Real-Time Criminal Identification System Using CNN-Based Facial Recognition and Haar Classifier on Mobile Platforms

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***Abstract*— Criminal identification systems are crucial in modern law enforcement, enabling rapid and accurate suspect recognition. This research presents real-time face recognition using an automated surveillance camera. The proposed system consists of 4 steps. First, training of real-time images. Then, face detection using the Haar-classifier. The next step is matching the security camera footage with the trained real-time images—the final result of the comparison. There is a need for automated monitoring systems that can detect watchlists. This research demonstrates a robust system capable of real-time face detection. In OpenCV, face tracking is accomplished using Haar-like classifiers. The facial recognition system works well. The suggested system's ability to recognize several faces quickly is invaluable for rapid suspect searches. The government of India uses Aadhaar to keep track of its citizens. To investigate crimes, we can utilize this citizenship database to distinguish between citizens and foreigners. Our dataset consists of 2000 images for five persons; every person has 400 face images. The system's accuracy is 95.5 % after splitting the dataset to 80% for training and 20% for testing using the CNN model.**

***Keywords*— Criminal Identification, CNN, Facial Recognition, Haar Classifier and Mobile Platforms.**

I. INTRODUCTION

For decades, people have relied on paper cards, such as Visa, MasterCard, etc., to obtain available services. These cards are used to identify the cardholder with his data and get his service after placing the cardholder [1].

Over time, the number of cards increases with the person, which exposes him to theft, or these cards are forged, leading to the impersonation of the cardholder [2]. From this point of view, we will develop a program through which the person is identified by taking a picture of the face. The features and characteristics are extracted from the face and compared to those in the database. Then, we will view the person's data and verify his identity [3], [4].

Everyone has distinctive facial characteristics that do not lead to falsification or impersonation of anyone through the program, which will be developed on Android [5].

The camera captures and analyses the image using artificial intelligence algorithms to ensure accuracy in identifying people and displaying the person's data correctly. As a result, traditional methods of identifying people using cards are replaced safely and are not subject to counterfeiting or forgery [6]. Humans are very good at recognizing faces and complex patterns. Even a passage of time does not affect this capability, and therefore, it would help if computers became as robust as humans in face recognition [7], [8]. Optimizing deep learning models can enhance security measures for mobile devices, a strategy that aligns with improving secure AI-driven recognition frameworks [9]. Based on biometric artificial intelligence [10], the program uses a person's facial texture and form to identify them uniquely.

It has evolved from a desktop program to one used on smartphones and even in robots. It works similarly to biometric authentication technologies like fingerprint or iris scanning [11][12]. Although face recognition systems are not as precise as iris or fingerprint detection systems, they are popular due to their contactless and non-invasive nature [13]. Its use in brand recognition and advertising has grown in recent years. Other uses include video databases, enhanced human-computer interaction, picture indexing, and video surveillance [14], [15]. Figure 1 shows a face recognition system.

II. LITERATURE REVIEW

In [16], the authors use surveillance video to compare images with a criminal database if fingerprints cannot be identified at the crime site. This approach has five stages, and the first is to plan an inquiry into the manufacturing process and its causes. Designing the system was the second step in the requirement analysis process. System design and process requirements were part of the third step, design. The final step is to build and test the system using Principal Component Analysis (PCA) [17], [18]. Regular maintenance was not done because this technology was created in a controlled setting. Using principal component analysis (PCA), the authors identified offenders in database images and videos by identifying similar traits[19]. The system will show the person's details from a database once FRCI recognizes their face. Visual Studio Code is used to construct the system interface, while MATLAB R2013b codes the database [20][21].

The model attained an accuracy of 80%. Using a Harr classifier for face recognition and real-time picture training are two of the four stages of this project. Step three compares the results of the two sets of images; step four implements the changes[6],[22]. One method for identifying faces is the Haar-classifier on Open-CV, while another is the Haar-cascading method [23], [24]. Using classifiers similar to Harr, OpenCV can track faces. The system's ability to identify many people suggests it might help locate possible perpetrators. Compared to its predecessor, the new method provides far more precise results. They can use the Adhar database to check whether someone is a criminal, identify foreigners and Indians, and more [25][26]. With this fix, we can use the existing citizenship database.

A. System design

While our system's requirements are pretty specific, there are multiple ways to design it. We need to answer various questions to determine which design to choose.

