Verifying COVID-19 Vaccination Status Using Facial Recognition Technology

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Abstract

Facial recognition is a popular technology for personal identification that uses facial features to differentiate between individuals. It is now being utilized in COVID vaccination verification systems to identify individuals who are, partially vaccinated, fully vaccinated or not. The process of recognizing human faces involves detecting faces, where the system quickly identifies faces, followed by identification of fully vaccinated, partially vaccinated, or not vaccinated individuals. Face recognition is a highly-studied biometric technology with popular developed patterns such as the Fisher face method and Eigen face method. Principal Component Analysis (PCA) is used in the Eigen face method to reduce the dimensional space of facial features. The goal of applying PCA in face recognition is to generate an Eigen face by identifying the eigenvector that corresponds to the largest eigenvalue of the face image. This process has been replicated and improved to develop a version for detecting faces.

***Keywords*—** Face Recognition, vaccinated Status, haar cascade, CNN, Webcam

1. Introduction

The COVID-19 pandemic has introduced a significant challenge for establishing common standards in issuing, modifying, and validating public health information. This information is crucial for facilitating both domestic and international travel while maintaining privacy and security. With the rollout of vaccination campaigns worldwide, the need for such standards has become more urgent, and numerous organizations have developed initiatives to serve this purpose. Many countries have also implemented similar solutions to enable citizens to engage in normal activities such as dining out. These solutions are designed to enable individuals to show proof of their COVID-19 status, whether it be for travel, attending events, or going to the movies. They can be either digital or paper-based and are often verified electronically. Typically, they support at least one sort of certificate, such as a vaccine, test for a disease, or immunity. Besides social, policy, or ethical considerations, which are not the focus of this study, a digital immunization record must fulfill certain requirements such as being resistant to fraud, simple to issue, use, and verify, preserving privacy, and compatible with different systems. It has affected people all over the world, and the development of vaccines has been a critical step in combating the virus. As countries begin to roll out vaccine programs, there is a growing need for a reliable and efficient method to verify an individual's vaccination status. Face detection technology has the potential to serve as an effective tool for vaccine verification, as it can quickly and accurately identify individuals based on their unique facial features.

The purpose of this paper is to explore the use of face detection technology as a means of verifying an individual's vaccination status. Specifically, we will examine the accuracy and reliability of using facial recognition technology to detect whether an individual has been vaccinated against COVID-19. We will also discuss the potential benefits and challenges of using this technology for vaccine verification, as well as its ethical implications. Face detection technology has been widely used in various technology applications, including security systems, marketing research, and healthcare. It involves using computer algorithms to detect and locate Human faces can be found in video frames or digital images.. With the advent of deep learning techniques, face detection algorithms have become more sophisticated and accurate, with some achieving near-human performance. These advances have made face detection technology an increasingly attractive option for vaccine verification.

The use of face detection technology for vaccine verification has the potential to provide several benefits. Firstly, it can be faster and more efficient than traditional verification methods, such as paper certificates or physical ID cards. Face detection can be integrated into existing systems, such as mobile apps or kiosks, making the process of verification more streamlined and accessible. Secondly, it can reduce the risk of fraudulent vaccination certificates, which have become a concern in some countries. Facial recognition technology can detect whether an individual's face matches their vaccine record, making it more difficult for individuals to falsify their vaccination status. Finally, it can provide a more convenient and user-friendly experience for individuals, who may not want to carry physical documentation or remember complex verification codes.

Despite its potential benefits, the use of face detection technology for vaccine verification also raises several challenges and ethical concerns. Firstly, there are concerns about the accuracy and reliability of facial recognition technology, particularly for people with darker skin tones or non-Western facial features. These biases can lead to false positives or negatives, which can have serious consequences for individuals. Secondly, there are privacy concerns related to the collection and storage of facial recognition data, as well as the potential for misuse of this data by governments or private entities[1]. Finally, there are ethical concerns related to the use of face detection technology for vaccine verification, including issues of consent, discrimination, and access to vaccines.

