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Enhanced Covid-19 Contact-Tracing System

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Abstract

Covid-19 is a global pandemic that has brought the world to a standstill. The virus originated from Wuhan China and has claimed the lives of over 5 million people according to World Health Organization. The Nigeria centre for Disease control is an agency that manages pandemics in Nigeria. They have created awareness son the management of Covic-19. Contact tracing of people that have come in contact with infected people poses a lot of problem. In this study, optimized system for con tact tracing of Covic-19 was carried out. Object Oriented Analysis Design Methodology (OOADM) was adopted and implementation was achieved with python programming language. The result obtained showed better and optimized performance in contact-tracing based on symptomatic (1) and asymptomatic (1+1) infection generation using fuzzy logic as an accurate decision making tool.

Keywords: covic-19; Contact-Tracing; sensor; swarm; fuzzy logic.

1. Introduction

Covid-19 is the acronym for corona virus disease 2019. It is a global pandemic which occurred in December 2019 at a sea-food market in Wuhan province of China. Symptoms of covid-19 encompass, cold, difficulty in breathing and the inability to taste and smell [1]. Furthermore, covid-19 has put the entire world in a state of lockdown that has also affected the socio-economic state of the world. Diagnosing Covid-19 comes with a lot of difficulties such as complexities in interpreting symptoms inform of mixed datasets, issues of patients who are asymptomatic and the exorbitant resources involved in isolating and treating an infected patient [2]. The study proposed an enhanced Covid-19 tracing system using Fuzzy logic technique. Furthermore, proper care and medication for victims of covid-19 especially the elderlies seems insignificant due to the absence of an enforced policy that governs the affairs of the elderly; and the elderly population is rapidly on the increase. The most recent policy was the Senior Citizens Centre Bill signed by the Nigerian President, Muhammadu Buhari on 28[th] January, 2018.

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However, implementation and functionality of this bill is the crux of the matter [3]. Recent research records have shown that Nigeria has over nine million (9, 000, 000) elderly population who are sixty (60) years and above. However, by the year 2030, it will increase to twenty million (20, 000, 000) as recorded by Global Age Watch Index [4]. The obvious challenges associated with ageing require the enactment and implementation of a working policy in order to cushion the effects of ageing in Nigeria.

1.2. Review of Related Literatures

Coronavirus disease 2019 (Covid-19) is an infectious disease caused by a newly discovered coronavirus. Most people infected with the Covid-19 virus will experience mild to moderate respiratory illness and recover without requiring special treatment. Many literature, techniques and methods have been written and adopted for tracing of covic-19 patient. Many expert systems designed to diagnose human diseases like an expert system that helps doctors and specialists to diagnose and get appropriate advice on covic-19.

