

COVID-19 TRANSMISSION PREVENTION USING ARTIFICIAL INTELLIGENCE DOOR

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Abstract

People are still dying every day, of covid-19. As of April 1, 2021, approximately 3 million deaths had been traced to COVID-19 globally, with over 2,000 deaths from Nigeria. These deaths are increasing, every hour, as a result of a continuous transmission of the virus among people, and also due to the violations of the covid-19 preventive measures, recommended by the World Health Organisation. However, to save humanity from this novel virus and also to prevent transmission of other future viruses, hence led to the purpose of this paper. This paper introduces an artificial intelligence door as a solution to covid-19 transmission in public buildings. It establishes how 3D sensor, facemask detection camera, infrared thermometer, and sanitizer dispenser will prevent human crowd, reduce violation of facemask rules, identify covid-19 suspects, and ensure hand sanitization respectively, when integrated in a door. The priority of this design is to save mankind.

Keywords: *AI, COVID-19, crowd, design, door, facemask, sanitizer, thermometer*

1. Introduction

1.1. COVID-19 Prevention

The acronym COVID-19, corona virus disease 2019, is no longer a new term in the world of today. On 1st April, 2021 approximately 3 million deaths (Fig. 1a) had been traced to COVID-19 globally [1], with over 2000 deaths traced to Nigeria (Fig. 1b), and yet some people argue that the virus does not exist. The virus is primarily spread through contact and respiratory droplets [2]. In order to prevent this transmission, the World Health Organisation (WHO) has already recommended measures like wearing of facemask, frequent hand hygiene, physical distancing, and also isolation of suspects as quick as possible [3], [4].

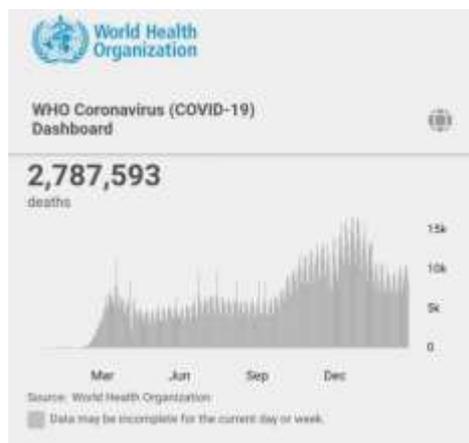


Figure 1a -COVID-19 Global Report as of April 1, 2021 [1]
Source: World Health Organisation

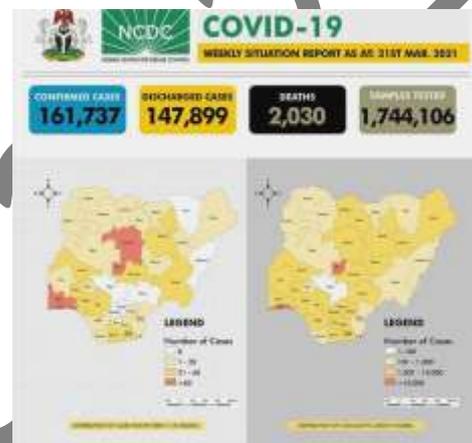


Figure 1b -COVID-19 Report in Nigeria as of April 1, 2021 [27]

Source: Nigerian Center for Disease Control (NCDC)

Despite all of the measures, COVID-19 transmission in Africa is of great concern. It was feared that the pandemic could be difficult to control in Africa, because many of the health care systems in the continent are inefficient [5], [6]. Currently attempts has been made to help prevent this transmission in Africa, the U.S. Agency for International Development (USAID) had already supported the Nigerian women training in Borno State to produce protective facemasks [8]. In addition the United Nation Inter Agency Task Force (UNIATF) also presents a developed index that measures the response of UN-member states to severe outcomes of COVID-19 at their 14th meeting held on July 10, 2020 [9]. Also Fig. 2 shows the level of prevention and control measures implemented by six African Countries namely Nigeria, South Africa, Egypt, Algeria, Senegal and Kenya [7]. Generally the most common public health measure taken by States against COVID-19 has been restricting freedom of movement [10].

