

An access control system for Covid19 using computer vision and deep learning techniques: A systematic review

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Abstract: After the emergence of the Coronavirus disease (Covid19) in December, 2019 the virus was confirmed by the World Health Organization (WHO) to be a dangerous virus that spread through airborne and droplets. One of the most effective way of preventing the spread of this virus is the use of facemask in public places such as banks, shopping mall, schools, offices and the likes. For this reasons people are advised to use facemask whenever they go out for their daily activities. However, some people have refused to wear the facemask in public places, thereby increasing the rate at which the virus spreads. Hence, there is a need to design an access control system for use in public places to grant access to people complying with the facemask regulations or deny access to those faulting them. Literature has shown that the use of computer vision and deep learning technology can play important role in the deployment of such access control system for face detection and facemask detection. The computer vision and deep learning techniques used in face recognition and facemask detection are describes in this systematic literature review.

Keywords: Covid19, Computer vision, deep learning, access control system, facemask detection, face detection.

1. Introduction

The emergence of Covid19 has presented a great challenge in global health system. As the virus continue to spread throughout the globe, public health emergency was declared by the WHO in March 2020 [1]. The continuous spread of the virus has led different countries to enforce measures like restricting travelling, national lock down, washing of hands regularly, the use of hand sanitizer, isolation and quarantine, social distancing and wearing of facemask in order to battle the pandemic [2]. However, these restrictions are difficult to adhere to, practice and maintain which eventually lead to unsatisfactory compliance by the public, particularly when there are significant effect on the economic, political, social and physical comfort of the affected citizens [3]. Notably, there are breathing protective tools which can prevent the spread of the virus like facemasks which protect individuals against infection through the respiratory system. The facemask is a protective mask that covers the nose and the mouth or the nose and the eyes. Facemasks are easier on use and affordable. The trend of using facemasks in public worldwide is now on the increase because of the Covid19 pandemic. Although, some people use facemasks before Covid19 in order to protect themselves from air pollution, others uses it to change their looks and hide their emotions from the society. It has been proven by scientists that using facemasks helps to avoid the spread of Covid19. Facemasks are still the most effective approach to stop the infection from spreading. Authorities

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have mandated the use of facemasks in public places where people are bound to come into contact, such as religious gatherings, shopping malls, workplaces, public transportation facilities, banks, and sports arenas, in order to avoid the continuous spread of the corona virus and to prevent re-infection of treated individuals [4]. The purpose of computer vision is in two fold. From the perspective of biological research, computer vision tries to develop human visual system's computational models. From an engineering perspective, computer vision strives to create self-contained systems that can perform the functions of the human visual system and even do better in certain cases. Access control on the other hand is concerned with determining which user is allowed to access a system resource. Access control systems can be implemented in a variety of locations and at various levels using the same information technology (IT) infrastructure to safeguard files and directories. Operating systems utilize access control systems for database management. Access control is implemented in most commercially available application systems, and it is often independent of the operating systems and/or database management systems on which they are installed. Human access control systems are the types of access control systems which are designed to grant access to or deny access to a certain areal or building. The physical access control systems are often install in order safeguard properties from theft, vandalism and trespass. This type of access control is always used in facilities that require high security and protection. Physical access control tries to controls who, how and when an individual can gain access to a place.

This literature review will provide answers to three (3) main research questions. It is going to show the importance of computer vision and deep learning to face recognition and facemask detection as they are applied to access control system. Different computer vision and deep learning algorithms that are being used for face recognition and facemask detection will also be discussed in this review.

2. Methodology

The methodology that is used in this paper is the systematic literature review. In order to answer the research questions, papers from 2000 to 2021 are reviewed.

The table below shows the inclusion and the exclusion criteria for this study.

Table 1. Inclusion and Exclusion criteria.

Inclusion Criteria	Exclusion Criteria
Paper is written in English language	Paper is not written in English language
Paper is open source	Paper is closed source
Paper is relevant to computer vision and face recognition	Paper is not relevant to computer vision and face recognition
Paper is relevant to deep learning and facemask detection	Paper is not relevant to deep learning and facemask detection
Paper is relevant to human access management	Paper is not relevant to human access management

The quality of the papers that were reviewed in this study were assessed based on the research work that those papers presented. Papers where researchers have discussed the application of

computer vision and machine learning to face recognition and facemask detection, and papers where the state of art access control model are being discussed were considered as good quality papers and are included in this review.

