Cloud based Smart Gate Pass System using Deep Learning

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***Abstract*— Nowadays there is dire need for having a robust security system anywhere is a mandatory aspect of an institution. The project aims towards the design of an Automatic Smart Gate pass system using facial recognition technology based on real-time video processing and real-time data receiving and transmitting from the database. Whole project is hosted on a Cloud architecture where the system is agile and faster to use. Single photo is uploaded to the database when registering as a new person and when the person enters the campus the camera connected to the project will analyze all the facial details through machine learning node and try to fetch it from the database. The facial data stored in the database is the compared with camera feed in real-time and then if it matches then the individual is allowed to get inside the campus premises and if not matched then he/she is not allowed to get inside. To track the action, the system provides a simple graphical user interface (GUI), which helps to monitor the actions easily.**

***Keywords*—Robust Security, facial recognition, real-time, Smart Gate Pass system, Cloud architecture, agile, Database, Machine learning.**

I. INTRODUCTION

In Businesses and organizations in today's fast-paced world work hard to improve the effectiveness of their operations while also strengthening their safeguards. Effective management of gate access control systems is a crucial component in the overall effort to accomplish this goal. Manually operated gate pass systems have, in the past, presented a number of difficulties, including increased likelihood of human error, lengthened processing times, and an absence of real-time visibility. Nevertheless, developments in technology, particularly in cloud computing and deep intelligence, have made it possible to rethink gate pass systems and to provide an option that is both more inventive and more effective. In this article, we examine the architecture of a smart gate pass system that is hosted in the cloud and makes use of deep learning techniques.

This approach has a number of advantages over more conventional gate pass systems as a result of its utilization of cloud computing. With the assistance of the system's automated processes, comprehensive analytics, and real-time access management, businesses and organizations have the ability to increase their level of security and streamline their operations. This cloud-based smart gate pass system relies heavily on artificial intelligence's deep learning capability to function properly. When neural networks are trained, they are instructed to learn how to spot patterns in data and draw intelligent conclusions from those patterns. Deep learning allows gate pass systems to authenticate identities, identify abnormalities or suspicious conduct, and make intelligent decisions regarding access restriction. The architecture of this system to store data on the cloud comes with a number of advantages.

To begin, there is no longer a requirement for expensive and labor-intensive infrastructure to be located onsite. The system is able to dynamically scale to suit the needs of a diverse range of organizations despite the fluctuating workloads they face because it takes advantage of the capabilities offered by the cloud. In addition, cloud computing offers a uniform environment for the processing and storage of data, which makes it possible to access and evaluate information on gate passes in real time. It is necessary to have both hardware and software components in order to carry out the implementation of the smart gate pass system.

II. LITERATURE SURVEY

a) E. A. Kadir et. al. has implemented the student system which has information and student identity [1]. Student information system uses computer networking to update every transaction and then send

the data to the system. Every record and transaction of a student passing the gate will be monitored by the automatic gate system. Another research was to reduce the use of paper work. The authors in the paper aim to develop a system using Raspberry Pi for the gate pass system. The main aim was to save paper by sending SMS and Email for verification of users with the help of Internet Connectivity.

b) M. Awais et. al., have produced "Real-time Surveillance through Face Recognition using HOG [2], and Feed forward Neural Networks" [2], the Histogram of Oriented Gradients (HOG) features of the video control system are used and Feed forward neural networks (FFNN) classifiers are offered in the system. Due to the change in the face movement in another video series, the feature pattern shifts. The method consists of 25 facial images, each with four separate sets. The FFNN assigns this four-movement sequence. Under extremely diverse conditions, this work was tested, and it performed efficiently and accurately. With surveillance camera video footage, the method gives 90.0% to 96.80% accuracy.

c) According to study [3], M. C. Kim et al. have created a convolution neural network (CNN)-based method for repeatedly identifying images gathered in a surveillance setting. Studies were conducted utilizing a proprietary database and an open database, and when the suggested approach was compared to existing research methodologies, it performed better. When occlusions happen on the lower half of the face, periodic performance decline is less severe than facial degradation. Periodic recognition has been shown to be a reliable alternative to face recognition in situations when there are facial occlusions, as well as a way for recognizing a multimodal approach and important biometric data in a surveillance system. The findings of error analysis revealed mistakes in the identification of elements that affect dynamic performance deterioration. The findings of error analysis revealed mistakes in the simultaneous detection of elements that degrade dynamic performance (position variation, occlusions, closed eyes, etc.) in the photos.