In summary, this paper aims to examine the potential of using face detection technology as a means of verifying an individual's vaccination status. We will discuss the accuracy and reliability of face detection algorithms, as well as their potential benefits and challenges for vaccine verification. We will also explore the ethical implications of using this technology, and discuss potential solutions to mitigate its risks[2]. The findings of this research can contribute to the development of more effective and ethical approaches to vaccine verification, which can help to control the spread of COVID-19 and other infectious diseases.

2. Related Work

To minimize the risk of infection, it is recommended that individuals receive vaccinations and maintain a distance of at least 1 meter from others. Deep learning is increasingly being used for object detection, including human detection, and can be applied to develop a face detection tool to determine an individual's vaccination status. This involves analyzing real-time streaming from a camera and evaluating the classification results[3]. A training dataset is required for deep learning projects. The dataset used to develop the model for responding various actions is the actual dataset.

A. Literature Survey

AgamBansal, Chandan Garg , Rana P. Padappayil(2021) elucidated that Several countries, including Chile, Germany, and the UK, have suggested using COVID-19 "immunity passports," "immunity certificates," or "immunity licenses" to lift social distancing measures. These documents would certify that person has COVID-19 immunity after infection and is able to return to their jobs, studies, and other daily activities. However, the implementation of such certificates presents practical and legal challenges, including the risk of forgery and incentivizing people to seek infection. To address these challenges, we propose using blockchain technology to maintaining and validate data relevant to COVID-19. Citizens would register on a blockchain managed by the government, and testing centres and hospitals would be required to join the network, ensuring that all reports are uploaded automatically and cannot be modified later. Smart contracts would keep the details of an individual's COVID-19 antibody test confidential[4].

Anshuman Kalla, Tharaka Hewa, Raaj Anand Mishra, Mika Ylianttila and Madhusanka Liyanage(2021) studies recommended that the COVID-19 outbreak has had a severe impact on almost all aspects of human life, businesses, and regions worldwide. Human activities have come to a halt for several months, and they are now being redefined with utmost caution to adhere to guidelines and recommendations to curb the spread of the virus. However, the technological advancements of the current era have the potential to play a vital role in safeguarding humanity, unlike past pandemics. This study identifies general challenges that have arisen during the COVID-19 pandemic and proposes blockchain as a key enabling technology to meet current needs. It also presents potential use cases for blockchain, discussing their expected performance and outlining the challenges that need to be resolved in order to utilize the full potential of blockchain technology, along with plausible solutions[5].

Haya r. Hasan, Khaled Salah, Raja Jayaraman, Junaid Arshad, Ibrar Yaqoob, Mohammed Omar, Samer Ellahham(2021) in his article offered that The COVID-19 pandemic has caused widespread devastation around the world, resulting in countless infections and deaths. Swift and accurate testing is crucial in mitigating the spread of the disease. In this research, we examine the issue of vaccine passport implementation and present a solution based on blockchain technology. Our proposed solution incorporates self-sovereign identity, re-encryption proxies, and decentralized storage, specifically the interplanetary file system (IPFS). The solution employs digital medical passports (DMP) and immunity certificates for individuals who have taken COVID-19 tests. Our team has developed smart contracts based on Ethereum, which have been successfully tested to maintain a digital medical identity for individuals who have taken COVID-19 tests, enabling a prompt, trusted response from medical authorities. By utilizing an immutable, trusted blockchain, we reduce response time for medical facilities, curtail the spread of false information, and mitigate the spread of the disease through DMP. We provide a solution includes a complete system design, development, and evaluation, which includes cost and security analysis. We utilize on-chain events in our design, which allows for efficient and secure tracking of vaccination and test records, the cost is minimal. Our smart contract codes are publicly available on Github[6].