For example:

- What platform should the system be deployed on? Mobile platforms? Desktop? Web?
- What Database system to use? SQLite engine? No-Database system?
- What type of programming language/s to use? One that favors performance? or one
- Does that have the proper tools for the job?
- We have chosen to build this system as a mobile application since it is the most suitable to our system structure with the user interface.

B. Context Diagram of the system

While not the most comprehensive diagram. We will then expand it into a complete data flow diagram and explain its functions.

C. Data flow diagram

It is then used as a reference in the implementation chapters to guide us to what functions must be implemented.

D. Activity diagram

the activity of the system The sequence diagram depicts an interaction between the user, system, and dataset in a sequential order. The state diagram describes the system's behavior, and the use case diagram describes the interaction among the elements.

E. Context diagram

Everything, both within and outside the system, as well as its interactions with external components, is laid out in this diagram, which serves as an overview of the system that will be shown.

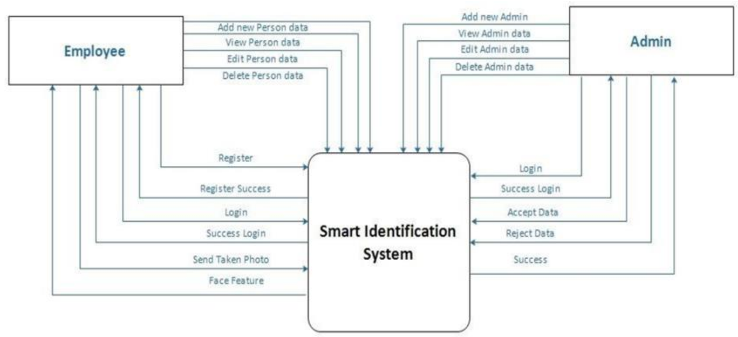

Figure 1. Context Diagram.

F. Sequence diagram:

The following Figures 2 and 3 demonstrate the system sequence diagrams. These diagrams show the communication messages between the user and the system. There are two scenarios for the sequence diagram: first for the employee scenario and second for the admin scenario.

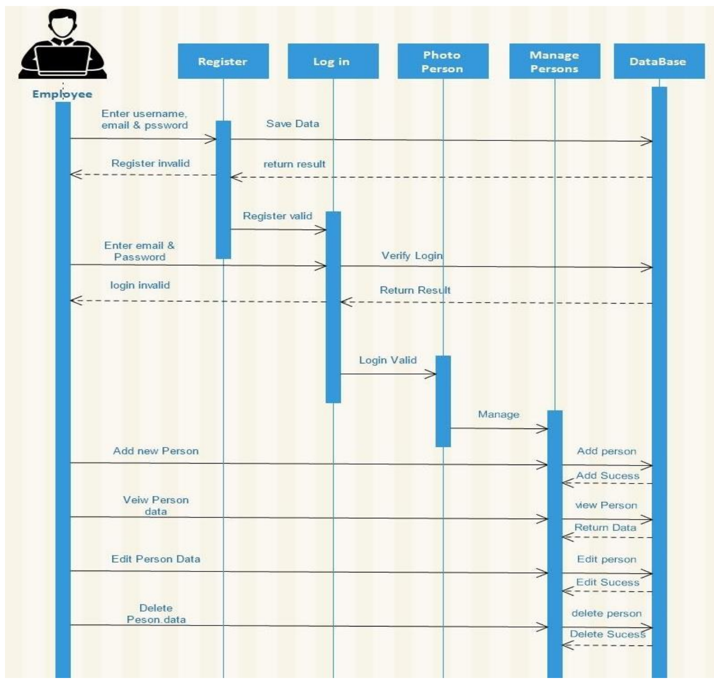

Figure 2. Employee Sequence Diagram.

