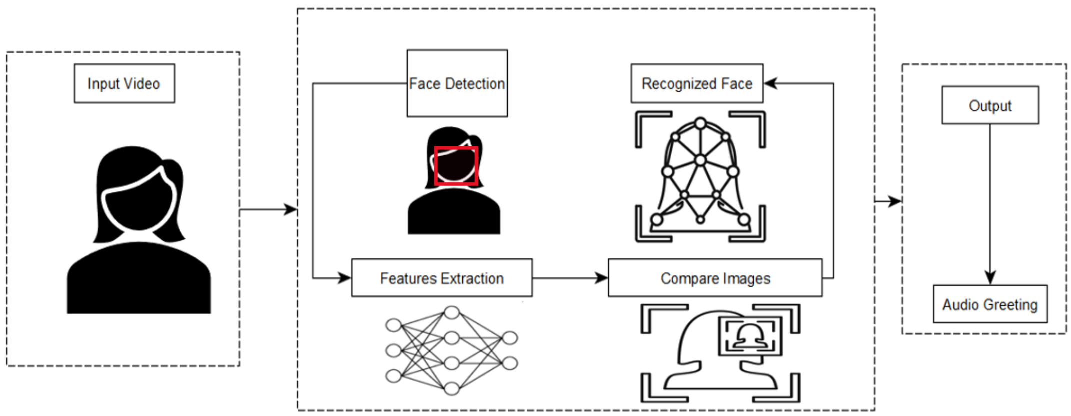


Figure 2. System Block Diagram

Function Means Matrix

Table 1 shows the summary of the agent design space selected means for each of the functions. The input video BESDER shows favorable results based on the other webcam. For the detection of faces, HAAR Cascade was the priority mean with 83.75% it is a known algorithm for face detection and recognition that produces a quick result (Mital & Shivnani, 2016). For the extraction of facial features, the priority means, HOG Descriptor, focuses on the structure or shape of an object and extracts the gradient and orientation of the edges where the orientations are calculated. When selecting the mean for face classification, the factors to consider were the objectives, accuracy, reliability, and robustness, as well as its corresponding priority weight which means SVM is the priority with a score of 92%. In record fetching of the previously recorded recognized face, the priority means is the Interpolation Search Method, as it was the fastest algorithm out of all the means in terms of record searching. Lastly, for the greeting, it was stated that using PYTTSX3 is accurate, and it is being used for a variety of purposes due to its simplicity and robustness, which resulted in a 93.75 percent accuracy.

Table 1. Function Means Metrix

Functions	Means		
Input Video	SRICAM	BESDER	Xiaomi
Detect a face	HAAR Cascade	Viola-Jones	Blob Analysis
Extract facial features	PCA	HOG	LDA
Face Classification	CNN	SVM	Naïve Bayes
Record Fetching	Linear Search	Binary Search	Interpolation Search
Greet	gTTs API	espeak	pyttsx3

Legend:

1st Option	2nd Option	3rd Option

The first function of the system is the captured image from a live video. The system uses an integrated web camera with 2MP and 30 fps for the real-time input video of RAMY.

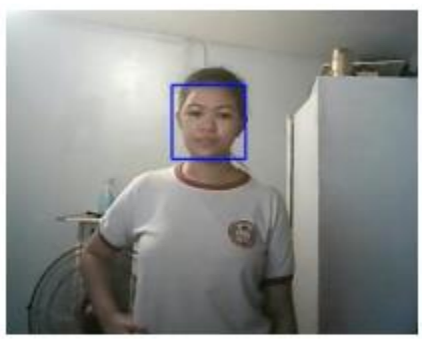


Figure 3. Detect Face

Figure 3 shows the system detects the frontal faces and profile face using HAAR Cascades. The location of the face will be determined using HAAR Cascades and a bounding box will be made around the face using the coordinates from HAAR Cascades. The bounding box will follow the face while the web camera is running.

Figure 4. Gray scale using OpenCV-python

Figure 4 shows the image that is converted into a gray scale using OpenCV-python and cropped using the location from HAAR Cascade before the feature extraction.