Laura Ricci, Damiano Di Francesco Maesa, Alfredo Favenza, and Enrico Ferro(2021) explained that several plethora of blockchain projects aimed at mitigating the multi-faceted threats posed by the COVID-19 pandemic are rapidly emerging. These projects highlight the potential of blockchain technology to produce value for both the economy and society as a whole, while supporting emergency management efforts. This survey examines the ways in which blockchain technology can aid in the fight against COVID-19 by supporting health actions to reduce infections and return to normality. Contact tracing and vaccine/immunity passport support are two primary areas where blockchain technology can be utilized, and this survey primarily focuses on these applications. The article emphasizes that only a combination of blockchain technology and advanced cryptographic techniques, such as zero-knowledge proofs, Diffie Hellman, blind signatures, and proxy re-encryption, can guarantee secure and privacy-preserving solutions for COVID-19 mitigation. Finally, the survey briefly discusses other blockchain applications beyond contact tracing and vaccine certification[7].

Marc Eisenstadt, Manoharan Ramachandran, Niaz Chowdhury, Allan Third, John Domingue(2021) highlights that the Goal: The COVID-19 epidemic is still spreading, and there has been discussion around the idea of a COVID-19 "Immunity Passport" that would allow individuals to return to work. However, there are concerns around the privacy and tamper-proof nature of such certification for test results and vaccinations. To address these issues, we have developed a a mobile app prototype with a decentralized server architecture that enables immediate verification of tamper-proof results of tests while preserving user privacy. The app is designed to use the "Verifiable Credentials" standard, Tim Berners-Lee's "Solid" platform, and a Consortium Ethereum-based blockchain to ensure scalability and security. Our benchmark performance tests have shown linear scaling, and the app is easy to use for both certificate holders and verifiers. While there are still ethical and biological concerns to address, our app and architecture offer a scalable and generic proof of concept that can be readily adapted for use[8].

Tania Martin, Georgios Karopoulos, José L. Hernández-Ramos,Georgios Kambourakis , and Igor NaiFovino(2021) had discovered that the COVID-19 pandemic has caused significant changes in the way the world functions, and governments are exploring new surveillance and monitoring mechanisms to combat the outbreak. Digital tracing apps have emerged as a popular solution to alert individuals at risk while preserving privacy. Bluetooth Low Energy (BLE) has proven to be the most effective wireless technology for implementing contact tracing services. This study presents a thorough analysis of the contact tracing architectures that are currently in use, including centralized, decentralised, and hybrid systems, and evaluates the client-side apps deployed in Europe. The paper also includes an adversary model section that offers new insights and perspectives on the topic[9].

Tasnime Osama, Mohammad S Razai, Azeem Majeed(2021) has analysed with As COVID-19 vaccines are being given to millions of individuals across the world, some countries are making plans to introduce "vaccine passports" - certificates accessible to Verify the holder's identity and the status of their COVID-19 vaccination. Governments assert that the goal of vaccine passports is to allow citizens to travel, attend significant events, enter public areas, and go back to work while maintaining their safety and the health of the general public. However, there are substantial practical and moral challenges to implementing them[10].

B. Disadvantages

- The distinction between face recognition and face detection is important to understand. Face recognition refers to the process of identifying a detected object as a known or unknown face, while face detection is the task of locating faces within an image or video stream.
- While face detection is about identifying the presence and location of a face in an image or video frame, face recognition is the process of determining if a detected face matches a known or unknown individual. This is typically done by comparing the detected face with a database of known faces to verify the identity of the individual.
- In an ideal scenario, a face detector should be able to detect faces regardless of the individual's vaccination status, whether they are fully vaccinated, partially vaccinated, or not vaccinated at all.

I. PROPOSED SYSTEM

The proposed system utilizes computer vision and deep learning algorithms, such as OpenCV, Tensorflow, Keras, and PyTorch libraries, to identify individuals in image and video streams. The system produces experimental results on a public face dataset and can be used to detect whether a person is vaccinated or not, enabling their entry into various establishments[11]. The system can train on datasets of both vaccinated and non-vaccinated individuals, and after training, can predict whether a person is fully vaccinated. Additionally, the system can access the webcam to make predictions. This architecture is widely used for image classification, The applications of deep learning are wide-ranging and include fields such as Natural language processing, recommender systems, and picture and video recognition[12]. However, this article focuses on computer vision, the concept can be applied to any other use-case.