Lots of papers were gotten from different sources like springer, Scopus, Web of science, and PubMed. However, not every one of this papers are related to this research. So, firstly the papers were separated based on the abstract and the titles. The abstract provided a summary of the paper. Secondly, the relevant part of the paper were then studied and reviewed.

3. Research questions

In this research, there are three research questions that will be answered based on valid arguments. The questions are as follows.

RQ1: What are the AI techniques that are being used for facemasks detection, which facemask image dataset sources have been used and what are the performance accuracy of these techniques?

RQ2: What are the AI techniques that are being used for face detection, which face image dataset are being used and what are performance accuracy of these techniques?

RQ3: Which access control models are used for physical access control?

This questions will be answered in the result and discussion part of this literature review.

4. Result and Discussion

4.1 Answers to RQ1: What are the AI techniques that are being used for facemasks detection, which facemask image dataset sources have been used and what are the performance accuracy of these techniques?

[5] presented an intelligence access control method that can reduce the probability of Covid19 and also swine the transmission of flu type of disease which can be transferred from one person to another through direct or indirect contact. The researchers proposed a method that gives free access control which is a combination of eyes and voice retina based person identification intelligence. The voice recognition logic works on Siamese network and CIFAR network gives an accuracy of 88%, while the eye retina- based person recognition logic is based on retina vasculature uniqueness.

A systematic review on the application of deep learning algorithms to diagnose and detect Covid19 was done by [6]. The researchers conducted the review by searching the databases of PubMed, Scopus, and Web of science from 1st of November 2019 to 20th of July 2020. Their result shows that deep learning models have the ability to produce an accurate and efficient system for detection Covid19. The researchers concluded that the application of deep learning in Covid19 radiologic image processing will reduce false negative and positive errors in the detection of Covid19 virus and offer an opportunity to detect it quickly.

A study on the application of machine learning techniques in confronting Covid19 pandemic was carried out by [7]. The objective of their study was to provide a current technological aspect of AI and relevant technologies to fight against Covid19 and reduce the spread of the virus. The study address the connection between these technologies, the epidemic and the potential impact of the technologies in health care.

A survey on the application of deep learning on the reduction of the spread of Covid19 was carried out by [7]. The paper covers deep learning application in Natural language processing,

epidemiology, life science, and computer vision. One of the key finding is that deep learning framework such as Tensor Flow, PyTorch and Karas provides accessible interface to models with ImageNet trained weight. So no need for pre-train on ImageNet themselves.

A research with the aim of reducing the spread of Covid19 by using deep learning based models to detect facemask was published by [8]. The research aim to get an accurate and real-time model that can detect masked faces in public effectively. The technique proposed in their paper is an ensemble of one stage and two stages detector in other to achieve high accuracy and low inference. They used ResNet50, AlexNet and MobileNet model for the implementation and achieved an accuracy off 98.2% when implemented with ResNet50.

[9] also did a review on the application of machine learning and deep learning techniques on the detection of Covid19 facemask. Their study aim is to find a comprehensive review of AI models used in detecting facemasks. Their studies revealed that the deep learning InceptionV3 CNN achieved 99.9% accuracy in detecting facemask. They also stated in their report that wide and deeper deep learning algorithms like Mask R-CNN, YOLOv3, DenseNet, Xception and Faster R-CNN are not yet been implemented to detect facemask.

A research that applied Artificial Intelligence techniques to prevent the spread Covid19 was carried out by [10]. Deep learning modes like MobileNet, VVG, and ResNet Classifier were used for the implementation and a comparative studies of these models was done. The model was evaluated based on recall, precision, F1 score, specificity, sensitivity, support and accuracy. The researchers stated in their report that the system can be used with existing embedded camera infrastructure to enable their analytics which can be applied to various verticals.

[11] introduced a facemask detection model that can be adopted by the authorities to fight against Covid19. They proposed a machine learning algorithm through image classification methods (MobileNetv2). The researchers used two different dataset to conduct the experiment. The first dataset was obtained from Real World Masked Face dataset and Kaggle dataset while the second was obtained from 25 different cities in Indonesia. The researchers stated that their proposed model can be integrated with surveillances camera to reduce the spread of the corona virus by detecting people who are not using facemask.