Figure 5 shows the system that extracts a feature of the face by its region, shape, and edges. It extracts features from the cropped and converted images in the datasets using CNN(Kamencay et al., 2017). The grayscale images are fed into the CNN model which undergoes convolutional operations such as convolution, pooling, normalization, flattening, and dense using TensorFlow Keras Layers which processes the input images and extracts the facial features.

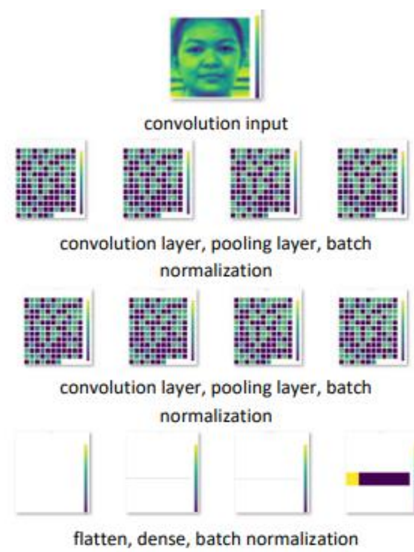


Figure 5. Extract Facial Features.

The system classifies extracted facial features of a detected face from input video and images from a dataset by comparing and identifying similarities between them. It classifies faces using the CNN-trained model after completing facial feature extraction. The system will compare the real-time detected face to the images in the datasets using the trained model of CNN which identifies similarities between the detected face and registered faces. The names of the registered people are in a CSV file which will be fetched and used to identify the names of the faces detected (Rahim et al., 2017). Figure 6 shows the face classification.

*Figure 6.*Face Classification

The system greets using the trained model of CNN which identifies similarities between the detected face and registered faces. The names of the registered people are in a CSV file which will be fetched and used to identify the names of the faces detected. It uses the pyttsx3 text-to-speech conversion library in Python to convert text-to-speech greetings. The current time will be taken from the device being used to determine the appropriate greeting for the current time. The name that was classified from the face classification function will be used to greet the detected face by name.

The system matches the names of detected faces from the input video to recorded names of already greeted faces. It records the name of the faces detected in a CSV file as well as the time when the face was detected with the format Hour: Minutes: Seconds. The time will be taken from the current time on the device being used. The name already in the CSV file will not be greeted for a specific period. This is done to avoid greeting a person continuously at a certain time.

Functional and Test Cases

Figure 7 displays the overall test phase for each function. The test for each function would start from input video to face detection then followed by Extract Facial Features. The next function would be Face Classification and the last function which is the output wherein the recognition would be greeted by an audio greeting.

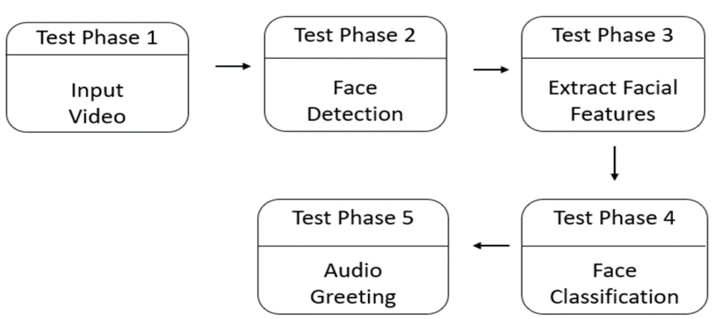


Figure 7. Function Test Phase

Figure 8 shows Test Phase 4 which is divided into two test phases 4.1 Compare Faces and 4.2 Match Faces. The compare faces would be the comparison between the faces on the input video to the faces in the dataset. On the other hand, match faces are to recognize which person the face belongs to. In other words, the matching phase is face recognition.

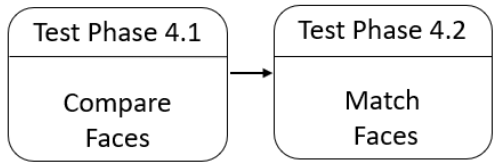


Figure 8. Classification of Faces

System Test

Figure 9shows the overall system phase of the RAMY Greeting System's test process. The figure shows the flow of the RAMY Greeting System's accuracy, reliability, and robustness once all the system's test phases are observed to achieve the system's desired output and if the objective of the project was accomplished.