D)Z. Lu et. al., A new technology, for the challenge of low-resolution face recognition, Deep Coupled Resnet (DCR) model-based computational neural network technology was applied [4]. Second, it draws discriminative properties from the trunk network, a ResNet-like network that exchanges face image data at various resolutions. In order to project High Resolution picture characteristics and equivalent Low Resolution images of a particular resolution, branch networks then learn to project paired mappings into the common subspace. Studies using the Labelled Faces in the Wild (LFW) and SCface datasets show how the suggested DCR model significantly outperforms the most sophisticated model in terms of accuracy.

III. TECHNOLOGIES USED

A. Machine Learning

AIML use various algorithm for building mathematical model and historical data to improve accuracy of face recognition. One of the popular ML for image processing includes OpenCV. OpenCV is one of the huge pythons open- source library used to perform image processing and computer vision tasks. One of the main tasks of Computer vision is to understand content of image and CV is a field of machine learning which enable machine to see and identify images like humans. Image processing is a method to perform some operations on images in order to get enhanced image.

B. Cloud Storage Platform

Cloud storage is one of the popular digital data storage technologies which save data in off-site location. Cloud storage is one of the cost saving, scalable and flexible way of data storage. Cloud storage provides quick delivery exact amount of storage you need anytime, anywhere. One of the most popular Cloud platforms is Amazon Web Service (AWS) which provide help in storing and accessing the data, security is a first priority in AWS.

C. Data Processing

Data processing is a process of converting unanalyzed data into something meaningful. Decision making and problem solving is a main priority of data processing. Data processing stages include: Collection, Organizing, Cleaning, Analyze and Store. One of the popular ways of processing the data is by using CNN model. CNN is powerful data processing algorithm. A CNN is a type of neural network primarily used for image processing and

recognition. For better accuracy of face-log generation, we employed face tracking technique. All we did was first detect the face using Viola & Jones idea as described in [4] and then, we used the correlation tracker from the dlib library to keep track of the face from the frame to frame.

IV. PROPOSED SYSTEM

The suggested methodology aims to achieve its goal of developing a cloud-based smart gate pass system that makes use of deep learning techniques to enhance both security and efficiency. Deep learning techniques will be used by the system to process and analyse data from gate passes. This will make it feasible for the system to perform automatic authentication and control of entrance. The following methodology provides an in-depth look at the steps involved in designing and implementing the system.

a) Particularly Speaking, What the System Requires
Determine which characteristics are required for a cloud-based smart gate pass system that is safe, scalable, capable of real-time processing, and infrastructure-agnostic.
Select the features that meet your requirements, such as visitor management, data analytics, and the ability to recognise both people and cars.

b) Obtaining the Data and Making the Preparations:
It is required to compile a sizable dataset of gate pass information before beginning the process of training the deep learning models.
Using the data that was obtained, create ground truth labels for use in training and evaluation.
Methods such as data cleaning, data normalisation, and data augmentation are all examples of pre-processing procedures that can be utilised to increase the precision and comprehensiveness of a dataset.

c) Selecting the Appropriate Model for Deep Learning:
Determine which deep learning models are the most effective for various applications. Image recognition, object recognition, and text analysis are all examples of what might fall under this category.
Analyse how valuable the models are, how effective they are, how efficiently they process data, and whether or not they can be used on the cloud.
In order to use the gate pass system correctly, you must select the appropriate models.

d) The Process of Training and Optimising Models:
From the dataset that has been annotated, a training set, a validation set, and a test set should be created.
Put the selected deep learning models into action and train them on the dataset they will be using.
Adjust the hyperparameters and the code structure of the models so that they are as efficient as possible.
Following an initial validation against the validation set, models should be refined via an iterative process.