New a review of Age-friendly Virtual Assistive Technologies and their Effect on daily living for care givers and dependent adults. The study uniquely drew together the small volume of literature from the fields of gerontology, gerontechnology, human computer interaction (HCI), and disability. The authors did a good job but could not implement the discussed review to a model to show more clarification and understanding [5]. Hayley and his colleagues in [6] looked at the role of healthcare robots for older people at home: a review. The study aimed to identify the areas of need that older people have, and the available solutions. In particular, the robotic solutions are explored and critiqued and areas for future development identified. Furthermore, the authors reviewed several literatures for factors that influence admission to nursing home care, and for technological solutions to these factors. The authors did a good job. But the study could not be implemented with real-life health robotics. Daniel and his colleagues in [7] presented a study on Agent-based M and S of Individual Elderly Care decision-making. The authors developed an Agent-based model that enables the simulation of individual decision-making processes. The presented model in the study was based on socio-demographic data to take systemic properties and individual situations into account. Additionally, sociological actor types were used to implement individual preferences and characteristics of care recipients. The authors did a good job. However, a major limitation of their study is that the developed model was deficient in benchmarking and cost benefits analysis. Stefano and his colleagues in [8] looked at an agent-based architecture for adaptive supervision and control of smart environments. The study described architecture and functionality of a generic agent that is in charge of handling a given environment in an Ambient Intelligence context, ensuring suitable contextualized and personalized support to the user's actions, adaptively to the user's peculiarities and to changes over time, and automated management of the environment itself. Furthermore, the architecture was implemented in a multiagent system, where different types of agents are endowed with different levels of reasoning and learning capabilities. The authors did a good job. However, the analysis of their adopted methodology showed that they only simulated the implementation, and failed to deploy the work to a real smart environment. Juan and his colleagues in [9] presented a study on an agent-based architecture for developing activity aware systems for assisting the elderly. The authors new an activity-aware computing that allows smart environments to provide continuous activity awareness and opportunistically offer assistance aimed at supporting the elders' current activity. The new paradigm called for novel tools to help developers mirror human activities in the digital domain, and adapt smart environments based on the activities executed by the users. The authors did a good job. However, they were unable to apply the developed system on other software engineering tasks that rely on text analysis using topic models. Pekka and his colleagues [10] new a study on an In-home Advanced Robotic System to manage Elderly Home-Care Patients' Medication. The study examined the safety profile and usability of an integrated advanced robotic device and telecare system to promote medication adherence for elderly home-care patients. The authors did a good job. However, their developed model failed to proffer solution to identified cases of missed doses that were followed up in real-time. Ayman and his colleagues [11] presented a study on an adaptive intelligent alarm system for wireless sensor network. The study new a basic and adaptable remote arrange for domestics computerization of temperature, moistness, gas, movement and light by executing dependable sensor hubs which can be controlled too observed. The innovation offered energizing and new chance to build the availability of devices inside the home for the home computing. The authors did a good job. However, they had a vague result due to their simulation and non-implementation with a real hardware sensor device.

2. Materials and Methods

In the quest to developing an effective covic-19 system application, the authors employed an iterative object oriented design software engineering methodology known as Object-Oriented System Development Methodology (OOSDM). Object-Oriented System is a software Engineering process that provides a disciplined approach to assigning tasks and responsibilities within a development organization. The Object-Oriented System aims at viewing, modelling and implementing the new system as a collection of interacting classes and objects. A RUP activity creates and maintains models and emphasizes the development and maintenance of models-semantically [12]. OOSDM is adopted because it is more effective, efficient, reliable, reusable and a faster way of developing systems. In addition, the Object-Oriented System Development Methodology (OOSDM) for this research work involves the following phases:

- Analysis,
- Design,
- Implementation and
- Testing

We will follow the phases as detailed to get the research completed

2.1 Existing System

The existing system addressed by the study is a system for modeling contact-tracing strategies for covid-19 in the context of a relaxed physical distancing measures and is illustrated in fig 1. The study used a mathematical model to examine the potential for contact tracing to reduce the spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in the context of relaxed physical distancing, under different assumptions for case detection, tracing, and quarantine efficacy. The existing system can work in heterogeneous environments to speed up clinical decision making, automated learning systems, and assist caregivers in treating patients during diagnosis and treatment.