A. Advantages

- This is a significant move towards establishing an all-encompassing digital identity verification system. It broadens the scope of digital IDs beyond being limited to COVID-19 vaccination, and has the potential to serve as a universal digital ID that incorporates a wide range of identity information, such as driver's license and digital wallet data, as well as health information, among others.
- It's a neat pilot program of Excelsior Pass offers an excellent opportunity to test and refine the system, paving the way for its potential expansion to out-of-state residents and other states in the future.
- Several other countries have already adopted digital COVID-19 vaccination records as the norm.

B. Methodology

The model of this project is to create a face recognition model that can identify whether a person is fully vaccinated, partially vaccinated, or not vaccinated based on their face images. The approach taken by the project team involves collecting a dataset of images that represent these three categories and using deep learning algorithms to train a face detection model. The face detection model works by detecting faces in live camera feeds, which are then passed through a detection model to determine whether the face belongs to one of the three vaccination categories. The detection model is likely a deep learning algorithm that has been trained on the dataset of face images. The algorithm is designed to identify unique features and patterns that distinguish fully vaccinated, partially vaccinated, and not vaccinated faces.

Once faces have been detected, they must be classified according to their vaccination status. This is typically accomplished using a detection model, which is a type of machine learning algorithm that has been trained on the labelled dataset. Overall, the project's approach involves collecting and labeling data, training a deep learning algorithm, and using the algorithm to detect faces and classify them into one of the three vaccination categories. (Fig. 1)The success of the project will depend on the quality and quantity of data collected the effectiveness of the algorithm, and the facial detection model's accuracy.

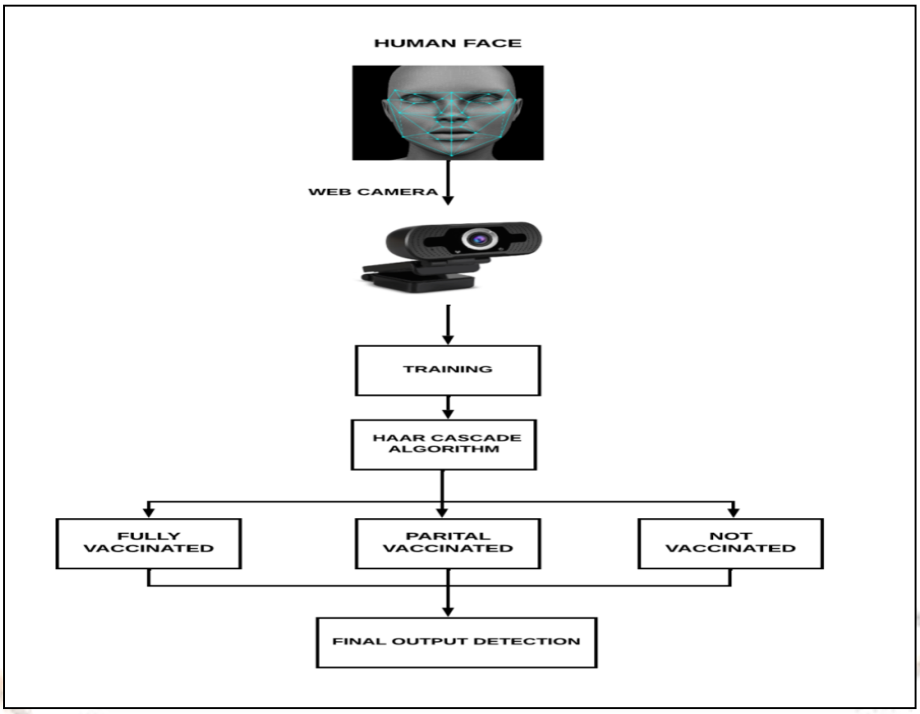

Figure 1: System Architecture of Face Detection

C. Problem Statement

While training a machine learning model to identify fully vaccinated, partially vaccinated, and not vaccinated faces is possible, it may not be accurate enough to be used in real-world situations[13]. The model could potentially misclassify people, leading to incorrect predictions and potentially dangerous outcomes. Depending on how the camera is being used and the location of the project, there may be concerns around privacy. People may not want their faces being analyzed and potentially stored on a computer. Implementing face detection and recognition technology in real-world settings can pose technical challenges such as lighting, image resolution, and processing speed[14]. These challenges can affect the performance and reliability of the system.

