International Journal on
"Technical and Physical Problems of Engineering"
(IJTPE)
Published by International Organization of IOTPE

ISSN 2077-3528
IJTPE Journal
www.iotpe.com
ijtpe@iotpe.com

December 2021 | Issue 49 | Volume 13 | Number 4 | Pages 97-103

# ARTIFICIAL INTELLIGENCE AUSCULTATION SYSTEM FOR PHYSIOLOGICAL DISEASES

**M. Mbida [1] A. Ezzati [2]**

*Department of Emerging Technologies Laboratory (LAVETE), Faculty of Sciences and Technology, Hassan I University, Settat, Morocco, m.mbida@uhp.ac.ma, abdezati@gmail.com*

**Abstract-** Nowadays, several physiological diseases need to be detected into the patient in real time to avoid complications and contaminations in the next hours , hence the classic detection in this situation becomes dangerous, tedious and long, however for an instant and daily monitoring , this article presents and evaluates a new intelligent approach which is based on the extraction of physiological values (photoplethysmography technique) through a smart phone or computer camera, and to process them in an neural auscultation networks. to detect and specify the type of the cases disease, for acting quickly to treat them on the campus.

**Keywords:** Smart Cameras, Hybrid Intelligent Systems, Artificial Neural Networks, Computer Applications, Medical Information Systems.

## 1. INTRODUCTION

Classical auscultation compared to artificial networks auscultation [1, 2], is a complex basic ability to learn and apply to a patient's physical examination, it is both a screening mechanism, providing an initial diagnosis of a patient's clinical condition. But also, a skill difficult to master, which increases the rate of false results on the physiological state of a patient according to the augmentation number of patients, as in the case of a university campus. This method begins with an interview of the patient to detect the type of disease as well as the intensity of the symptoms felt, then we proceed to a classic observatory and automated auscultation which varies according to the disease which we will detail some examples in the following article.

### 1.1. Classic Cardiac Auscultation

Cardiac diagnosis is a procedure that occurs usually during patient treatment and permits the detection of abnormal heart sounds that inform the clinician to the possibility of a cardiac abnormality. For the reason of its regularity of occurrence and its interest in providing exceptional patient care, the nurse should repeat the auscultation to ensure results are obtained at least twice [3].

### 1.2. Classic Pulmonary Auscultation

Pulmonary auscultation is one component of the physical examination to assess respiratory condition, the others being inspection, palpation and percussion. To be of clinical value, the noises perceived with the stethoscope must be identified and interpreted [4]. Specifically, it aims to assess the quality, frequency, duration and intensity of physiological noises and to discover additional or abnormal noises such as Stridor, wheezing/hissing, Ranchi, /Crackling/Grating/Crackling rales and Friction pleura which involves Chronic disease like ASTHMA.

### 1.3. Classic Temperature Auscultation

The gallium temperature diagnosis is the most used in health centers, which gives one of the deterministic values to mainly ensure that the patient does not suffer from any internal respiratory infection [5], like Covid-19 or other related diseases at an increase in body temperature. However, measurements are taken by buccal, sublingual and rectal way.

## 2. RELATED WORKS

Several related auscultation works have been carried out, for one but to facilitate the identification of the disease, with an almost absolute accuracy of the physiological parameters of the patient, we mention in this part the most important and topical projects in this axis of research.

### 2.1. Boosted Frame-Similarity Technique for Detection of Cardiac Rhythms and Respiratory in Auscultation Reports

An algorithm has been developed to determine rhythms of cardiac and respiratory activity in auscultation signals. The basis of this technique is to specify the energetic analogy of the parts of the initial recording at their superposition with an evolving time gap. To recognize the temporal progression of the frequency content of the signal, the short-term Fourier transform is implemented in the recordings acquired by the portable digital auscultation complex with one developed channel [6].

### 2.2. Unnatural Heart Rhythm Discovery Using Spectrogram of Heart Sound with Convolutional Neural Network

This project mainly aimed at the development of a classification scheme for heart disease based on the spectrogram of heartbeat noises, in order to amplify the degree of auscultation precision, while applying a convolutional neural network algorithm (CNN) [7]. The computer-assisted classification result gave an accuracy that exceeds compared to the conventional auscultation.