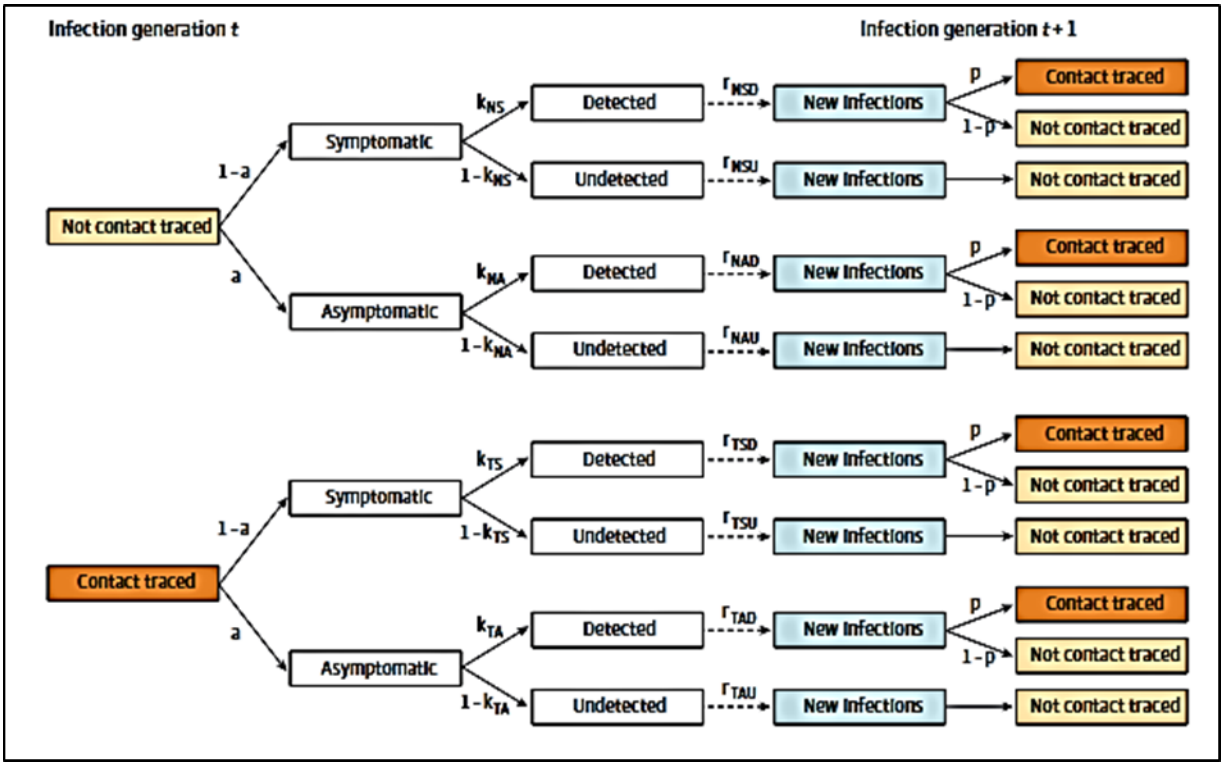

Figure 1: Shows the Existing Architecture (Alyssa and his colleagues 2020).

Algorithm 1: Genetic-based learning process

Procedure: Information extraction task

Input: Trained and pre-processed documents

Output: Extraction of key information from the pre-processed health data

1. Generate initial population.
2. Compute fitness of each text.
3. WHILE NOT finished DO
4. FOR population size DO
5. Select two document functions randomly from old generation.
6. Apply Crossover to give two document functions
7. CONTINUE (until desired numbers of document functions are generated)

8. FOR population size DO Select 1 or 2 document functions randomly.

9. For each selected document function, select bits randomly to apply Mutation operation.

10. CONTINUE (until desired numbers of bits are mutated)

11. Compute fitness of each document function in new generation.

12. IF acceptable level of change in fitness achieved THEN Finished

13. ELSE Repeat Step 3

Advantages of the Existing System

The advantages of the Existing System are:

- A graphical user interface that allows the administrator to mark diseases for detection, choose the detection methods to be applied to each diagnosis/subtype and manage the list of epidemiologists that will receive alerts in case a warning is generated.
- Latency reduction and medical diagnosis optimization

Disadvantages of the Existing System

The disadvantages of the Existing System are:

- The inability develop a data visualization technique for accurately and specifically pin-pointing an unsuspecting carrier of covid-19
- Compromise and inconsistencies of health information, which encompass data leakage and malicious sabotage by guilty agents of the system.

2.2 An Enhanced Covid-19 Contact-Tracing System

The new system is an improvement of the existing system as shown in Figure 2. It is an enhanced contact-tracking system for covid-19. The new system uses rule-base and fuzzy logic learning oriented concepts for contact-tracing and tracking. This is because, the key aspect in the contact-tracing process is the preparation of data, including the selection of input data, problem formulation and model representation (rules, decision/regression trees, etc.). After this preparation, the algorithms search in the space of model parameters for those most suitable to the specific data set used in training.