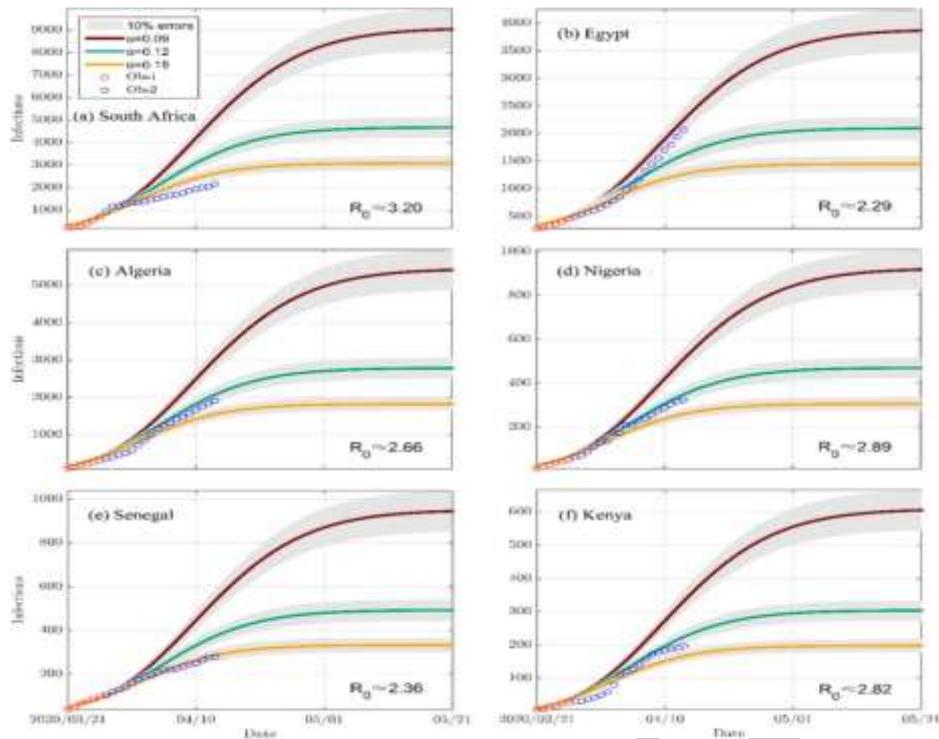


Figure 2 -Simulation Prediction of Epidemic Spreading Trends in (a) South Africa (b) Egypt (c) Algeria (d) Nigeria (e) Senegal and (f) Kenya (Both Obs1 And Obs2 Mean the Confirmed Cases Before and After March 25, R_0 is the Basic Reproduction Number) [7]

1.2. Artificial Intelligence Door

Generally, doors are constructed for legal entry into a building. There are many kinds of doors, designed for different purposes. The most common type is the single door (Fig. 3a), which has a single rigid panel that fills the doorway [31]. The double leaf door (Fig. 3b) is commonly used in large halls where much person passes, to avoid clusters. Currently doors are designed with Artificial Intelligence (AI) technology to give access for only known persons. Artificial Intelligence is one of the leading and trending technologies of the early 21st century world that involves the use of machines to perform human related task which requires reasoning [11].



Figure 3a. -Single Leaf Door

Source: Pinterest



Figure 3b. -Nnamdi Azikiwe Library Double Leaf Door

With AI technology, doors (Fig. 3a and 3b) could be redesigned to prevent covid-19 transmission in public buildings by restricting visitors without facemask or visitors with fever from entering a building. AI technique has become an essential part of the technology industry, helping to solve many challenging problems. Even companies like Tesla, Google and Apple have also adopted the use of AI in problem solving [12].

1.3. Aim and Objectives

The aim of this design is to prevent COVID-19 transmission in public halls through an entry restriction for persons who violates the COVID-19 preventive measures. Hence the objectives of this paper are;

- a) To restrict persons when a certain maximum number is reached, this is to prevent the transmission through crowd.
- b) To restrict persons without facemasks, this is to prevent the transmission through droplets.
- c) To identify and isolate persons with fever, this is to identify persons who might have the virus.
- d) To restrict persons whose hands are not sanitized, this is to prevent the transmission through touch.
- e) And finally to grant an unlock command for automated doors after a successful screening.