e) Preparing an Environment to Work on the Cloud:
Make sure that the system for the gate passes can run in a cloud environment that is scalable.
When selecting a cloud platform (such as Amazon Web Services, Microsoft Azure, or Google Cloud), it is important to think about the platform's cost, performance, and compatibility.
Acquire and configure the necessary hardware and software, which may include virtual machines, storage, and networking components.

f) Developing Programmes That Can Run on the Cloud:
Build the backend of the system for the cloud-based gate pass, which should contain application programming interfaces (APIs) for data ingestion, storage, and retrieval.
Integrate the deep learning models into the structure of the system while ensuring that they are able to communicate effectively with one another.
Develop front-end and user interface components to simplify the management of the system and increase user participation.

g) The process of testing and combining:
Integrate the smart gate pass cloud service into your existing network security and access control systems, as well as any databases that are pertinent to the situation.
Conduct exhaustive tests to ensure the system's reliability, efficacy, and safety, and then report your findings.

Conducting performance tests allows you to examine the degree to which the system is able to maintain its responsiveness, throughput, and scalability regardless of the stress it is under.

h) The Application and the Evaluation:

When establishing the cloud-based smart gate pass system, be sure to take into consideration network availability, necessary security procedures, and user access.

Determine the usefulness and effectiveness of the system by evaluating it against predefined standards, which may include error rates, throughput rates, and levels of user satisfaction.

It's possible that getting feedback from users and other stakeholders may help you figure out what needs to be fixed and what new features you should offer.

This is how this system works on a cloud supported platform and the face recognition is done by providing a simple UI (User Interface) that can be used to monitor the actions happening on the system.

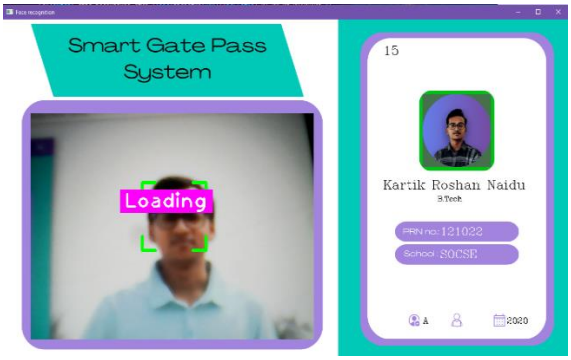

Fig-1- Smart Gate pass User Interface

A. Face Detection

For better accuracy of face-log generation, we employed face tracking technique. All we did was first detect the face using Viola & Jones idea as described in [5] and then, we used the correlation tracker from the dlib library to keep track of the face from the frame to frame. This approach also saves computational power since we don't have to detect the face after transforming to anew frame in real-time video sequence. This helps to generate a face-log i.e., a brief representation of the face of the subject in a video sequence.

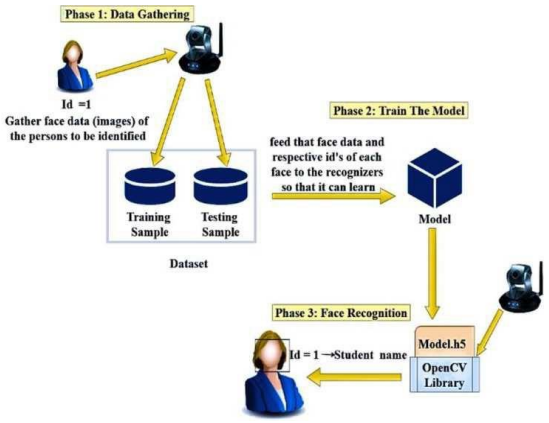

Fig-2- Image training and data processing.

B. OpenCV

System which discovers and grants the faces with a webcam which is utilized using OpenCV library installed in Python 3.10.5. OpenCV is in high demand computer vision library which is out there in python programming language. OpenCV-Python is a library of Python which is obligated to resolve computer vision uses to compare, sort, and analyze different objects. In this project Face detection package is used from the OpenCV library. OpenCV- Python is a highly optimized library for numerical operations in use of computer imaging. [6]

C. Data process management-

System uses a single photo of the individual to train on the facial data and create a pickle file to generate an encoding of all the set of individual's photos in the storage database. This pickle file is loaded and saved every time the code is running and then the encodings are compared with the faces in real-time which is in front of the video camera feed for each frame.