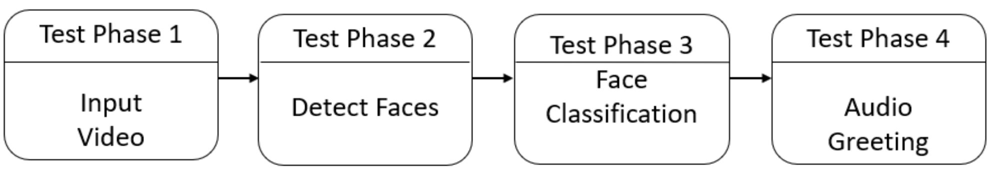


Figure 9. System Test Phase

RESULTS and DISCUSSION

The researchers conducted a system test to determine the objectives' accuracy, reliability, and robustness. The tests aim to detect and identify faces correctly and greet the person it identifies. The tests conducted were randomized where several people have undergone testing multiple times. In addition, the scenario during each trial was random such as the lighting and face orientation.

Accuracy

Table 2 shows the results of the Accuracy Testing of the RAMY Greeting Feature with a total of 180 trials. The table shows the total number of correctly and incorrectly classified recognitions. The trial conducted was randomized where several people have undergone testing multiple times. The scenario on the testing is also random, where there are times when the trial was conducted at bright or dark illumination as well as front or side view of the faces. During the testing, the researchers observed that the accuracy level of the RAMY Greeting Feature in face classification and recognition varies on scenarios such as illumination or factors that hinder the Greeting Feature to classify and recognize faces in general. The results showed that the system had an overall average of 85.16% accuracy in correctly detecting and identifying human faces in the video.

Table 2. Summary of Accuracy Testing Results

Person	No. of Trials	Total Correctly Classified	Total Incorrectly Classified	Accuracy Rate
A	30	21	9	70
B	30	21	9	70
C	30	29	1	96
D	30	29	1	96
E	30	26	4	86
F	30	28	2	93
Total	180	154	**Average Accuracy**	85.16

Reliability

Table 3 shows the results of the reliability testing. The true positive and false positive results were considered in the computation where 'True Positive' is when the name is identified correctly and 'False Positive' is when the name was incorrect and when an unregistered person was called a name from the registered people's names. The computation for the Reliability Testing of the Greeting Feature had a result of 87% precision ability to correctly identify faces. This is to know if the accuracy result of the system testing is on par with the percent average of the RAMY Greeting Features' Reliability are on terms with each other.

Table 3. Summary of Reliability Testing Results

Person	TP	FP	TN	FN	Total
A	21	9	0	0	30
B	21	8	0	1	30
C	29	1	0	0	30
D	29	1	0	0	30
E	26	3	0	1	30
F	28	1	0	1	30
Total	154	23	0	3	180

Robustness

Table 4 shows the result of the robustness testing of RAMY Greeting Features. The robustness testing is the testing of the farthest distance that the system can correctly detect, recognize, and greet people registered and unregistered. The testing consists of a total of 180 trials wherein there are a total number of 6 registered people that had undergone testing. The order of testing is random as well as the total number of trials per person. The average distance was taken from the trials made per person and the total was computed and divided by the total number of people that were in the test. The results showed that the robustness of the RAMY Greeting Feature has an overall average of 3.52m which exceeds the highest scale for the Greeting Features' Robustness objective.

Table 4. Summary of Robustness Testing Results

Person	No. of Trials	The average distance correctly classified (in meters)
A	30	3.08
B	30	3.54
C	30	3.39
D	30	4.21
E	30	3.4
F	30	3.5
Total	**180**	**3.52**

CONCLUSIONS AND RECOMMENDATIONS

The researchers aim to design a Greeting Feature for the RAMY Robot with facial recognition that greets faces that it detects. The researchers listed the design project objectives of the Greeting Feature, the Accuracy, Reliability, and Robustness.