Figure 2: Architecture of the New System.

Equations of the New System: The following are fuzzy logic equations of the new system

Step 1: Let X be a fuzzy-based finite set for optimizing contact-tracing of covid-19

$$X = \{x_1,x_2,...,x_n\} \qquad (1)$$

Step 2: The subset A of X consisting of the single element x_1 can be described by then-dimensional membership vector Z (A) = (1,0,0,...,0), (2)

Step 3: where the convention has been adopted that a 1 at the *ith* position indicates that x_i belongs to A. The set B composed of the elements x_1 and x_n is described by the vector

$$Z(B) = (1,0,0, ...,1). \qquad (3)$$

Step 4: Any other crisp subset of X can be represented in the same way by an n-dimensional binary vector. We can define the fuzzy set C with the following vector description:

$$Z(C) =(0.5,0,0, ...,0) \qquad (4)$$

Algorithm of the New System

The following is the new system algorithm:

Algorithm 2: Fuzzy logic system

Procedure: Fuzzification and Defuzzification of contact-tracing information

Input: Crisp sets

Output: Defuzzified information on contact-tracing

1. Initialize Fuzzy System
2. Input crisp sets for optimal performance of contact-tracking system
3. Fuzzify crisp inputs using knowledge-base
4. x_0 x_1 x_2
5. x = [[1., 0., 0.],
6. [1., 0., 1.],
7. [1., 1., 0.],
8. Compute authenticity of each text