2. Literature Survey

Covid-19 has attracted millions of research works all around the world, with fewer contributions from the disciplines of engineering, in Nigeria. However to reduce the transmission of COVID-19 with zero human intervention, almost a near perfect artificial intelligence design will be required. During the course of this review, I found a system designed by Microsoft Team to monitor hospital entrance [13]. Microsoft calls this system 'AI masks and infrared temperature 2-in-1 detection device'. This device (Fig. 4) checks people entering Cardinal Tien Hospital in Taiwan to make sure they are wearing facemasks and whether they have a fever [13]. Also the department of metallurgical and materials engineering, University of Nigeria Nsukka, recently developed a locally made surveillance door for covid-19 transmission prevention. The both designs are limited to restricting entry, preventing crowd, identifying persons with fever, and also ensuring hand sanitization. This limitations, hence leads to the purpose of this work.



Figure 4. –Women face with mask detected by Microsoft AI Detection Device [13]

3. Materials and Method

The required materials for this design are 3D sensor, detection camera, infrared thermometer, and automated sanitizer dispenser. These four materials when integrated in a modern door

will prevent covid-19 transmission by encouraging physical distancing, wearing of facemasks, detection and isolation of suspects, and hand sanitization respectively.

3.1. Covid-19 Prevention Using 3D Sensor

3.1.1. Overview of 3D Sensor

3D sensor or people counter (Fig. 5) is an electronic device that can be used to measure the number of persons entering through a certain door. Before the advent of 3D sensor or electronic people counters manual counters were used. These manual counters required a store employee to stand near the entrance of the store and click on a counting device each time a person entered the store [14]. This was considered to be inaccurate due to high level of human error.



Figure 5. -A 4th Generation 3D Sensor
Source: Online

3.1.2. Characteristics of 3D Sensors

The purpose of using a 3D Sensor is to encourage physical distancing. The sensor records the number of persons entering a designated area through the doors and also programmed to restrict persons from entering the hall when a certain maximum number of persons is reached. Many different technologies are used in people counting devices. 3D sensor which is a current generation (4th generation, 2016-till date) of people counter, utilize stereoscope imaging to overcome the limitations imposed by previous generations such as shadow issues, high traffic counting, and disruption of patterns on the floor [15].

3.1.3. Integration of 3D Sensors

Fig. 6a shows the block diagram of a proposed design system which has also integrated both the way in and way out counter to calculate the exact number of people in a particular location for uni-directional door [16]. The sensor provides input and output to an ADC (analogue to digital converter) which then gives this input and output to an algorithm. The count gets incremented if people get in and decremented if people go out. Each count is saved in a non-volatile RAM and also sent to an LCD screen which displays the current number of persons inside the hall as shown in Fig. 6b. The current count is also sent to an algorithm which has been programmed to restrict persons from entering inside the hall when a certain maximum number of persons is reached. This maximum number is dependent on the choice of the user (hall manager) or the size of the hall, which is also computable by the user. Though this system in Fig. 6a is designed for a uni-directional door, but can also be easily redesigned to support bi-directional door system. [17] and [18] in their work also show how this could be done. With this design the door will prevent crowd by restricting entry for persons when a certain maximum number of persons is reached.

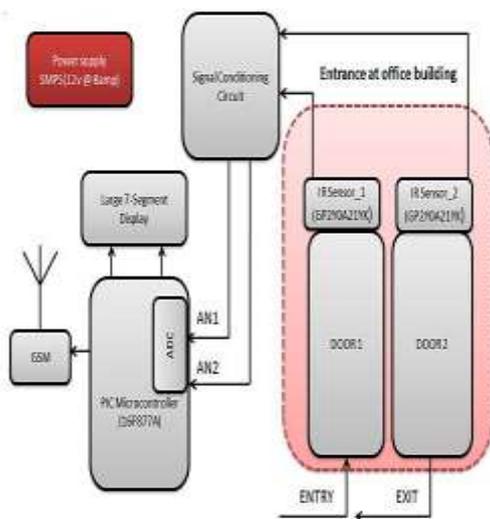


Figure 6a. -Block Diagram of Proposed System (Uni-directional Door) [16]



Figure 6b. -LCD screen displaying the current number of persons inside a hall

Source: Online

3.2. Covid-19 Prevention Using Facemask Detection Camera

3.2.1. Overview of Facemask Detection Camera

Facemask detection is a system that uses a rotating camera (Fig. 7) combined with computer vision to detect people with mask or without mask. Face mask detection is also a computer

technology being used in a variety of applications that identifies human face in digital images [19]. A reliable face detection approach is based on the genetic algorithm and the eigen-face technique which focus on the detection of frontal human faces [20]. The face mask detection system uses AI technology to detect the person with or without a mask [21].