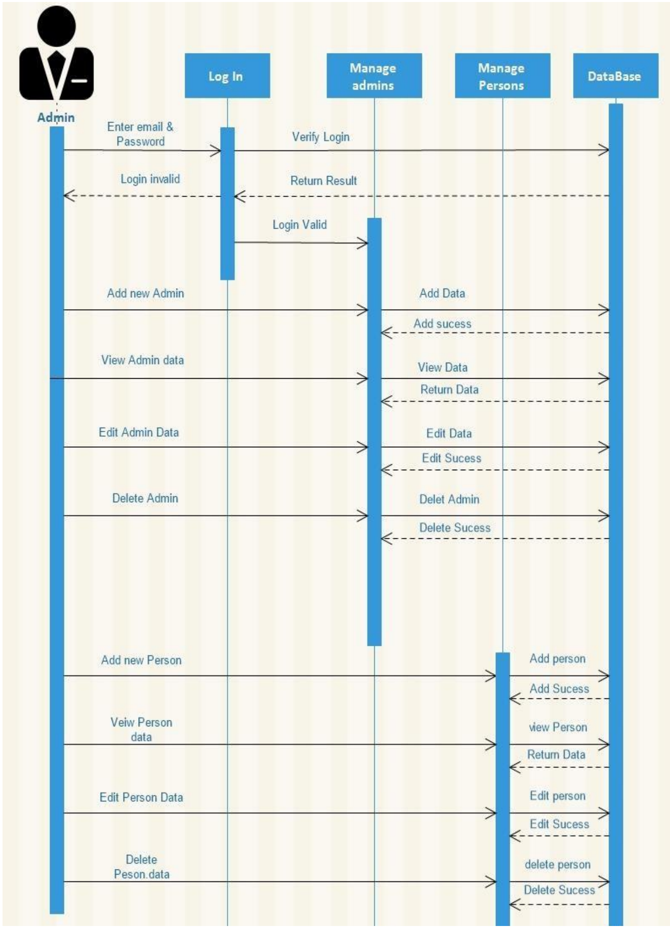

Figure 3. Admin Sequence Diagram.

F.State diagram

State diagrams show how the system or its parts are in their current condition at certain times. Figure 4 shows a behavioral diagram with a limited number of state transitions. Another name for state diagrams is state charts. However, they are sometimes called state machines.

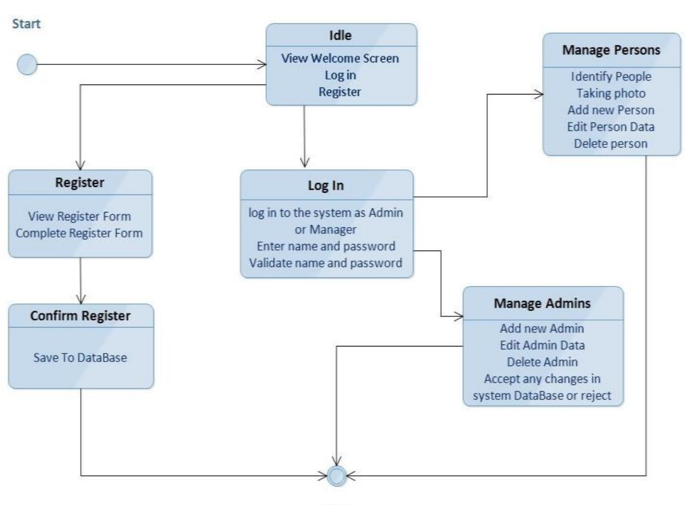

Figure 4. State Diagram.

G. Use case diagram:

It presents the case diagram of the proposed system, which demonstrates the system usage from its manager's and admin's perspectives, i.e., it shows the interaction between the system and its users in terms of what each user can do in the system [27] [28]. Fig. 5 shows the case diagram. Managers can manage admins and manage persons. Also, the admin can manage persons, make registrations, and take images of them for detection.

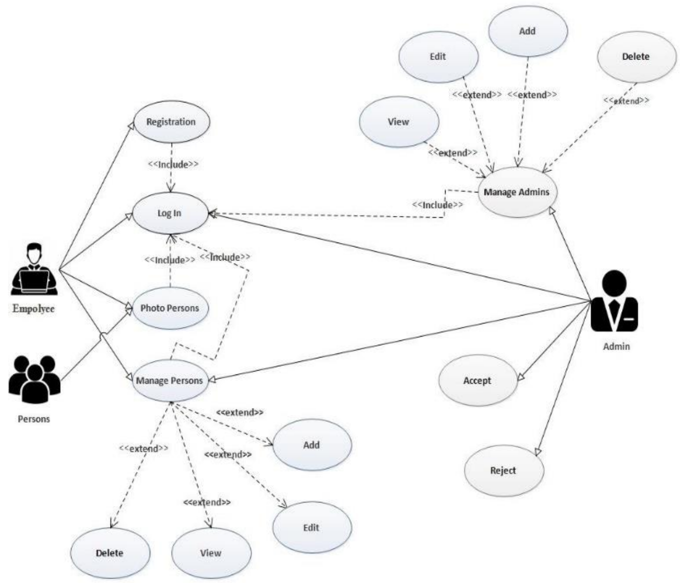

Figure 5. Use case Diagram.