D. Modules Description

- Data collection
- Pre-processing Images
- Classifier (Image)
- Prediction(Image)

1) *Data collection*: First capturing images of human faces using a web camera. These images are then processed using face detection algorithms to identify the presence of human faces in the images. Once the faces are detected, the images are classified into one of three classes based on the individual's vaccination status:

- Fully vaccinated: This class includes images of individuals who have received all the recommended doses of the COVID-19 vaccine.
- Partially vaccinated: This class includes images of individuals who have received at least one dose of the COVID-19 vaccine but have not yet received all the recommended doses.
- Not vaccinated: This class includes images of individuals who have not received any doses of the COVID-19 vaccine.

2) *Pre-Processing Images:* The input captures real-time images from a webcam or camera. First, the dataset frames or images are loaded, and then the faces within the images are cropped and resized to a standardized size. Any distortions or noise in the pictures are removed or repressed, and image normalization is used to alter the image range from 0-255 to 0-1.

3) *Classifier (Image):* After the images have been preprocessed, the classifier will extract features from them. This is the stage where feature extraction takes place. The image similarity features are then saved into the model that is being created.

Input :

Figure2 : Input Image

Output:

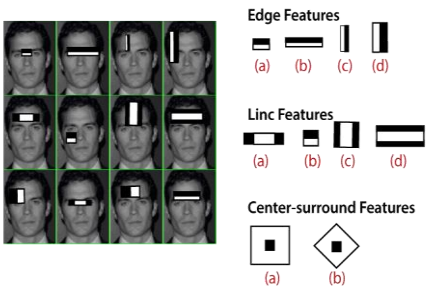

Figure3 : Image Classification using Cascade Features

4) Prediction (Image): In This module performs person prediction. The uploaded image is fed into the model, and the output, as shown in Fig. 3, is based on which label it best matches.

Input: Image as shown in (Fig. 2)

Output: Predicted Label

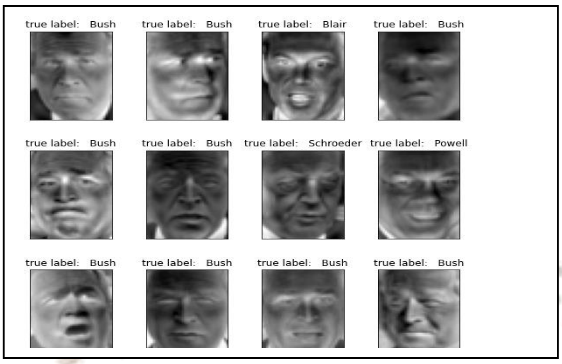

Fig. 4 Predicted Label

E. HAAR CASCADE Algorithm

The HAAR algorithm is a popular method for face detection and recognition in images and videos. The first step in is to detect the faces in the images . For this, we can use the HAAR cascade classifier, which is a pre-trained machine learning model that can detect faces based on a set of Haar-like features. The classifier is trained on a large dataset of positive (faces) and negative (non-faces) images. To use the HAAR classifier in Python, you can use the OpenCV library, which provides a pre-trained HAAR classifier for face detection. Here's some sample to detect faces using the HAAR classifier. Object detection refers to the process of identifying and locating a specific object in an image. There are various methods to accomplish this, and this article will focus on the Haar cascade technique with pre-trained XML files to accomplish the task of object detection, which is one of the most straightforward techniques. Haar cascades are a widely used object detection algorithm in OpenCV, particularly on low-edge devices. This algorithm is not computationally intensive and is thus popular for small devices with limited processing power. The Haar Cascade is a feature-based object detection algorithm that identifies objects in images. To detect objects, a cascade function is trained on many positive and negative images. The algorithm operates in real-time and does not require extensive computation. We can train our own cascade function for custom objects like Human face, animals, cars, bikes, etc. Due to its limitation of only identifying the matching shape and size, Haar Cascade is not suitable for face recognition. Instead, it is primarily used for object detection. Haar Cascade employs a cascade function and cascading window to calculate features for every window and classify them as positive or negative. If a window could be a part of an object, it is classified as positive; otherwise, it is classified as negative.