9. WHILE NOT finished DO

10. FOR scanning size DO

11. Select two document functions randomly from old generation.

12. Apply crossover to give two document functions

13. CONTINUE (until desired numbers of document functions are generated)

14. Display Fuzzified Crisp Datasets as Output

15. End

2.3 Use Case Diagram

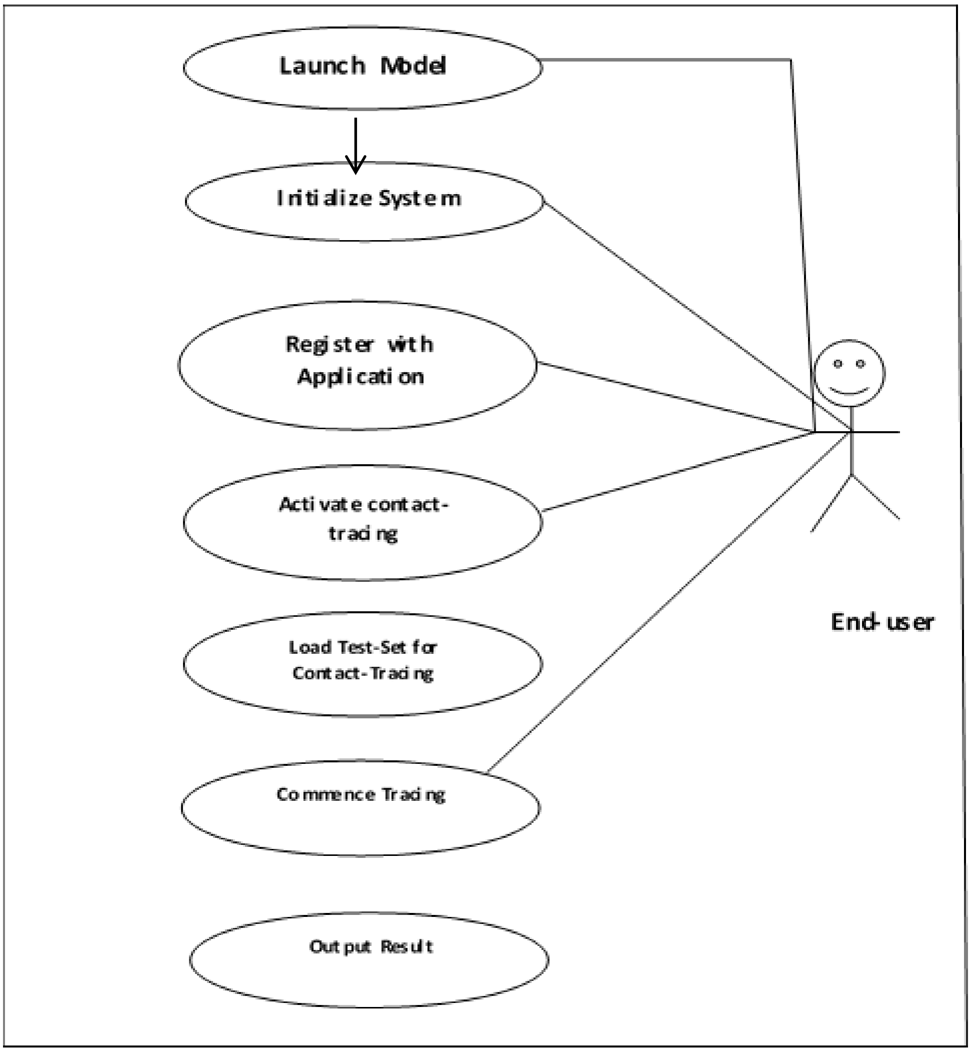

Figure 3: Use-Case Activity Diagram of the New System.

A use case diagram is a behavior diagram and visualizes the observable interactions between actors and the system under development. The diagram consists of the system, the related use cases and actors and relates these to each other:

System: What is being described?

Actor: Who is using the system?

Use Case: What are the actors doing?

A use case diagram describes the desired functionality of the system and relates it to use cases and actors. That way it can represent existing viewpoints of the system and how they are interpreted differently only through this can requirements be completely understood. Use cases are normally presented as ovals. A use case represents a functionality of the system from the viewpoint of the user and describes the goals of their use. Here, the order of the action can and should be entered. For example insert card, enter PIN, and so on.

Advantages of the New System

The following advantages of the New System are:

- Active and efficient framework for tracking unsuspecting carriers of covid-19 in quick response time
- The ability of the new system to be secured to potential malicious agents who intends to compromise confidential health data
- The ability to track, detect and prevent potential cases of the novel corona virus disease
- A graphical user interface that allows the administrator to mark diseases for detection, choose the detection methods to be applied to each diagnosis/subtype and manage the list of epidemiologists that will receive alerts in case a warning is generated.
- Latency reduction and medical diagnosis optimization

3. Result

Figure 4.1 shows the welcome page of the new system. The welcome page has three navigation links

titled the home, register and Initialize Tracking. Figure 4.2 shows the new user registration page.

Figure 4.3 shows the registered user login page. Figure 4.4 shows the test-set input page which enables the system to initialize the contact-tracing process. Figure 4.5 shows the contact-tracing result of the new system. The concept of the contact tracing technique of the new system is based on the neural network framework. Automatically learning the features with deep architectures, i.e. architectures composed of multiple layers of nonlinear processing, can be considered as a relevant choice. Indeed, some highly nonlinear functions can be represented much more compactly in terms of number of parameters with deep architectures than with shallow ones (e.g. SVM).