H. Description of entities

- Employee: the employee responsible for identifying a person, entering, updating, and deleting personal data.
- Admin: The manager controls the whole system.
- Criminal: the person who will get identified by the system and store his information.

I. Description of relations

- Employee- – Person is one too many relationships as one employee can manage many people's data.
- Employee-Person Features: There are too many relationships as one employee can save and select many persons' features.
- Admin – Employee is one of many relationships; one admin can manage many employees' data.
- Admin – Criminal is one of many relationships; one admin can control many people's data.

J. Entity Relationship Diagram (ERD)

Databases play a crucial role in software. An excellent database design is ensured for development, administration, and maintenance when an ER diagram is used effectively in database engineering. Communication is made easier using ER models [29]. Pictured in Figure 6 is an ERD depicting database entity sets. An entity is a data object in this context. Identifiable entities are a part of entity sets. The attributes of these entities can be defined by their traits [30]. The nouns are called entities, and the verbs are called connections. They mirror grammatical structure, with entities as nouns and relationships as verbs [31].

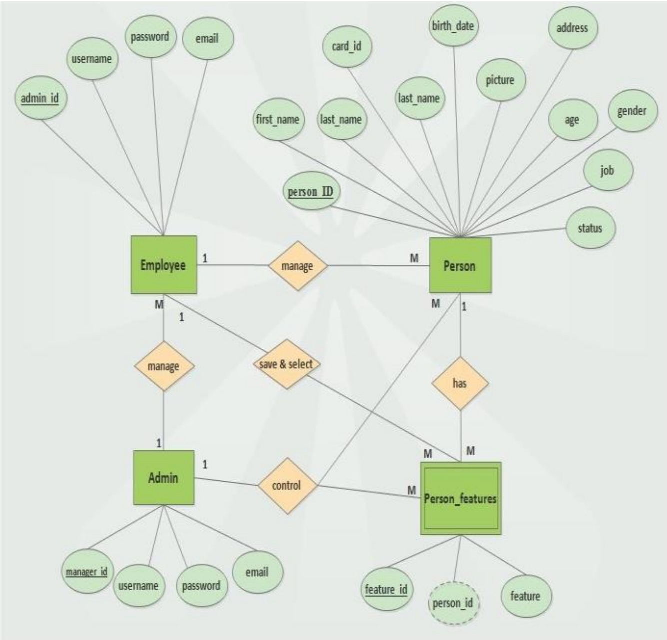

Figure 6. Entity relationship diagram (ERD).

K. *Class diagram*

A class diagram in the Unified Modelling Language (UML) is a type of static structure diagram that describes the structure of a system by showing the system's classes, attributes, operations (or methods), and relationships among objects. Fig. 7 shows the class diagram.

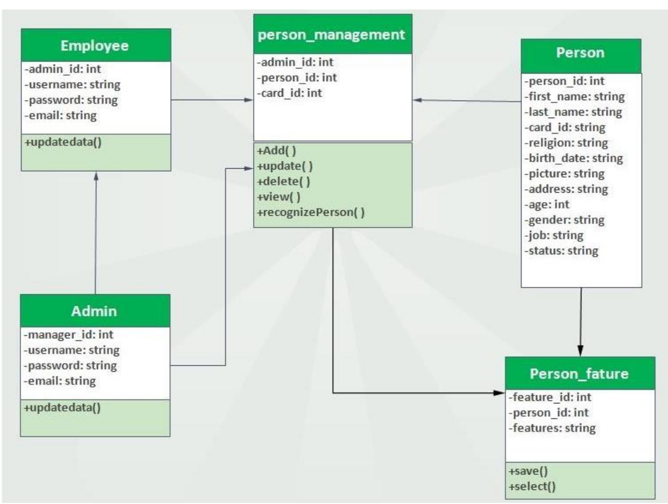

Figure 7. Class Diagram.

III. METHODOLOGY

A. *Face detection using haar cascades*

A paper written by Paul Viola and Michael Jones in 2001, "Rapid Object Detection using a Boosted Cascade of Simple Features," states that object identification using cascade classifiers based on Haar features is successful [32]. With machine learning and a flood of positive and negative pictures, it trains a cascade function. Following that, it can recognize items in different images [33].