Figure 7. –Rotating detection camera
Source: online

3.2.2. Characteristics of Face Detection Camera

The purpose of using facemask detection system on the door is to restrict an entry for persons without facemask, as it is illegal to be found in publics without mask during the corona virus epidemic. Also guaranteeing human rights for everyone amidst this pandemic poses a challenge for every country around the world to a differing degree [10]. Also the purpose of using a rotating camera is to detect faces of different height.

3.2.3. The Integration of Face Mask Detection Camera

To develop a facemask detection system that can work on any existing RTSP camera without the installation of any new camera requires a deep learning model. To train a model that classifies whether a person is wearing mask or not, we need to find a good dataset with a large amount of images for both classes. Currently the real-world masked face recognition dataset (RMFRD) which includes 5,000 pictures of 525 people wearing masks, and 90,000 images of the same 525 people without masks is the world's largest real-world masked face dataset [22],[32]. After a successful model training and testing, the model would be integrated in a camera using a micro-controller (Raspberry pi) which sends the output to an algorithm. If the

output sent to this algorithm confirms that the detected face is not wearing a facemask, then it immediately alerts the person through the LCD screen to wear its facemask and after a few seconds, if facemask is still not detected, the door will remain locked till a facemask is detected. Also using this dataset, [23] already trained a facemask detection model using PyTorch Lightning. Hence the product of the model in Fig. 8 shows a successful training. With the help of an algorithm programme persons will be restricted from entering when facemask is not detected and also grant entry when facemask is detected.

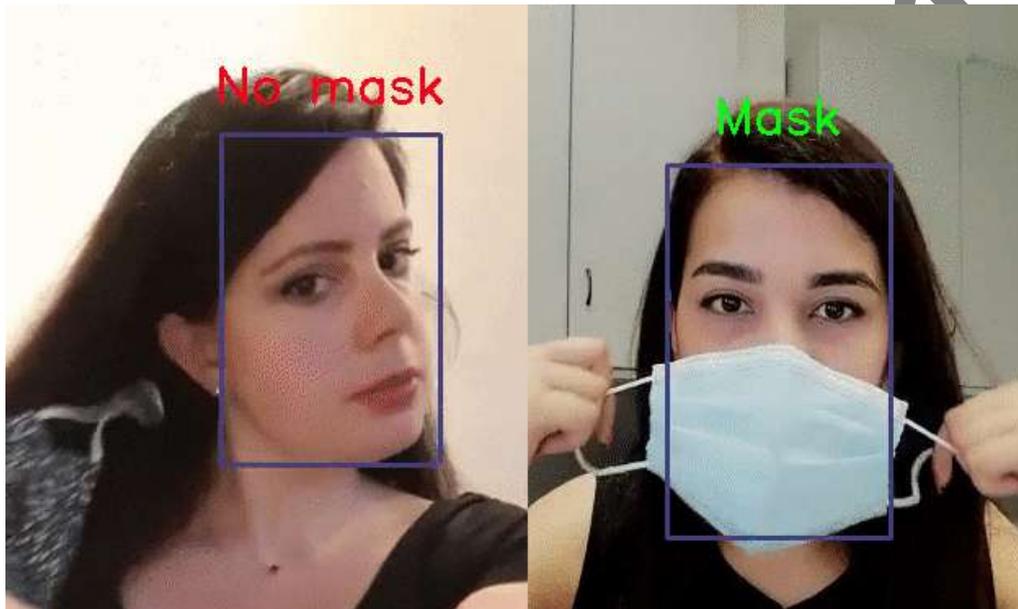


Figure 8. –Trained model detecting face with mask and face without mask [23]

3.3. Covid-19 Prevention Using Infrared Thermometer

3.3.1. Overview of Infrared Thermometer

An infrared thermometer sometimes called laser thermometer (Fig. 9) is a non-contact thermometer which measures a body temperature from a portion of a blackbody radiation at a distance. The design is essentially consist of a lens to focus the infrared thermal radiation on to a detector whose temperature will be displayed [24].



Figure 9. -An Infrared Thermometer
Source: Online

3.3.2. The Characteristics of Infrared Thermometer

The purpose of using an infrared thermometer technology is to enable doors check for the body temperature of persons from a distance before granting an entry, and most importantly alert the COVID-19 health care unit when a fever (human body temperature above 38°C) is detected, all at the same time, since identifying and reporting suspected cases as quick as possible is one of the best way to prevent the virus transmission [2]. Also Infrared thermograph was recommended as an early detection strategy for infected person [25], since fever is one of the symptoms of COVID-19. Also the smart thermometer can be used to achieve a non-contact measurement when placed in the forehead for a few seconds to get the body temperature [26].