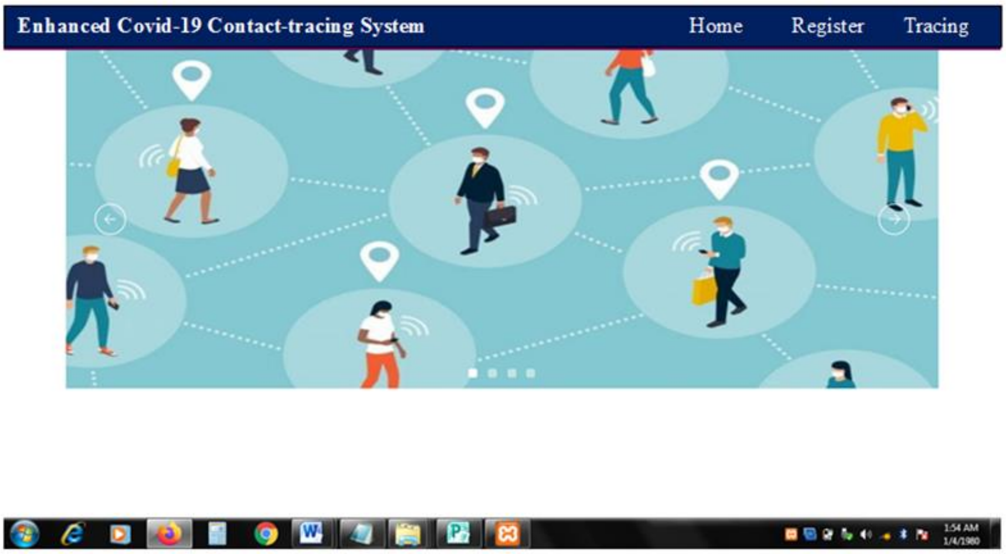

Figure 4: Welcome Page.

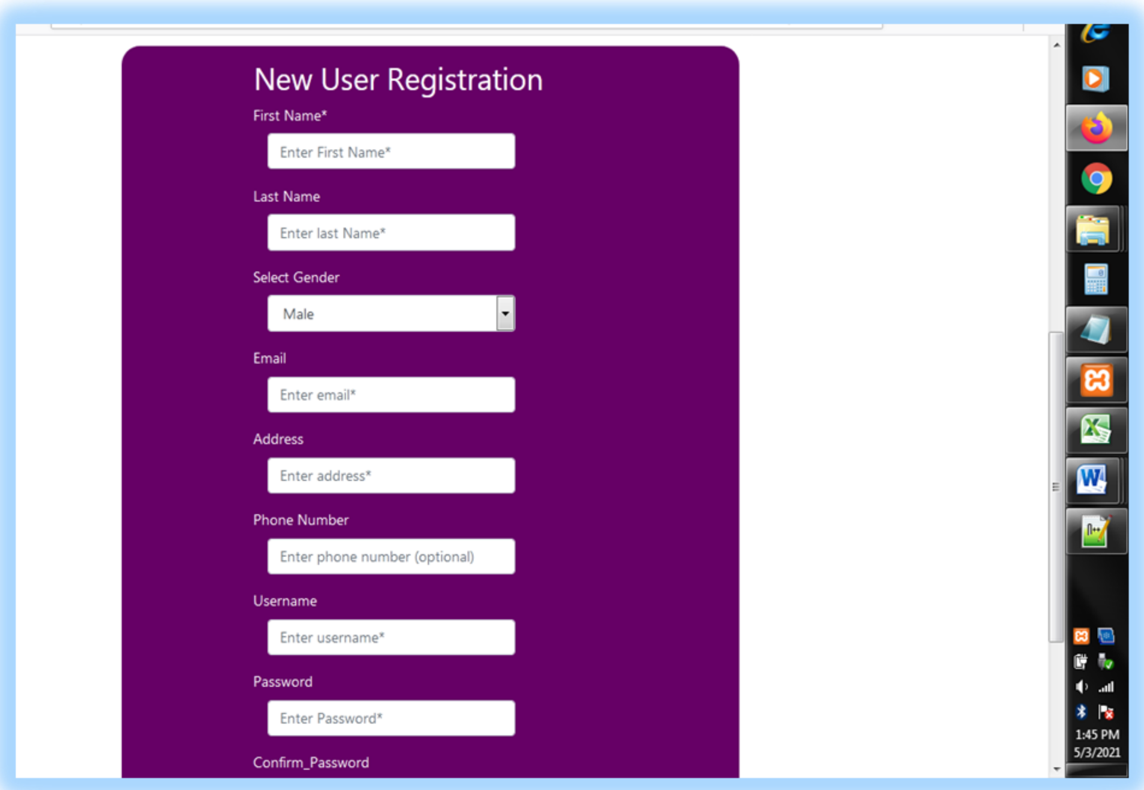

Figure 5: New User Registration Page.