### 2.3. Forecasting Respiratory Abnormality and Diseases with Recurrent Neural Networks

In this work, a learning framework for respiratory diagnostic sound information was realized, combining advanced feature extraction techniques and advanced deep neural network architectures. The modeling of this learning system is based on a recurrent neural network to facilitate the clinician to intercept respiratory diseases, whether at the level of abnormal noises or of pathology classes [8].

### 2.4. Detection of Unexpected Respiratory Sounds Based on Convolutional Neural Network

This realization is based on artificial auscultation (AI) using an electronic stethoscope of respiratory diseases to detect and identify two types of adventitious respiratory noises linked to respiratory diseases: wheezing and crackling. The exploitation of respiratory data is done in this study by deep learning in big data under the control of a CNN [9].

## 3. SMART AI AUSCULTATION

The classic diagnosis most used in a campus is characterized by a general auscultation (GAu) to measure the physiological values of the student, in the case of an anomaly values, the nurse proceeds to a second diagnosis for the type of disease to be treat through the determination of certain physiological parameters that indicate the disease. However, due to the large number of students on a campus, the task becomes very difficult when we want to auscultate the campus daily as in the case of the current Covid-19 pandemic, this requires a very long duration of auscultation with a lot of material and human resources, moreover this leads to measurement errors which imply an increase in the rate of contamination on the campus. To deal with this, we propose an AI auscultation process which is based on the capture of physiological parameters using a smart phone or computer camera, and to transfer these values to a deep neural network which will make an investigating each student's condition and reporting cases that require emergency treatment to avoid contamination and disease complication, and to perform human nursing intervention only in the treatment proceedings of the disease (Figure 1).

### 3.1. Photoplethysmogram Extraction Technique

Photoplethysmography (PPG) is an optical mechanism used to collect changes in the volume of blood in the peripheral circulation of the body. It is a non-invasive method that takes measurements on surface of skin [10].

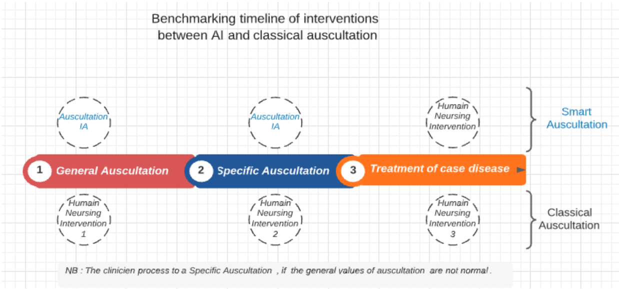



Figure 1. Time process AI and Classical Auscultation

This technique gives valuable information to our cardiovascular system. Recent advances in technology have confirmed the interest in this technique, which is widely used in physiological measurement and monitoring, however this technique is mainly used by scanner camera of a smart phone or computer to obtain valid plethysmograms, such as in the case of this project which is based on a PPG Camera measurement to obtain the heart / respiratory rate and the body temperature of the student, in order to do a general or specific AI auscultation (SAu), for the type of disease linked to these three physiological values.

### 3.2. Deep Neural Network Auscultation

The classic diagnosis generates several imperfections in terms of auscultation times and human resources, however this can give false auscultation results which lead to inadequate treatment for the patient. For this reason AI Auscultation corrects these drawbacks to this standard method, which is presented by a technique of PPG extraction of physiological, and then relaying the data to a deep neural network for students (DNNst) to auscultate and detect students who require nursing intervention (Figure 2). In the case of a Covid-19 detection, the system inform students of the campus by email, to take a maximum precautions, especially in neighborhoods (Red Time Line) of classes affected by the virus, to avoid any contact and contamination.

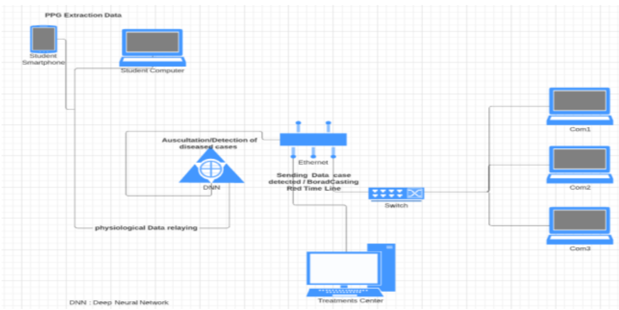
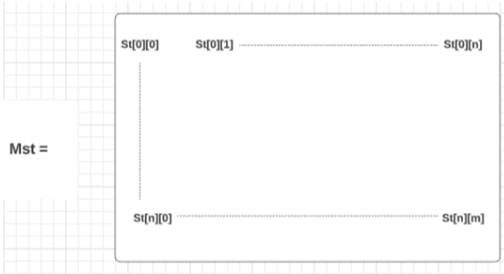