In this case, face detection is being used. The technique requires many pictures, both with and without faces, to train the classifier. We must remove its characteristics. Figure 8 displays the Haar characteristics that were used for this purpose. Our convolutional kernel is similar to them. The number of white rectangle pixels subtracted from the number of black rectangle pixels yields a single value for each feature. Currently, many characteristics are computed using all kernel sizes and locations. Consider the amount of processing power that would be required [34].

A 24x24 window has over 160,000 characteristics. Add all the pixels below the white and black rectangles when calculating features. They solved it using integral pictures.

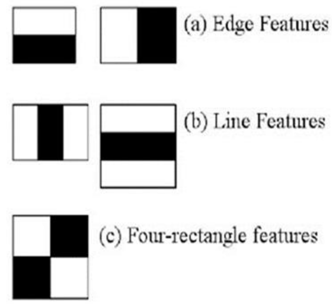

Figure 8. Haar features.

It sets a cap of four pixels for the pixel sum computation. Efforts are multiplied. Our computed characteristics are primarily meaningless. Here is the picture that was requested [35]. There are two positive aspects to the top row. The first distinguishing feature is a darker eye color than the rest of the face, especially the nose and cheekbones. Considering that the region around the eyes is darker than the nasal bridge provides the basis for the second characteristic. It makes no difference, however, if the windows on different body parts are identical [36].

B. *Haar Cascades detection in OpenCV*

An OpenCV detector and a trainer are available. Use OpenCV to create the classifier for vehicles like cars and aircraft. Find faces using OpenCV and Haar cascades, as shown in Figure 9.

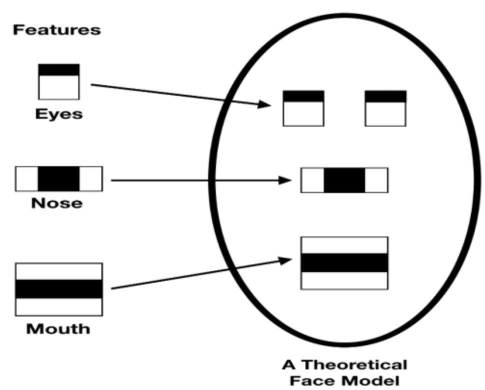

Figure 9. Face Detection using OpenCV with Haar Cascades.

C. *Face recognition with CNN*

CNNs [37] [38] are a category of Neural Networks that have proven very effective in areas such as image recognition and classification. CNNs are a type of feed-forward neural network made up of many layers. Picture recognition and classification are two areas where convolutional neural networks (CNNs) shine [39]. Layered feed-forward neural networks are known as convolutional neural networks (CNNs). Convolutional neural networks (CNNs) use filters, kernels, or neurons whose parameters, biases, and weights can be learned. Every filter takes in data via convolution and, if desired, adds non-linearity [40]. As seen in Figure 10, a typical CNN design is demonstrated. Convolutional neural network (CNN) layers can be wholly linked or pooled.

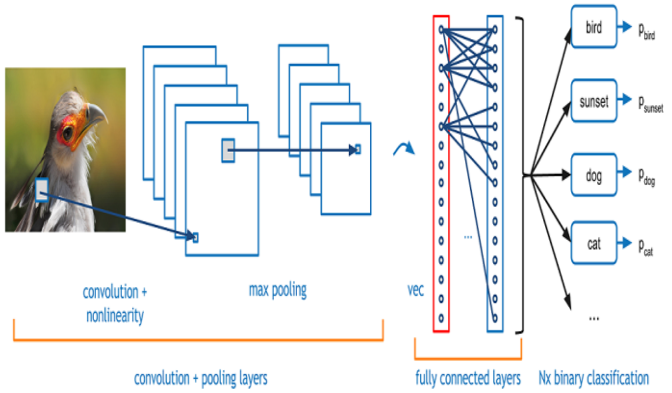

Figure 10. CNN architecture.

- Convolutional Layer:

A convolutional layer is the central component of a convolutional network and is responsible for most computations [41]. The convolution layer receives images and uses them to extract features. Learning picture attributes from tiny input image squares while preserving pixel spatial relationships is what convolution is all about. Learnable neurons muddle input images [42]. Figure 11 displays the CNN kernel filters. Consequently, the output picture becomes an activation map or feature map fed into the subsequent convolutional layer. Figure 12 depicts the convolution layer.