For example, it has been proven that the parity function for n-bit inputs can be coded by a feed-forward neural network with O (log n) hidden layers and O (n) neurons, while a feed-forward neural network with only one hidden layer needs an exponential number of the same neurons to perform the same task. Moreover, in the case of highly varying functions, learning algorithms entirely based on local generalization are severely impacted by the curse of dimensionality. Deep architectures address this issue with the use of distributed representations and as such may constitute a tractable alternative. In deep learning, each level learns to transform its input data into a slightly more abstract and composite representation. In an image recognition application, the raw input may be a matrix of pixels; the first representational layer may abstract the pixels and encode edges; the second layer may compose and encode arrangements of edges; the third layer may encode a nose and eyes; and the fourth layer may recognize that the image contains a face. CAPs describe potentially causal connections between input and output. For a feed-forward neural network, the depth of the CAPs is that of the network and is the number of hidden layers plus one (as the output layer is also parameterized). For recurrent neural networks, in which a signal may propagate through a layer more than once, the CAP depth is potentially unlimited.

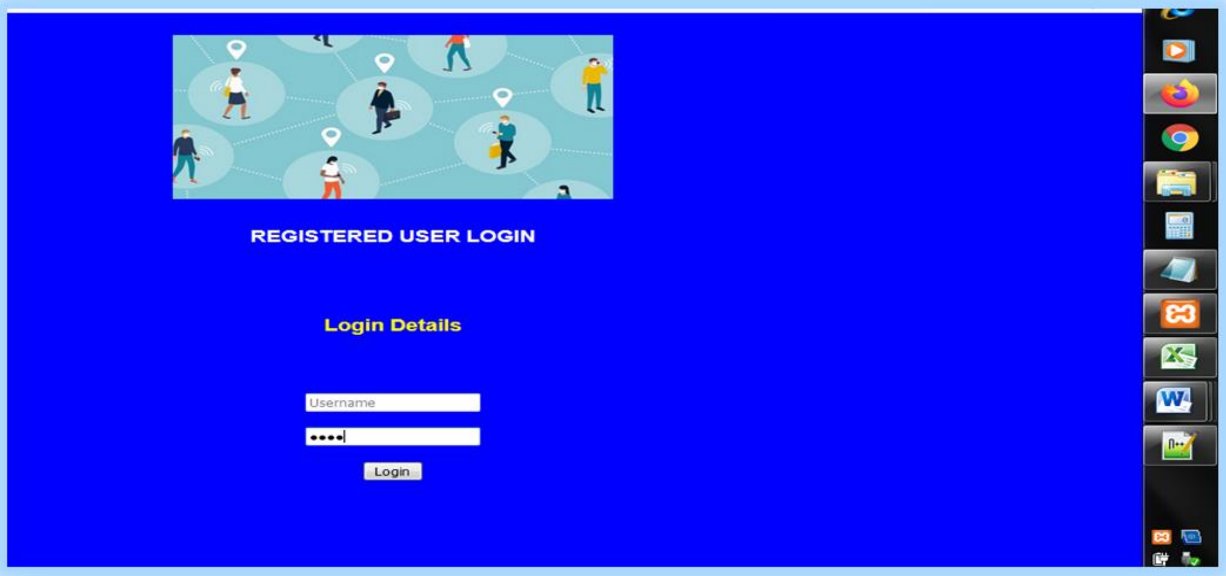

Figure 6: Registered Users Login.