A Covid19 facemask detection model was developed with the use of computer vision by [12]. Python, openCV, keras and Tensor Flow were proposed for the implementation by the researchers. The main aim of their research is to identify individuals wearing or not wearing facemask in pictures or video stream with the help of deep learning and computer vision.

A deep learning based unmanned approach from real time monitoring of people wearing facemask was published by [13]. The researchers used some object detection algorithm such as YOLOv3, YOLOv3Tiny Faster R-CNN, and SSD using dataset from Moxa3K.

[14] developed a model that detects persons wearing helmet in real time. TensorFlow and Keras in OpenCV were used for the implementation of the project. Their proposed model showed a great performance when compared to some previous models predicted wrongly whenever a rider is wearing clothes to cover their face. Their model gave an accuracy of 98% when tested.

[15] cascade a framework for facemask detection. The model was built with the use of MobilenetV2 and deep learning. Their model could identify whether a person is wearing a facemask or not. A dataset called the Masked Face dataset (MAFA) was used. The accuracy of their model was not specify.

The Retinafacemask, a facemask detector model developed by [16]. The Retinafacemask adopted the structure of RetinaNet, Feature Pyramid Networks and Single Shot MultiBox to detect facemasks. ResNet and MobileNet algorithms were used to build Retinafacemask model. The MobileNet was able to achieve 83.0% accuracy and the ResNet achieved 91.9% accuracy. Image datasets from Facemask Dataset, Masked Faces dataset, and Wider Face were used.

A model that distinguishes faces with facemask from faces without mask with the use of image super-resolution and classification networks was developed by [17]. The researchers used CelebA medical masked dataset from kaggle. The model was able to achieve an accuracy of 98.70%.

[18] developed a hybrid model of support vector machine and decision tree to detect facemask. The hybrid model achieved an accuracy of 99.64%. The hybrid model used dataset from Real-World masked Face Dataset.

[19] developed a facemask detection model using Inceptionv3. The Inceptionv3 has 22 layers in order to make the model more accurate. Simulated masked face dataset was used to train the model. The model was able to achieve an accuracy of 99.9%. The image dataset used was small so, the model could be retrained with the use of a large dataset and then tested in live video streaming.

A Lightweight neural network that applied a single shot detector and MobileNetV2 was used to detect facemasks by [20]. The model uses a custom face crop dataset which consist of faces with different types of facemasks. The dataset consists of 3165 images. An accuracy of 85% was achieved.

A Covid19 facemask detector system was developed by [21]. The system uses a deep learning based model to classify a face with mask, a face that is not properly masked and a face without mask. Face mask dataset and simulated masked face dataset were used. The model achieved 98.6 % accuracy.

A model that can identify pictures of people with and without facemask was designed by [22]. The model was trained with the use of deep learning algorithm. Pictures of people with facemask and without facemask that was monitored with the use of CCTV cameras in the environment was uses to train the model. The mode was able to achieve an accuracy of 98.7%.

Real-Time deep learning model that was based on multiple scale face mask detection and classification was designed by [23]. The model integrated FMY3, Resnet and YOLOv3 algorithms to detect facemasks. The model achieved 98.01% accuracy.

[24] uses R-CNN model to detect facemask. Other models like the MobileNet V2 and SSD Inception V2 model were compared with R-CNN model to determine how efficient the model is. The R CNN model outperformed other model compared with an accuracy of 68.72%. COCO dataset was used to train the model.

ResNet-50 and YOLO-v2 deep learning models were used to detect facemask by [18]. The researchers used ResNet-50 to extract features and then applied YOLOv2 to detect facemask. Datasets from facemask dataset and medical mask dataset was used to train the model. 81.01% accuracy was achieved by the model.

A real-time facemask detection system was designed by [25]. The model was based on MobilenetV2, single shot multibox detector, Keras, TensorFlow, and OpenCV. The model used Kaggle's Medical Mask dataset. The system achieved 93% accuracy.

A model that can detect mask from video footage was developed by [26]. The model uses MTCNN model to identify individual faces and uses MobileNetV2 object detection. The dataset used consist of video footage that were captured in public. Facial prediction was 81.74% and facemask detection accuracy was 81.85%.

[27] developed a novel deep learning model that uses convolutional neural network algorithm to identify people without facemask and gathers their details for further punishment. The model was 91.20% accurate.