Summary of Findings

Table 5. Summary of findings

<table>
<tr><th rowspan="2">Objective</th><th rowspan="2">Total number of trials</th><th colspan="3">Measure Parameter</th><th rowspan="2">Scale</th><th rowspan="2">System Rating</th></tr>
<tr><th>Minimum</th><th>Maximum</th><th>Average</th></tr>
<tr><td>Accuracy (%)</td><td rowspan="2">180</td><td>70</td><td>96</td><td>85.16</td><td>84.10%-89.99%</td><td>Good</td></tr>
<tr><td>Reliability (%)</td><td colspan="3">87</td><td>Below 89.39%</td><td>Poor</td></tr>
<tr><td>Robustness (%)</td><td>180</td><td>3.4m</td><td>4.21m</td><td>3.52m</td><td>Above 3m</td><td>Excellent</td></tr>
</table>

Table 5 shows the summary of findings after the researchers conducted the series of tests for each objective namely accuracy, reliability, and robustness. The table for the summary of findings includes the objective and the parameters that were measured, as well as the scale and the rating for the system. The results of the findings were evaluated based on Table 1 Metrics Description and Scale Measurement in Table 1.

In the summary of findings, the measured parameters included the minimum, maximum, and average values that were taken from the summary of a testing results table. The average value will be considered to evaluate each objective result. In accuracy, the average value is 85.16% which falls under the scale of '84.10%-89.99%' with the rating 'Good'. The reliability has an average of '87%' which belongs to the scale 'Below 89.39%' and the system rating of 'Poor'. For the robustness of the system, the average distance computed was '3.52m', it falls on the scale of 'Above 3m' with a system rating of 'Excellent'.

From the results, the researchers observed that the recognition rate varies for each person. The dataset images, the illumination, the view of the face whether it is the front view or side view, and if the person is wearing accessories that cover their face plays a vital role in the rate of recognition. Firstly, the dataset images are the most important. The number of dataset images, the quality, illumination, and variety of images regarding facial expression and view of the face help the system recognize the face of a person better. Next is the illumination, where the illumination affects the recognition rate greatly and is important to consider in the dataset images and during the trials as well.

The view of the face also affects the recognition rate whereas the full profile view of the face is barely detected and recognized. To be able to detect the face well, the person should face front and only do a partial side view of the face. The presence of accessories and anything that covers that face in dataset images will result in a high loss and lower accuracy so faces in the dataset should be completely seen. On the other hand, the system could still recognize the faces most of the time even with accessories during testing. The factors mentioned affected the accuracy and reliability of the system whereas the two have a system rating of 'fair' and 'poor' respectively. In particular, the lighting played the most critical role during testing. To be able to consistently recognize a person's face, the lighting on the dataset images should have a variety of bright and dark illumination so that during testing, the faces can be recognized in different illumination.

For the distance, the furthest that the researchers were able to test the distance was 8 meters in which the faces were correctly detected and recognized. The system's face detection works well in both bright or dark illumination and for far distances. However, the facial recognition rate varies per person and continuously decreases as distances increase. At a distance where face detection still works, the recognition is misinterpreted where another name is mentioned, or the person was recognized as a guest only. During testing, most of the people undergoing the testing were recognized above 3 meters already so the distance started at a high distance. As a result, the robustness objective yielded a scale of 'excellent' wherein the system rating is above 3 meters.

Conclusion

In conclusion, the researchers were able to design a greeting feature for the RAMY Robot using facial recognition that can detect and recognize a person in real time. In addition to that, it can recognize a person by their name through various distances as stated in the group's specific objectives. As for the real-time video streaming of the RAMY Greeting Feature and the face image data gathering for the datasets, by the guidelines of Asia Pacific College in data privacy, the group obtained permissions first before the gathering of data. On top of that, the group conducted the system testing with only the faces of those who have given permission to be recorded in respect to the privacy of students, faculty, staff, and others. The group also managed to use python as the programming language to create the Greeting Feature.