3.3.3. Integration of Infrared Thermometer

To be able to detect the human body temperature and restrict persons with fever, without human intervention, there is a need to locate the human forehead which is the region of interest for detection. To locate this forehead a forehead detection dataset will be needed to train a model and after a successful training and testing, the model will be integrated into an infrared thermometer with a rotating camera module which will help detect the human temperature through the forehead. The resultant temperature figure for this detection will be sent to an algorithm which classifies this result as either normal temperature ($36^{\circ}\text{C} - 38^{\circ}\text{C}$) or abnormal temperature (38°C and above). If the temperature count is above 38°C , then this algorithm will send a notification to both the visitor and the Hall Manager while the door remains locked. For the visitor it will display 'please wait for our medical team' on the LCD

screen and for the hall manager or medical team it will alarm that persons with fever is detected and at the same time send the temperature figure as a text to a GSM module, which then forwards this figure to any registered mobile number. For example Table 1 shows the official lines managed by state ministries of health in Nigeria that could be registered and notified when a high body temperature is detected in Nigeria [27]. Also 6232 is an alternative number that could be notified for covid-19 cases all around Nigeria.

Table 1. Official Line Managed by State Ministries of Health in Nigeria

S/N	STATES	HOTLINE
1	Abia	07002242362, 0700ABIADOC
2	Adamawa	08031230359, 07080601139, 08115850085
3	Akwa Ibom	08189411111, 09045575515, 07035211919
4	Anambra	09034728047, 09034668319, 08163594310
5	Bauchi	08059600898, 08036916398
6	Bayelsa	08039216821, 07019304970, 08151693570
7	Benue	09018602439, 07025031214, 08033696511
8	Borno	08088159881, 08009999999
9	Cross River	09036281412, 08031230527
10	Delta	08031230480, 08031230481, 08031230528
11	Ebonyi	09020332489, 08159279460, 07045910340
12	Edo	08084096723, 08064258163, 08035835529
13	Ekiti	09062970434, 09062970435, 09062970436
14	Enugu	08182555550, 09022333833
15	Gombe	08103371257, 07026256569
16	Imo	09059995559, 09040045164, 07043954215
17	Jigawa	08035997118, 08036440532, 08069323005
18	Kaduna	08035871662, 08025088304, 08032401473
19	Kano	08039704476, 08037038597, 09093995333
20	Katsina	09035037114, 09047092428
21	Kebbi	08036782507, 08036074588, 08032907601
22	Kogi	07088292249, 08150953486, 08095227003
23	Kwara	09062010001, 09062010002

24	Lagos	08023169485, 08033565529, 08052817243
25	Nasarawa	08036018579, 08035871718, 08033254549
26	Niger	08038246018, 09093093642, 08077213070
27	Ogun	08188978393, 08188978392
28	Ondo	07002684319, 07012684319, 08002684319
29	Osun	08035025692, 08033908772, 08056456250
30	Oyo	08095394000, 08095963000, 08078288999
31	Plateau	07032864444, 08035422711, 08065486416
32	Rivers	08056109538, 08031888093, 08033124314
33	Sokoto	08032311116, 08022069567, 08035074228
34	Taraba	08065508675, 08032501165, 08039359368
35	Yobe	08131834764, 07041116027
36	Zamfara	08035626731, 08035161538, 08161330774
37	Federal Capital Territory	08099936312, 08099936313, 08099936314

3.4. COVID-19 Prevention Using Automated Dispenser

3.4.1. Overview of Automated Dispenser

Hand sanitization is already one of the preventive measures mapped out for COVID-19 transmission prevention by the WHO. Automated sanitizer or soap dispenser (Fig. 10) is a device that dispenses soap or sanitizer usually in small quantity when a sensor detects motion under the nozzle [28]. Also 1 litre of liquid sanitizer can provide sanitizer for up to 400 persons [29].