[28] used YOLOv3 to classify Covid19 facemask. YOLOv3 together with Google co-laboratory was implemented to classify facemask. The dataset which was gotten from Google co-laboratory datasets consist of 650 images. The YOLOv3 model was able to achieve an accuracy of 96.00%.

A model was developed to detect facemask by [29]. The model was trained based on convolutional neural network. Datasets from CamH7 camera and online kaggle dataset. The

convolutional neural network model was able to achieve an accuracy of 99.79% for training and accuracy of 99.81% for testing.

A system that uses Serverless Edge Computing to detect facemasks in a browser was designed by [30]. The model can work on any device that is connected to the Internet. The dataset was collected from the Widerface dataset. The model achieved an accuracy of 89.00%.

[31] used Multi-Stage convolutional neural network Architecture for Facemask Detection. The system was designed to detect whether a mask is properly worn or not. The system uses dual-stage convolutional neural network architecture to detect facemasks from CCTV cameras. Kaggle dataset with 853 images was used. The model gave 98% accuracy.

[32] developed a facemask detection System which is based on ANT-Colony Optimization and genetic algorithm. The detection model was able to detect and recognize faces in videos and images. This model gave 96.00% accuracy.

A facemask detection system was designed by [33]. Three attributes were extracted from the GLCMs of the facemasks micro photos dataset. KNN algorithm was used to build the model. The model detects facemask from facemask's micro-photos by applying a grey level co-occurrence matrix. The model was 82.87% accurate.

The MOXA model was developed by [34]. The model incorporates YOLOv3Tiny, YOLOv3, Faster R-CNN and SSD to detect facemasks. Moxa3K benchmark dataset and Kaggle's medical mask dataset was used by the model. YOLOv3 achieved 63.99% accuracy which outperforms the other algorithms.

A model that combined deep learning and posture recognition technique to perform video analytics was designed by [35]. Images that were taken from real life scenarios were used to train the model. The model achieved an accuracy of 95.8%. A limitation to the study is that the dataset used was relatively small.

A study that applied MobileNetV2 lightweight convolutional neural network in the detection of facemask was conducted by [36]. The researchers used facemask datasets from kaggle. The model was able to achieve an accuracy of 99.98%.

A study with the aim to detect Covid19 facemask was carried out by [37]. The study used Yolo-v4 algorithm which is easy to prepare, very quick, solid and more stable than the preceding versions of YOLO. Image dataset from MAFA and WIDER-FACE were used for training and testing of the model. The Yolo-v4 algorithm achieved 99.97% accuracy.

A study that uses deep learning frameworks like Keras, TensorFlow, and OpenCV libraries to detect facemasks in real-time was carried out by [38]. The researchers used dataset from Kaggle and PyImageSearch to train and test their model. The model achieved 99.00% accuracy.

Convolutional Neural Network model was utilized to detect facemask by [39]. Facemasks dataset containing 853 images from kaggle was used for the modelling. The model achieved 96.00% accuracy. A limitation to the study is that the model was trained with a few dataset.

A study that applied ResNet-50 with Multi-Task Convolutional Neural Networks, and Feature Pyramid Network to detect Covid19 facemask was carried out by [40]. The study used dataset from Context CelebFaces features Dataset, Custom Mask Community dataset and WIDER FACE dataset. The model achieved 87.7% accuracy.

A study was carried out with the aim of detecting Covid19 facemask by [41]. The researchers used VGG-16, Inceptionv3, MobileNetV2, CNN and ResNet-50 to train and test their model. The researchers used three different datasets from Bing, MAFA and Masked Face-Net. The VGG-16 outperformed other compared algorithms with an accuracy of 99.81% while the MobileNetV2 achieved an accuracy of 99.60%.

An approach to detect face mask was offered by [42]. The researchers used Machine learning techniques like TensorFlow, Scikit, OpenCV and Keras. Two different dataset was used, the first

data set was gotten from gthub and the second dataset was gotten from kaggle dataset. The system was able to detect a face in a picture and also recognize a person that is using face mask from those that are not using face mask. The model was also able to detect faces with face mask in motion. The researchers also optimized Convolutional Neural Network model parameter values in order to detect the masks properly without over-fitting the model. A precision of 95.77% was achieved on the first dataset and 94.58 % on the second dataset.