For the project evaluation using the engineering design constraints, the RAMY Greeting Feature is considered above standard when it comes to health and safety. The system replaces an actual person by recognizing and greeting faces at a distance to avoid unnecessary contact. With this, the benefits exemplify how the RAMY Greeting Feature offers a safety process where it implements public health and safety. The system is also low-cost and budget friendly as the researchers were able to minimize the budget for the project which was allocated to a web camera at a low price with a reasonable specification. In addition, the RAMY Greeting Feature greets the people caught in front of the web camera's field of view. They will receive a greeting from RAMY whether they are a registered or an unregistered person. A registered person, once recognized, receives a greeting with their name while an unregistered person receives a greeting calling them 'guests'. However, not all people caught in front of the camera receive a greeting due to certain factors such as lighting conditions, distance, face orientation, and accessories covering the face that affects face detection and recognition. Furthermore, the RAMY Greeting Feature ensures the privacy of the people caught within the camera range as the greeting feature doesn't record the live-video streaming of the greeting feature and the only ones included in the dataset are those who have given their permission to take face images for classification.

The design functions implemented for the RAMY Greeting Feature using datasets, which were acquired via a smartphone camera to get images added to the dataset is one of the key roles, as the result of the overall system evaluation depends on the input and quality of the images in the dataset. The illumination in the image as well as in the input video also plays a big part in the face classification or recognition of the greeting feature as observed in the Accuracy and Reliability Testing trials where some of the faces in the dataset are not recognized and classified correctly in certain circumstances due to having not taken different illumination for the dataset which resulted to a face not recognized in bright illumination at a certain distance but is recognized and greeted when the lights are turned off or when the illumination is dim. This means if a certain face only gets its dataset taken in a bright illumination, then the person would only get to be recognized by the Greeting Feature with a bright illumination. Distance Testing, on the other hand, depends on the quality and resolution of the image in the dataset. In conclusion to this, the RAMY Greeting Feature has proven to be able to detect, recognize, and greet faces as the group's objective to design a Greeting Feature for RAMY Robot using Facial Recognition. The detailed results of the group's specific objective are summarized and were able to conclude the following:

- The RAMY Greeting Feature had an accuracy of 85.16% which is evaluated as Good and 87% for reliability and an evaluation of Poor in the group’s objective metrics and scale measurement.

- The Robustness of the RAMY Greeting Feature achieved an excellent system evaluation with a 3.52m average distance to correctly detect and identify a face.
- The Greeting Feature shows potential in detecting and recognizing faces at far distances if given better specifications for input video and high quality and resolution for datasets.

Recommendations

During the testing of the system and project development, the researchers distinguished some things about the designed project that can still be improved. Due to time restrictions, some issues were not settled during the development. For future researchers, the researchers recommend those listed below to use reference as a study in developing a similar technical design to make further improvements.

- For the Greeting Feature to thoroughly classify and recognize the face the needed datasets per person is 200 pictures with no distractions like Id lace, designed shirt or polo, etc. or replace HAAR Cascade with a non-sensitive algorithm for better cropping.
- Use an algorithm that can retain a pre-trained model to reduce training time and only trains the new datasets.
- Add a function that automatically takes picture of faces and adds it to the datasets and crops the images in individual folders to stack new ones inside it, rather than overwriting everything with new cropped images.
- Use histogram equalization to improve the contrast and illumination of the pictures.
- For better performance of the system, equipment with a GPU and at least 8 to 16GB RAM is preferred.

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The researcher wants to express their gratitude to Almighty God for assisting them in finishing this task and for bestowing upon them the courage, health, and fortitude to overcome all the challenges. They also give God praise for guiding them each day from the outset. The researcher wishes to convey their sincere appreciation to everyone who helped them during the system development and planning phases. APC teachers, students, and security guards willingly provided test data and free time to execute test cases.

DECLARATIONS

Conflict of Interest

All authors declare that they have no conflicts of interest.

Informed Consent

The images of humans involved as participants in the study are the researchers of the project and have full consent to submit and publish in international journals.

Ethics Approval

The conducted research uses only scene text datasets which are gathered through system testing and images of humans as participants in the proceedings are the researchers themselves and have the consent of the full ethics to be published.

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