Figure 10. -An Automated Sanitizer Dispenser
Source: online

3.4.2. Characteristics of Automated Sanitizer Dispenser

The primary purpose of adopting this dispenser design is because of its hands-free dispensing quality. This implies that there's no hand contact before and after use and since COVID-19 could be transmitted through touch [2], the design will help prevent this form of transmission. It is also proven that a concentration of 70% alcohol in sanitizers can kill corona virus on hands [30].

3.4.3. Integration of Automated Sanitizer Dispenser

To restrict persons whose hands are not sanitised the automated dispenser will need to be powered. Immediately it is powered and ready for use, a notification will be sent on the LCD screen displaying 'please use our sanitizer dispenser' also this notification will remain on the screen till the sanitizer dispenser is used. After a successful hand sanitisation the algorithm will automatically grant an unlock command to the door system and at the same time display a welcome note for the visitor on the LCD screen, also if the sanitizer is not used the door system will remain locked. Also within few seconds after the dispensing of sanitizer to an individual, the door automatically opens and then closes after a successful entry.

4. Methodology

At first, the four sensory materials are positioned at various parts of a modern door, with each material interconnected to form a network. The network is regulated by the algorithm program shown below.

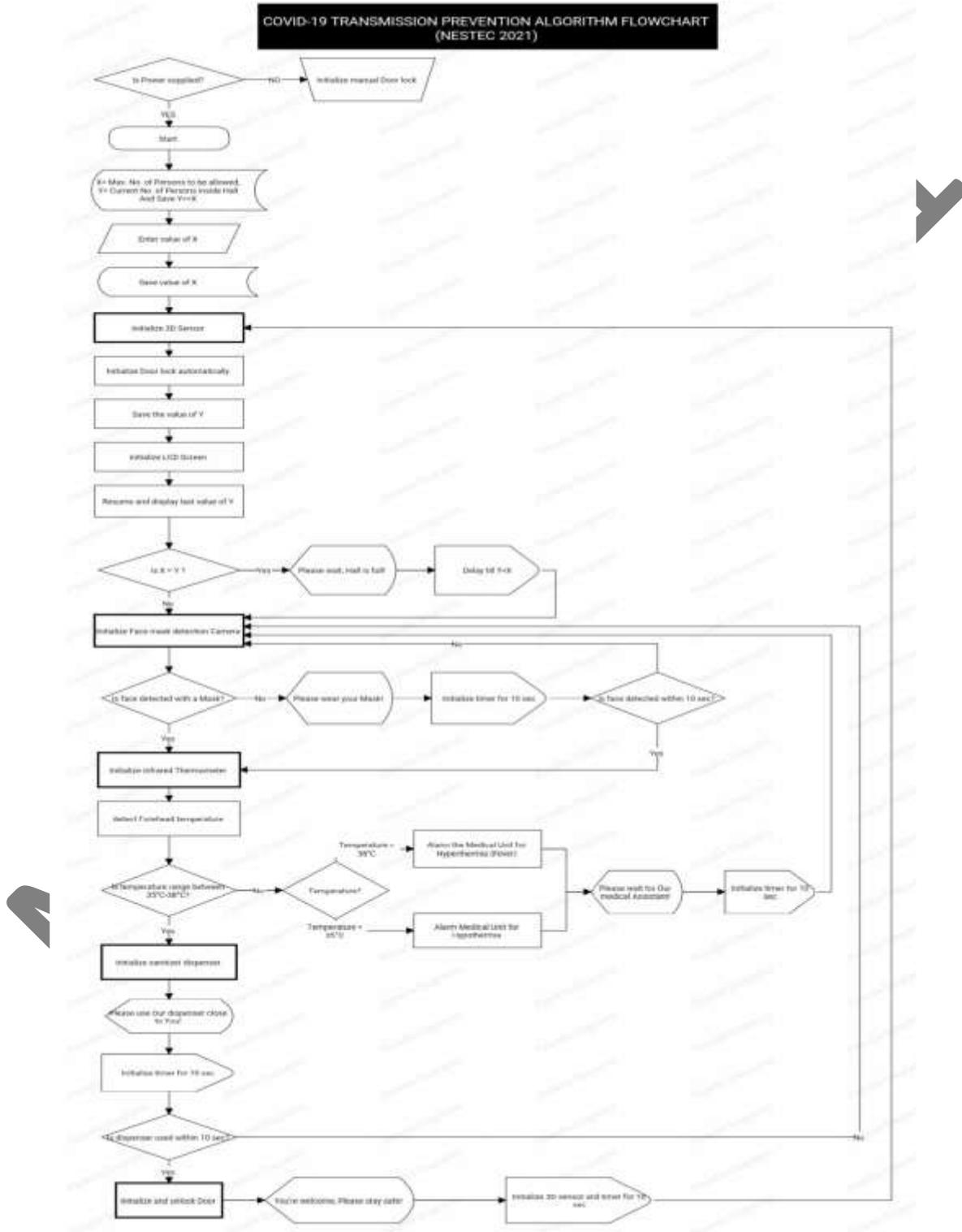


Figure 11. –Covid-19 Transmission Prevention Algorithm Flowchart

5. Results

From the above works, the system prevents virus transmission using current technologies in 3D sensor, facemask detection camera, infrared thermometer and automated sanitizer dispenser to enable the door restrict access for persons when a maximum number of persons is reached (crowd prevention), when persons are without facemask, when persons has fever, and lastly when persons hands are not sanitized. Also with the help the algorithm program, this design is set to alert the COVID-19 task force member when a person with fever is detected. Fig.12 below also shows a 2D picture of persons finally allowed by the door, for meeting the door screening criteria, and also persons restricted by the door for not meeting the criteria.



Figure 12. –2D Picture of persons allowed and persons restricted from entering a P.O.S Hall
Source: V-count

6. Discussions

Unlike the Microsoft detection system and the University of Nigeria surveillance door, this work includes other important features, which includes crowd control, restricting people without facemask, alerting the covid-19 task force of persons with high body temperature, and finally ensuring hand sanitization. This system also uses a solar as a source of power for its

operation. Also this will prevent future SARs virus transmission in designated halls like stores, airports, supermarket, shopping malls, casinos, events, amusement parks, museums, restaurants, gyms, libraries, classrooms, transportation vehicles, and so many smart buildings.

6.1. Limitations of Design

- Requires constant power supply.
- Requires a deep knowledge of programming for its development.
- Can not work on doors with padlock systems since its supports only automatic door lock systems.