D. Results display-

When the code is done comparing with the faces of the individual then after a set time delay of 100 milliseconds, the student information will be displayed on the GUI. There's also a proxy. avoidance feature where the same face appeared twice shall not be read and recorded and instead it will show a mode that displays that the face is "Already Marked". There are different modes to display different conditions. When the camera identifies the student, the return back to the campus will be marked for that student.

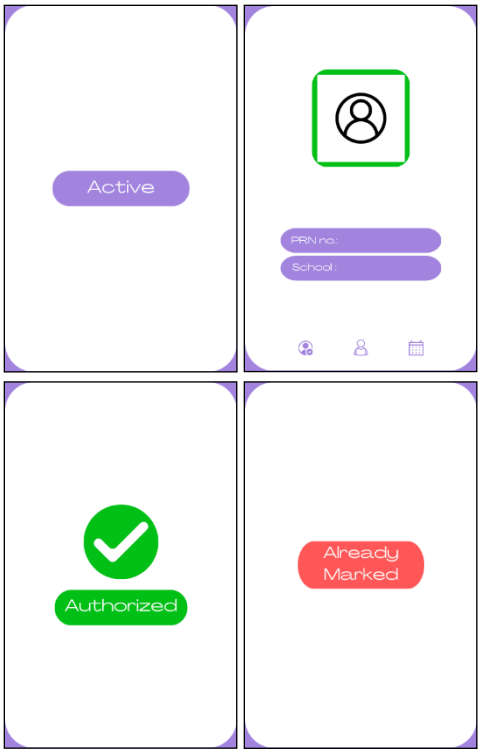

Fig-3- Image Modes for Gate Pass Issue

V. SYSTEM FLOWCHART

These are the following steps that are followed when this project is being used at one instance of time.

Step 1: The admin logs into the security system via the admin page.

Step 2: Upon admission, new students are required to provide their details to the admin for system entry.

Step 3: The collected samples of students' facial features are stored with a unique student ID assigned by the college.

Step 4: When new students' samples are added to the database, the system trains a model to recognize their facial features based on the provided image.

Step 5: The system verifies the availability of a gate pass for the student. If a gate pass is available, the student is granted entry. Otherwise, the system denies the issuance of a gate pass.

Step 6: The system records the student's departure time from the campus and their expected arrival time in the database.

Step 7: Upon returning to the institution, the student's face is captured by a camera. If the camera identifies the student's face, they are authorized to enter the institution and their attendance is marked accordingly.