Figure 2. General model of DNNst Auscultation system

#### 3.2.1. Theorical Deep neural network auscultation

The DNNst is the heart of the AI auscultation system, its role primarily in collecting physiological data from students, and initiating auscultation to identify the presence of respiratory or heart disease cases on campus. In this work, the Java modeling of this DNNst is defined by a matrix of multi-parameter's [11] student objects (Figure 3), which encapsulates for each student their personal information, as well as their daily physiological values (Heart Respiratory rate and Body temperature). The descriptive DNNst prototype of this project is defined by *N* objects input stream and *L* output which represents confirmed infected students (Figure 4).




Such as the $M_{st}$ matrix java object includes the following parameters: $St_{obj}$ [$x_i$][$y_i$]: (first $name_{i1}$, last $name_{i2}$, $dept_{i3}$, $numclassi_4$, $adrhomei_5$, $CFi_6$, $Rfi_7$, $Tempi_8$, $Parameter_{ij}$) / (*i*: *i*th Student, j: *j*th parameter) & (*n*: Number of students campus, *m*: Number of general and physiological parameters)

Figure 3. Composition model of a matrix objects in a DNNst

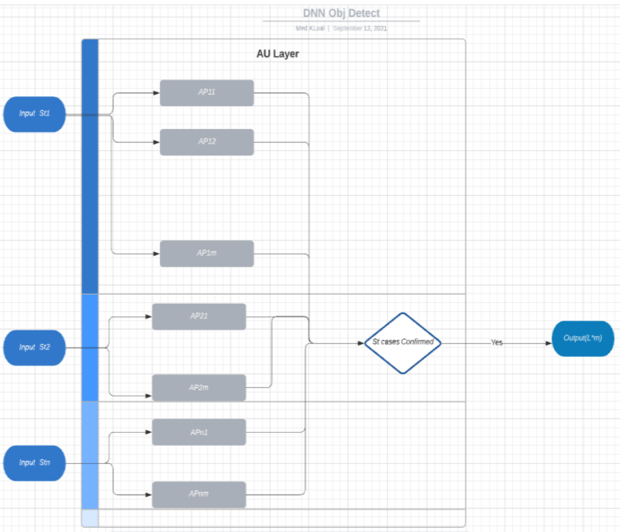


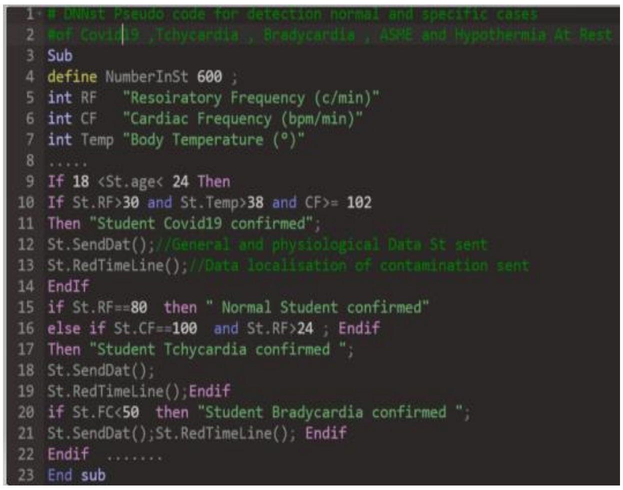

Figure 4. Prototype of a DNNst for auscultation and detection of disease cases

### 3.2.2. Specification of Cases Disease According to Physiological Parameters and Age

The DNNst of this work is based on some diseases related to breathing, heartbeat and body temperature, in addition the physiological input parameters will be compared with existing values in the learning base of the DNNst, which vary depending on age intervals. In the case of a student who suffers from the symptoms of a particular disease, their values will be saved and sent to the treatment center on campus for a care intervention (Figure 5).