- Intensive knowledge of 3D sensor, detection camera, infrared thermometer and sanitizer dispenser will be needed for the development.
- The door might not detect face in darkness mostly at nights due to problem of night vision, although this problem could be overcome using lamps or light bulbs.

6.2. Strengths of Design

- It will help prevent transmission of the virus and other possible future virus of the SARS family.
- It will help solve the problem of Crowd in public halls during and after the COVID-19 era.
- It will help prevent the spread of the virus even in the midst of ongoing businesses and other activities.
- It will help identify persons who might have the virus through alerting the COVID-19 screening team when persons with fever is detected.
- It will help save and revive the worlds economy through the ease of lockdowns, since the door is designed to prevent transmission in the midst of on-going businesses and other activities.
- It will also eliminate the COVID-19 taskforce members, those who stand at doorways to ensure that covid-19 preventive measures are observed.
- The design is also flexible, this implies that you can skip any of the screening process, for example after the COVID-19 era you can disable unnecessary features like the hand sanitization process.

- It will help increase the intervention factor in most affected countries, for example countries whose intervention factor is less than 0.5 will be helped will through the adoption of this design.

6.3. Recommendations

- The NCDC should partner with the Blue Apple Foundation on their mission to encourage research among 5,000 young engineers within 5 years for a better Nigeria, and for a better world.
- The system should be further modified to prevent other virus diseases
- Nations should strengthen and encourage research and development in their health sector.
- The WHO should support the development of this door and also recommend it for countries as it will help enforce the COVID-19 preventive measures and also control future virus spread.
- The FG should encourage research and development among young engineers in tertiary institutions of Nigeria.

7. Conclusions

The increasing number of people dying of covid-19 is indeed hindering the world from getting better. And this is as a result of continuous transmission of the virus. But this paper presents one of the best measures for COVID-19 transmission prevention. Through the adoption of this artificial intelligence door, the transmission of the virus will be reduced, even as businesses and other activities are going on. It will help reduce stress for the covid-19 taskforce members, and also reduce their chances of contracting the virus. It will also help ease future lockdowns, and most importantly prevent the spread of any possible future virus of the SARs family. Among all, this door will also help in the restoration of global economic development, for a better Nigeria and for a better world.

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However owing to the need for facemask in Nigeria I would love to give 10% of my essay prize for the purchase and distribution of facemasks in the most affected School in the country. And please remember wear a mask and stay safe!!!

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