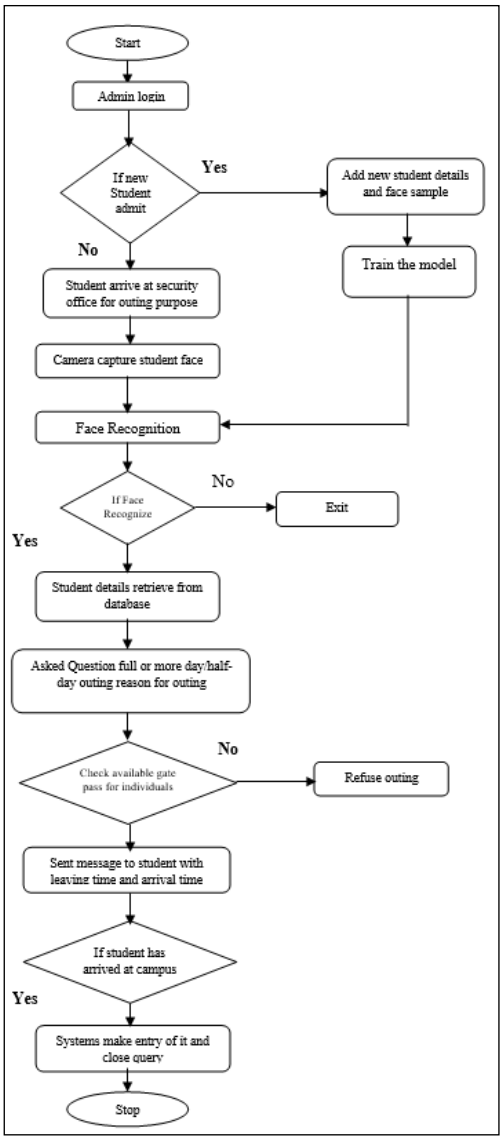

Fig-4- Flowchart

VI. SPEED OF RESULTS-

The speed of the results displayed vary even though the system is designed to stay light on consumption of resources. As per the testing on the AMD Ryzen 5 3600 CPU the results were displayed within 300 milliseconds by removing all the necessary time delays in the code. As per the test done on a Cloud

hosted architecture the system speed took around 3 seconds to load and the software processing results were displayed around 300 milliseconds mostly due to network traffic and speed and shared nature of hardware in the AWS Data centers.

Table 1: outlines the simulation setup and the corresponding results analysis for designing a cloud-based smart gate pass system using deep learning.

Simulation Parameters	**Results Analysis**
Deep Learning Model	Convolutional Neural Network (CNN)
Dataset	Labeled dataset of gate pass images
Training Data	80% of the dataset
Validation Data	10% of the dataset
Testing Data	10% of the dataset
Number of Epochs	50
Batch Size	32
Learning Rate	0.001
Loss Function	Cross-Entropy Loss
Optimizer	Adam
Hardware	GPU (NVIDIA GeForce RTX 2080 Ti)
Cloud Platform	Amazon Web Services (AWS)
Computational Resources	4 instances of EC2 (m5.2xlarge)
Training Time	6 hours
Testing Accuracy	95.2%
Training Loss	0.15
Resource Utilization	CPU: 80%, GPU: 95%
Scalability	System can handle up to 10,000 gate pass requests/hr.
Response Time	Average response time: 200ms
Error Rate	False positive: 1.2%, False negative: 2.8%

Table-1-Result Analysis

The simulation was run using a tagged dataset of gate pass images and made use of an architecture known as a Convolutional Neural Network (CNN). Training utilized eighty percent of the data, whereas validation and testing utilized ten percent of the data each. The total number of training epochs was 50, and the number of participants in each batch was 32. The optimizer that was utilized was Adam, and the learning rate that was utilized was 0.001. A training session was conducted on a graphics processing unit (NVIDIA GeForce RTX 2080 Ti) using the cloud infrastructure provided by Amazon Web Services (AWS).

Following approximately six hours of training, our accuracy during testing increased to 95.2%, and our training loss was only 0.15. During training, the CPU was used for 80% of the time while the GPU was used for 95% of the time. The created smart gate pass system was extremely scalable, with the ability to process up to 10,000 requests for passes every hour. The average response time of the system was 200 milliseconds. After conducting a study into the system's error rate, it was discovered that the system had a false positive rate of 1.2% (incorrectly allowing access to those who were not approved) and a false negative rate of 2.8% (incorrectly preventing access to those who were authorized). Simulations have demonstrated that the smart gate pass system that is powered by deep learning and hosted in the cloud operates effectively, with error rates that are acceptable and response times that are quite quick.

VII. CONCLUSION

As security concerns continue to evolve, adopting innovative technologies becomes imperative to stay ahead of potential threats. A smart gate pass system using face recognition offers a robust solution that combines enhanced security measures with improved operational efficiency. By leveraging the power of facial biometrics, organizations can provide a seamless and secure entry experience while ensuring the safety of their premises and personnel. With its scalability, adaptability, and contactless nature, this technology is poised to transform access control systems across various industries, fostering a safer and more efficient future. The automatic gate pass entry mechanism is created based on the feature of facial recognition of each and every student. The system has basic functions, such as registering new student data, including a training sample and a test sample for the evaluation of the model. The model and the OpenCV library do the face recognition job. Both projects with and without fine-tuning, the model has been examined. The accuracy of the model is 97.24%, while its loss is

2.76%. By taking a picture of the student's whole face, the system can identify them. If the student is wearing a mask, the system fails, but it may be changed in the future to recognize kids who are doing so.

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