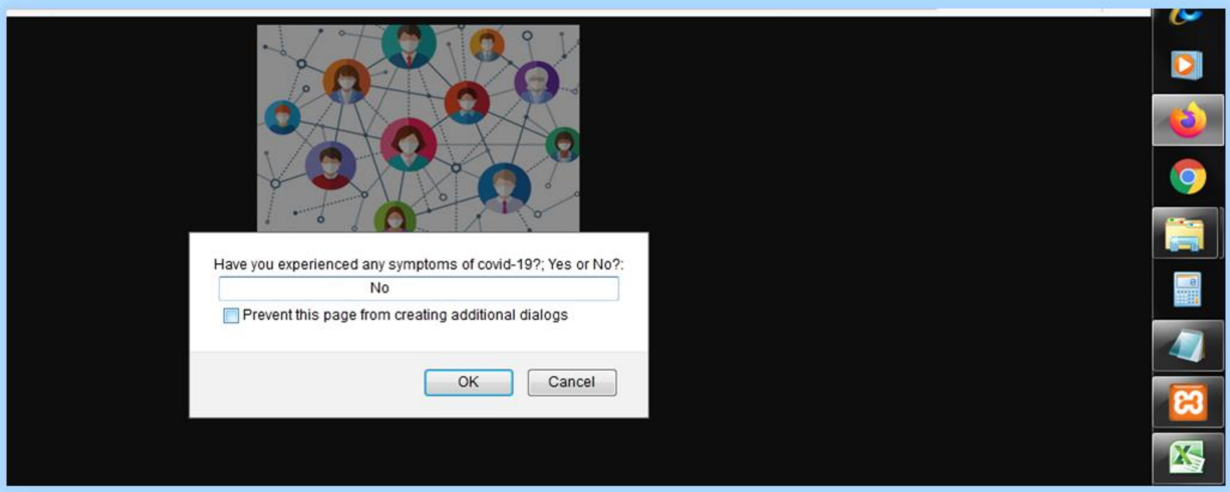

Figure 7: Test-Set Input Page.

CONTACT-TRACING RESULT

EXIT

YEAR	2021
CURRENT TEMPERATURE CHECK RECORD	27 Degrees Celsius
LAST TRAVEL HISTORY	Lagos, Nigeria
DETECTED TRACE OF COVID-19	Negative
ACTIVE VISUALIZED LOCATION	Choba, Axis, Obio-Akpor, Rivers State

Figure 8: Contact-Tracing Result.

Table 1: Result of the New System.

SN.	END-USERS WHO TESTED THE SYSTEM	DETECTED TRACE OF COVID-19
1.	User 1	Positive
2.	User 2	Positive
3.	User 3	Positive
4.	User 4	Positive
5.	User 5	Positive
6.	User 6	Positive
7.	User 7	Positive
8	User 8	Positive
9	User 9	Positive
10	User 10	Positive
11	User 11	Positive
12	User 12	Positive
13	User 13	Positive
14	User 14	Negative
15	User 15	Positive
16	User 16	Negative
17	User 17	Positive

Table 2: New System Result (Contd.).

SN.	END-USERS WHO TESTED THE SYSTEM	DETECTED TRACE OF COVID-19
37.	User 37	Positive
38.	User 38	Positive
39.	User 39	Positive
40.	User 40	Positive
41.	User 41	Positive
42.	User 42	Positive
43.	User 43	Positive
44.	User 44	Positive
45.	User 45	Positive
46.	User 46	Positive
47.	User 47	Positive
48.	User 48	Positive
49.	User 49	Positive
50.	User 50	Positive

4. Conclusion

In this study, we developed an improved contact-tracing model for covid-19. Any public health measure is ethically correct, if it provides sufficient public health benefit to justify the burdens associated with it. In this context global health experts like WHO, Johns Hopikins University and Oxford university released recommendations on ethics and governance on the use of Digital contact tracing technologies. Based on this principle a public health ethical review was done using available literature. Currently, there are no established methods for assessing the effectiveness of digital proximity tracking. More research to evaluate their effectiveness is needed. Governments, developers must ensure that COVID-19 contact- tracing apps satisfactorily address the ethical questions and must ensure the necessary but least intrusive measures for disease surveillance.

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