### 3.2.3. Red Time Line

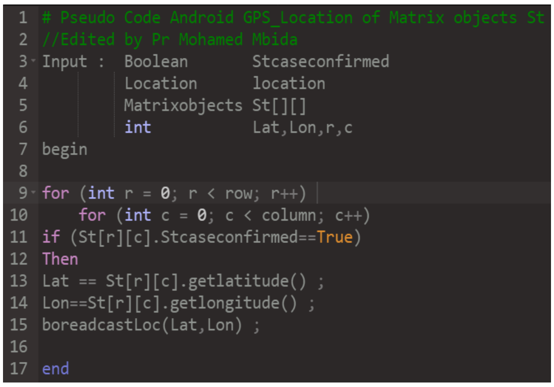
This module of the AI auscultation system allows the localization of a student affected by Covid-19. The goal is to alert the campus to take more precautions in its red zones, this geolocation is mainly based on the GPS location for Android in Java, and will be expressed as a function of the longitude and latitude which gives the location in degrees of the student (Figure 6).



```
# DNNst Pseudo code for detection normal and specific cases
#of Covid19 ,Tchycardia , Bradycardia , ASME and Hypothermia At Rest
Sub
define NumberInSt 600 ;
int RF   "Resoiratory Frequency (c/min)"
int CF   "Cardiac Frequency (bpm/min)"
int Temp "Body Temperature (°)"
......
If 18 <St.age< 24 Then
If St.RF>30 and St.Temp>38 and CF>= 102
Then "Student Covid19 confirmed";
St.SendDat();//General and physiological Data St sent
St.RedTimeLine();//Data localisation of contamination sent
EndIf
if St.RF==80  then " Normal Student confirmed"
else if St.CF==100  and St.RF>24 ; Endif
Then "Student Tchycardia confirmed ";
St.SendDat();
St.RedTimeLine();Endif
if St.FC<50  then "Student Bradycardia confirmed ";
St.SendDat();St.RedTimeLine(); Endif
Endif  .......
End sub
```

NB: The keywords RF / FR or CF / FC in the rest of this article have the same meaning.

Figure 5. Pseudo code of AI Auscultation modeled on Cardiac / Respiratory Frequency and Body Temperature



```
# Pseudo Code Android GPS_Location of Matrix objects St
//Edited by Pr Mohamed Mbida
Input :  Boolean        Stcaseconfirmed
         Location       location
         Matrixobjects  St[][]
         int            Lat,Lon,r,c
begin

for (int r = 0; r < row; r++)
    for (int c = 0; c < column; c++)
if (St[r][c].Stcaseconfirmed==True)
Then
Lat == St[r][c].getlatitude() ;
Lon==St[r][c].getlongitude() ;
boreadcastLoc(Lat,Lon) ;

end
```

Figure 6. Pseudo code GPS_ST Android for a location of a Covid-19 case

## 4. EXPERIMENTS

The modeling of the AI Auscultation system in this work begins with the creation of student profiles in an MS xls file (Figure 7), after each access the user activates the power spectral density, with a PPG capture to indicate the FC value (Figure 8), however the java DNNst deduces and fill in the FR and temp values through the FC values, due to the physiological dependence between these parameters [12, 13]. In the second step, the DNNst goes to the same file, to extract the data from confirmed cases, to structure them in a matrix of java objects (2D array of objects), and then relay them in SSL email mode to the processing center of the campus, accompanied with data on the locations of the cases, which will then be broadcasted to the whole campus Figures 9 and 10.