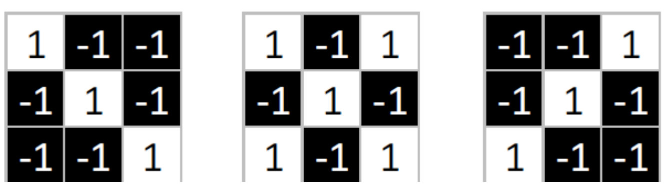

Figure 11. Some Kernel Filters in CNN.

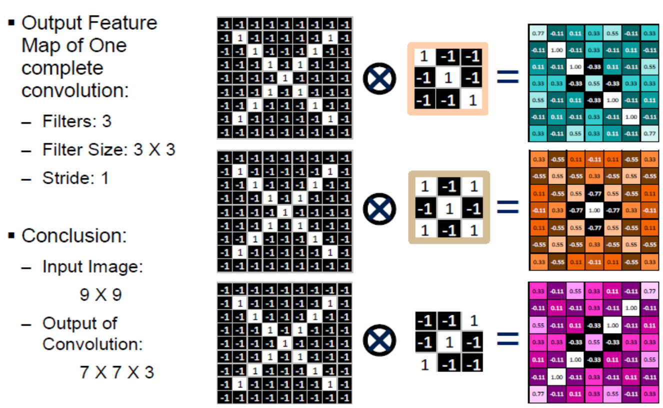

Figure 12. Convolution layer example.

- Pooling Layer:

Figure 13 demonstrates that the pooling layer retains the most crucial information while reducing the size of the activation map [43].

The supplied photos are cropped into non-overlapping rectangles. For each area, non-linear procedures like average or maximum reduce the sample size [44]. It is often placed between convolutional layers and improves generalization, convergence, translation, and distortion resistance.

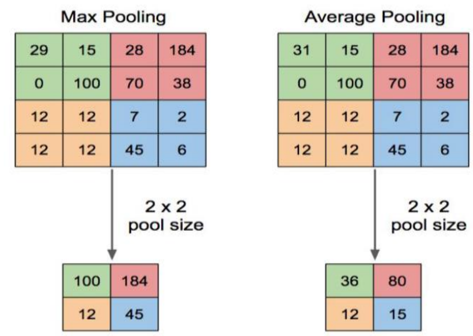

Figure 13. Max pooling example.

- ReLU Layer:

Referring to Figure 14, ReLU is a rectifier-based non-linear function. With this element-by-element method, we can ensure that every pixel has a positive feature map value [45]. In the neural network literature, the rectifier is defined as f(x)= max(0,x), and the input to a neuron is x; this assumption is made so that the ReLU can be understood.

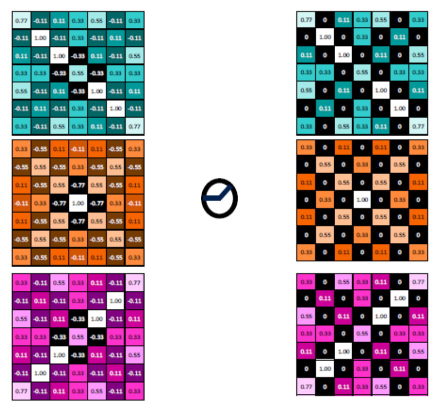

Figure 14. Relu Example.

- Fully Connected Layer:

When all of the filters in one layer are linked to all of the filters in the next layer, we say that the layer is fully connected (FCL), as shown in Fig. 15. Layers such as convolutional, pooling, and ReLU generate features at a high level for images. Based on these features, the FCL sorts incoming photos into predefined categories according to the training set. The features are taken from FCL, the last pooling layer, using a classifier that SoftMax triggers [46]. The Fully Connected Layer has a total output probability of 1. Using SoftMax_[47] [48] as the activation function ensures this. SoftMax can reduce a vector of real-valued scores to a vector of zero-to-one values that add up to one.