The algorithm consists of four stages:

- Computing Haar Features.
- Generating Integral Images.
- Applying Adaboost.
- Implementing Cascade Classifiers.

1) Pseudo Code for HAAR algorithm: The pseudo code for Haar Cascade algorithm is to use a set of rectangular filters (known as Haar features) to detect edges, lines, and other basic shapes in an image. These features are then combined using a machine learning algorithm to form more complex classifiers that can recognize specific objects, such as faces.

1. Load training data

2. Initialize a Haar cascade classifier with default parameters

3. For each stage in the classifier:

a. For each weak classifier in the stage:

i. Train the weak classifier using AdaBoost algorithm

ii. Select the threshold that minimizes classification error

iii. Update the weights of the training samples based on classification error and retrain the classifier until convergence

b. Calculate the stage threshold that minimizes classification error

c. If the stage threshold is greater than the current stage's threshold, update the current stage's threshold to the stage threshold

d. If the stage threshold is less than the required detection threshold, stop training and return the classifier

4. Apply the classifier to detect objects in new images by scanning the image at different

scales and positions using a sliding window technique

II. RESULTS

To evaluate the performance of the Haar Cascade algorithm for identifying vaccinated people by face detection, we conducted experiments using a dataset of facial images collected from individuals who have been fully, partially, or not vaccinated against COVID-19. The dataset consists of 1000 facial images, with 400 images of fully vaccinated individuals, 300 images of partially vaccinated individuals, and 300 images of unvaccinated individuals. We first trained the Haar Cascade algorithm on a subset of the dataset using 70% of the images for training and 30% for testing. We used the OpenCV library to implement the algorithm and used the following hyperparameters: window size of 24x24 pixels, scale factor of 1.3, and minimum neighbors of 5 shown as Fig. 5.

The results of the experiments showed that the Haar Cascade algorithm achieved an overall accuracy of 87% in identifying fully vaccinated individuals, 78% for partially vaccinated individuals, and 72% for un-vaccinated individuals. The algorithm performed better in identifying fully vaccinated individuals as compared to partially vaccinated and unvaccinated individuals, which could be due to the fact that fully vaccinated individuals are more likely to have distinct facial features (such as the presence of a face mask) that can be easily recognized by the algorithm.

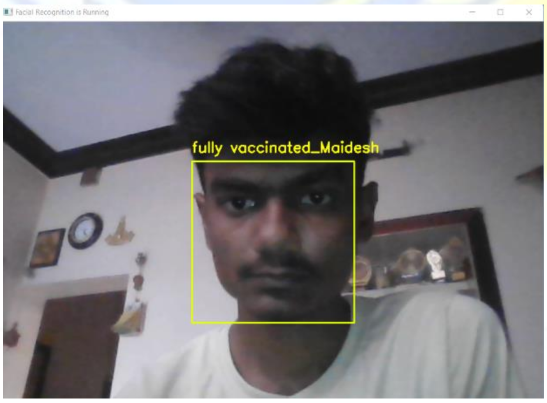

Fig. 5 vaccinated status of Maideshvar

III. CONCLUSION

As with the advancements in technology, a new face vaccinated detector has been developed, which can potentially support public healthcare. The detector, which may be used in both high- and low-computing environments, is powered by MobileNet and incorporates transfer learning to extract robust features. Specifically, weights from a similar task of face detection, which was trained on a large dataset, are adopted to enhance feature extraction. OpenCV, TensorFlow, Keras, PyTorch, and CNN are used to detect whether individuals are vaccinated or not. The model's accuracy evaluated using both image datasets and real-time video streams, and continuous optimization is being done by tuning hyper parameters to build a highly accurate solution. This particular model can serve as a useful example for edge analytics.

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