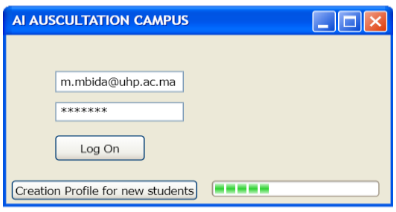



Figure 7. Access HMI prototype and creation of student profiles

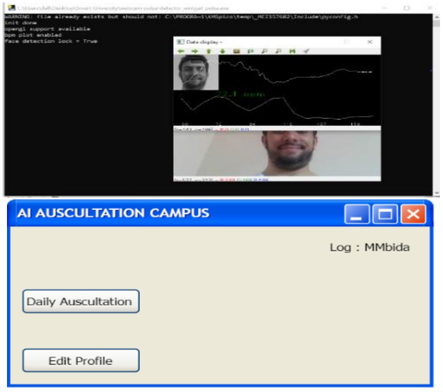



Figure 8. AI Auscultation activation interface and display FC parameters

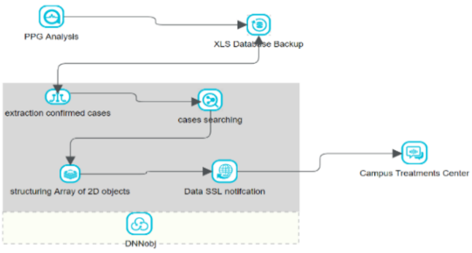



Figure 9. Technical model of AI Auscultation system


Figure 10. Pseudo_code AI Auscultation system

## 4.1. Analogy of Java DNNst in an Arena Model

After having modeled the AI Auscultation Java for campus, we will need simulations to obtain comparative statistics with the classical auscultation, which this one consists of an end-to-end human intervention, however this experimental part is based on an analogy by conversion of the Java in SIMAN language [14] to represent comparative studies in values. The experimental models take place on the ARENA platform, in the case of a classic auscultation with nursing interventions, and AI auscultation which defines an automated and smart solution. The two simulations are based on a measurement of the physiological parameters of Temp, FR and FC.

### 4.1.1. Siman Classic Auscultation

The classic experimental process begins with a general auscultation of the patient's condition, in the case of a positive result, the nursing center of campus moves on to a specific auscultation, in order to determine the type of disease (Figure 11). The overall configuration of the environment of this classic system is reflected in Table 1.

Table 1. Classic auscultation configuration parameters

| | |
|---|---|
| Number of Nurses Group | 10 |
| Max Arrivals / Day | 600 St |
| Entities per Arrivals | 6 |
| Number of Hours /Day | 16 H/Day |
| GAu Entity | Action: Seize/Delay /Release<br>Delay Type: Triangular, 10<br>Units: minutes |
| Process Resources mode | Cyclical |
| SAu Entity | Action: Seize/Delay /Release<br>Delay Type: Constant, 25<br>Units: Minutes |
| Priority Covid-19 process<br>Priority Bradycardia process | High |
| Priority ASTHMA process<br>Priority Tachycardia process | Medium |
| Priority Hypothermia process | Low |

### 4.1.2 Siman AI Auscultation System

The modeling of AI Auscultation under the Siman language, led us to configure our environment according to a logic which allows to simulate the management of the DNNst of the entire auscultation system, which is defined as a general or initial auscultation by a measurement of physiological values, and make a second in the case of abnormal cases, to confirm and specify the disease to be treated, then the Red zone entity signals the locations of disease cases (Figure 12), the following table presents the configuration of this Process .

Table 2. AI auscultation configuration parameters

| | |
|---|---|
| Number of Spheres of knowledge resources | 80 |
| Max Arrivals / Seconds | 4000 St |
| Entities per Arrivals | 2000 |
| Number Hours /Day | 24 H/Day |
| GAu Entity | Action: Seize/Delay /Release<br>Delay Type: Constant, 0.5<br>Units: seconds |
| Process Resources mode | Cyclical |
| SAu Entity | Action: Seize/Delay /Release<br>Delay Type: Constant, 0.5<br>Units: Minutes |
| Priority Process Covid-19, Bradycardia, ASTHMA, Tachycardia, Hypothermia | High |
| Time Line Red Zone Entity | Action: Seize/Delay/Release<br>Delay Type: Constant, 0.5<br>Units: Minutes |
| Decision entities | Type: N-ways by condition's |

NB: We use a group of Siman Resources entities configured as the sphere of knowledge of the DNNst, to define if the patient is a suspect case (GAu), and to determine the type of the disease (SAu).

## 4.2. Statistics Study and Discussions

In this part a comparative study was applied of the two models (AI and classic auscultation), which is presented in two sub-processes, the general auscultation to detect a suspected sick student, and the one which is specific which confirms the case of the patient with a definition of the type disease, to then move on to treatment intervention.