From the above reviewed papers, we noticed that the prevalent AI techniques used in facemask detection are Convolutional Neural Network, Recurrent Neural Network, Long Short Time Memory Network, ResNet50, MobileNet, Inception CNN MobileNet, SVM, Decision trees, YOLO, and Single Shot Multibox Detector. These state of art techniques have achieved accuracy above 81% when used in the detection of facemask. Also, these techniques have been used on different open source dataset such as face mask dataset from kaggle, PyImageSearch, WIDER FACE and Gthub dataset.

4.2 Answers to RQ2: What are the AI techniques that are being used for face detection, which face image dataset sources have been used and what are the performance accuracy of these techniques?

A model that detects major colors in real-time images and brightness was developed by [43]. The model uses RGB method for facial recognition and fundamental object. YOLO algorithm and MTCNN was used for object detection and facial recognition. Open CV libraries of python was used on local dataset from the environment for the implementation. The YOLO algorithm gave an accuracy rate of 63-80%, while the facial detection gave an accurate rare of 80-100%.

A face detection system was developed by [44]. The system uses nonparametric algorithms for pattern recognition. The authors made use of spectral data. The research's result from a foundation for important spectral features while dealing with forest monitoring.

An emotion recognition system was developed by [45]. YOLO and CNN assemble was used on facial expression recognition database. The real time performance tests on the application gave an accuracy of 72.47%.

A study that uses real-time video processing to detect faces was proposed by [46]. The study archived this by duplicating weight parameter and by reducing existing weights size. YOLO was used to detect large faces while MTCNN and BSMNet was used to detect small faces. They found out that it is possible to optimize accuracy and speed if some hidden layers in neural network are being eliminated.

[47] presents a real-time object detection system that was applied to detecting human face. The study used YOLO algorithm for face detection. Camera was used to recognize faces in real time. The researchers conclude from the result that YOLO facial detection performs better than other face detection algorithms in complex environment.

A system that track and detect human head in real-time video was proposed by [48]. Computer vision OpenCV library from python was used to implement the system. Images from webcam and CCTV were used for the implementation. Haar-like classifier was used by the researchers to detect the human head and CMT object tracking algorithm was used to track the human head. An accuracy of 68% was archived by the CMT that tracks the head and accuracy of 83% was achieved in detecting the person's head.

An approach for detecting real-time emotions and fixed images was proposed by [49]. So, before the detection of emotion, the researchers have to Haar classifier of OpenCV to identify

faces in real-time videos and static images. After identifying the faces, it will now be analyzed to detect other facial landmarks and categorized according to the emotions by using SVM. The researchers were able to achieve an accuracy of about 93.7 percent using SVM. And they stated that the facial landmarks may be tweaked to improve precision.

[50] conducted a research that aims to use OpenCV and Visual Studio 2015 software framework to solve issues involving face detection in different lighting conditions and create an effective and intelligent human face detection system. The photo processing approach from the researcher's experiment was able to recognize faces of people under various lighting conditions and an accuracy of 80% was achieved.

An image processing based system was proposed by [51]. The system can improve traditional attendance systems in universities, and also prevent high rate of time wasted when taking attendance. The Student Attendance system's main function is to incorporate and manage attendance of students, estimate the number of time present and absent of students based on affability of the class, and produce an automated document. OpenCV library from python was used, Haar-Cascade was used for face detection and LBPH was used for face recognition. An accuracy of 97% was obtained by the system.

A face recognition software which identifies faces from images and live video streaming was developed by [52]. OpenCV and ATmega328p Micro Controller with Pan-Tilt function were used for processing the images. Publicly available dataset from kaggle was used. The Housedorff gap, Camshift, AdaBoost, haar Cascade, Viola Jones, etc. were used to identify human faces. Cascade algorithm Haar was used by the researchers to classify faces. An accuracy of 83% was achieved by the Haar algorithm.

An attendance system that can take attendance of student in a classroom, or workers by detecting their faces was developed by [53]. Images of students were taken and used for the training of the model. Techniques such as Open CV, detectMultiscale and occupancy ratio were used. Haar cascade algorithm was used for face detection and it achieved an accuracy of 90% to 100%.

[54] developed a framework that combined the Open CV library with the Jones and Viola algorithms on facial employee database for personal identifier statement. An accuracy of 90% was gotten from the face detection system.

A model that can sense if a driver is asleep when operating a vehicle was proposed by [55]. Their research aimed at preventing public road collisions. OpenCV library and image processing in real time with a vision device on eye blinking and facial expression were used by the researchers. The artificial neural network algorithm was used. The model was able to achieve an accuracy of 90%.