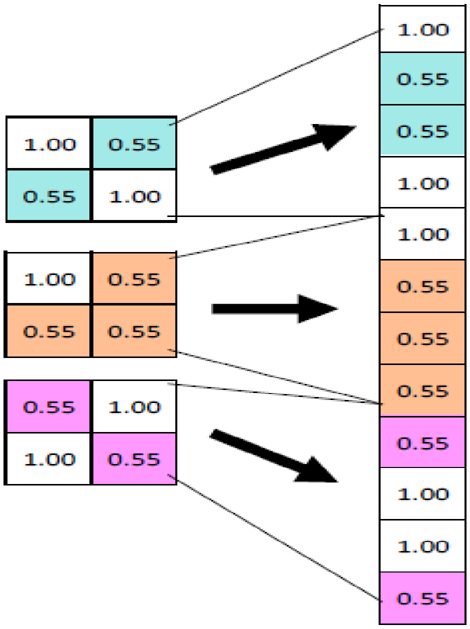

Figure 15. Fully connected layer example.

IV. Discussion AND EXPERIMENTAL RESULTS

This chapter discusses the development process, including face detection and face recognition steps.

A. TRAINING OUR MODEL:

The first step in training a machine learning model is creating the dataset. We captured the faces of the criminals to train the model on them using the Haar Cascades face detection method.

B. MODEL SELECTION:

Our first approach was to try out as many models as possible and pick the best-performing model. Thus, we did. Several models performed very well. After implementing the CNN model, we reach the highest accuracy of 95.5 %. Fig. 16 shows the search interface for a criminal. Fig. 17 shows the recognition of the criminal and his data.

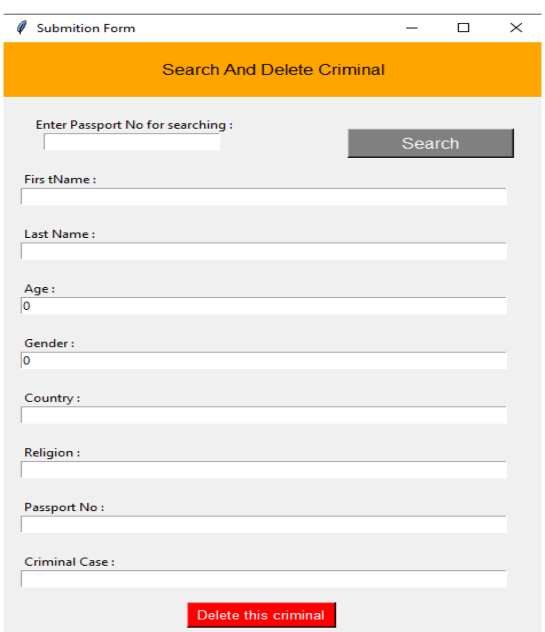

Figure 16. Search criminal and delete.

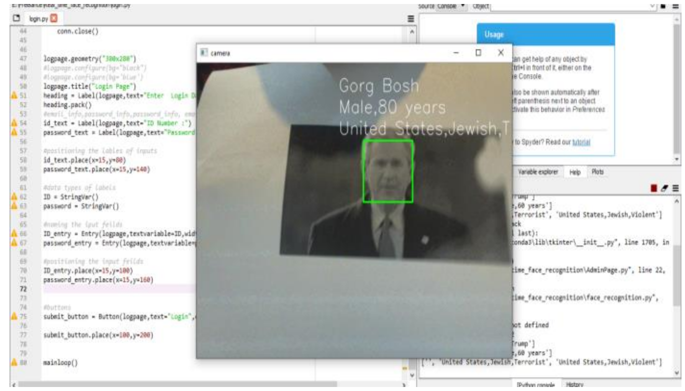

Figure 17. Recognition of criminals and their data.

V. CONCLUSION

We presented results for the face recognition system. We used a previously proposed state-of-the-art deep learning model by experimenting with different models on our news dataset. We are delighted with our work, although we wish for more time to continue perfecting our system and learning about the topic simultaneously. Unfortunately, this is all the time we have.

In the future, we will focus on understanding the image branch of fake news by understanding the image's metadata, which will provide information on the picture format and size, timestamps, types of metadata, description, missing data, and altered metadata.

Using the appropriate algorithm to achieve high accuracy in the image branch for resolution and face recognition will help them know how to detect fake news. We can enable users to enter news files with multiple types, like text and images, to detect if they are fake. We will also allow users to select one algorithm from the different algorithms implemented in the project. Finally, we can focus on understanding fake video news using the appropriate algorithm to detect it frame by frame.

- Conflict of Interest:

The authors state that our research is free of conflict of interest. We have no financial or personal associations that could bias it.

- Acknowledgement:

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