From the above reviewed papers, it is observed that the prevalent AI techniques used in face detection are YOLO, CNN assemble, BSMNet, Visual Studio, ANN algorithm and openCV libraries like MTCNN, Haar cascade algorithm, Jones and Viola algorithms. These techniques have achieved accuracy that ranges between 63% and 99.9%, when used in the detection of facemask. Also, these techniques have been used on different dataset from kaggle, spectral dataset, Facial Expression Recognition database and Images from webcam and CCTV cameras.

4.3 Answers to RQ3: Which access control models are used for physical access control?

[56] proposed an access control model called Generalized role-based access control. This access control model presented the idea of environment roles as different from subject roles. An environment role can be based on contexts that are temporary such as time and day, or context based

on location such as the room on a particular floor in a building. The Generalized role-based access control concepts can be extended to logical and physical access control to achieve a converged approach. Many higher-level requirements like the policy interoperability between multiple systems or granular rule specifications were not addressed by the model.

Geo Spatial Data Authorization Model is an access control model that combined location and time in authorizing an entity. This model was proposed by [57]. The model provides protection mechanisms that address issues that are specific to spatial image data that are stored in spatial databases. The model evaluates demands to manipulate or display spatial data and makes authorization decisions which may involve rendering maps at different detail levels based on conditions such as authorized objects, subjects, and spatiotemporal constraints. The model cannot be used directly in combination with other logical or physical access control systems, though its general idea may be adapted.

Geo role-based access control model was developed by [58] Principles of set theory and contextual information were used by the model to make decisions on access control. The model access control concept for logical resources can be extended to physical access control. A setback to the model is that it lacks some requirements that are important, like policy integration multiple object attributes.

[59] formalized a spatiotemporal role-based access control model and called it spatiotemporal role-based access control. The model designed by the researchers considers the interaction of time contexts and location with the classical role-based access control model in access control decision-making. Set theory was used in defining the model. The model was designed to use a single administrative authority. Therefore, it doesn't address the opportunity of more than one authorization domain.

The Generalized Spatiotemporal Role Based Access Control model was proposed by [60]. Physical and logical access control are both possible in the model. Predicate logic and set theory were used in defining the model. The spatiotemporal authorization functions in the model uses logic operations for making decision. A setback to the model is that users cannot activate multiple roles simultaneously.

The Enhanced STARBAC known as ESTARBAC is an access control model that was proposed by [61]. The model was designed to extend the capabilities of the STARBAC model. The model uses the idea of spatial separation of duty and algorithms for the evaluation of access control. Set theory and operations were used to define the model. Spatiotemporal evaluation functions are used by the model for making access control decisions. Since the model was designed to be used under a single policy administrative point, then an integration of rules from more than one entity is not part of the model specification. The model access controlled objects are limited to logical objects with spatiotemporal context. The model can support access control for physical spaces and physical objects.

From the papers reviewed, we noticed that access control models like the generalized role-based access control, geo spatial data authorization Model, geo role-based access control model, spatiotemporal role-based access control, generalized spatiotemporal role based access control model, and the enhanced STARBAC model are state of art access control model that are being used for physical access control. These models have been used by many organizations and have proven to be very reliable.

4. Conclusion

It is observed that the above methods are the prevailing methods used in the detection of facemask and publicly available dataset online have been predominantly used [6, 24, 39, 41] and [31]. Among these methods, the deep learning algorithms has significantly outperformed other techniques used, and the convolutional neural network has even perform better than the other deep

learning algorithms like YOLO, MobileNet, ResNet etc [6, 24]. The convolutional neural network model has constantly obtain accuracy values that ranges from 95% to 99.99%. In this contest, we propose the use of the convolutional neural network model to detect facemask using dataset collected locally from people who reside in Nigeria.

On the other hand, it is observed that the haar cascade algorithm from the OpenCV library has outperform other techniques that have been used in face recognition [49, 52, 53]. The haar cascade algorithm has constantly achieved accuracy that ranges from 90% to 100% [49, 53]. Hence, for the purpose of this research haar cascade algorithm is recommended for face recognition.

Finally, state of the art access control models has been reviewed and a set of features necessary for access control has been identified from the reviewed literature. This review on access control has established the advantage of building information models for spatiotemporal access control in confined spaces.

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