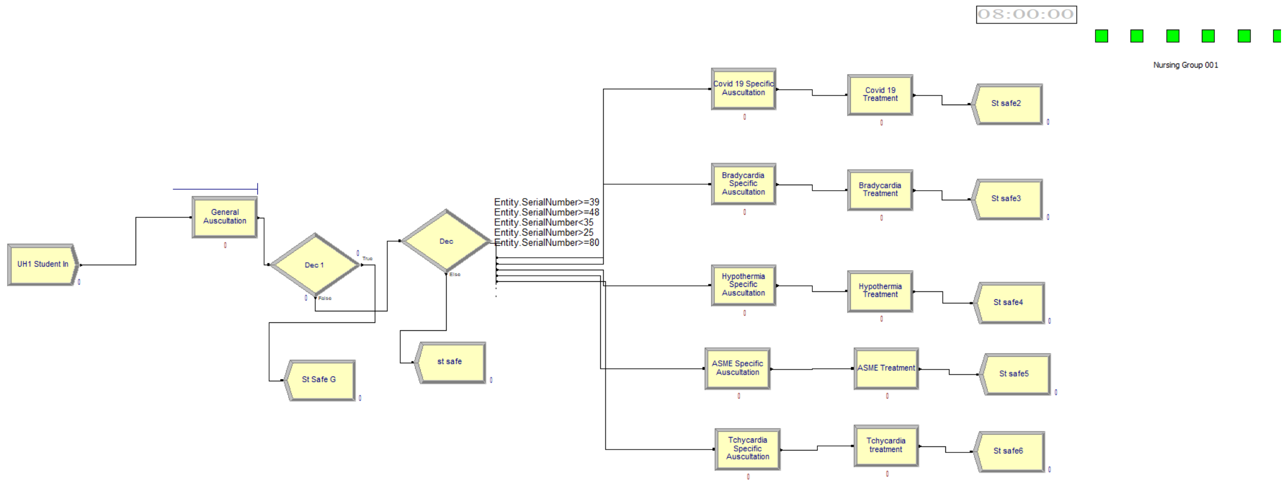



Figure 11. Classic model Auscultation scenario

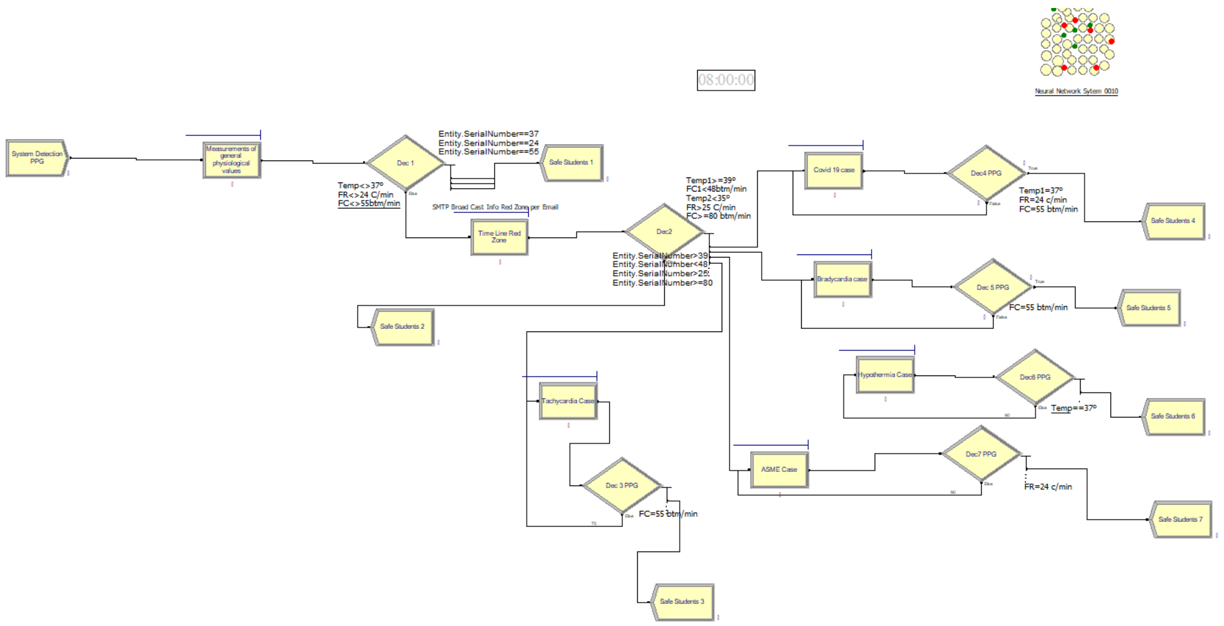


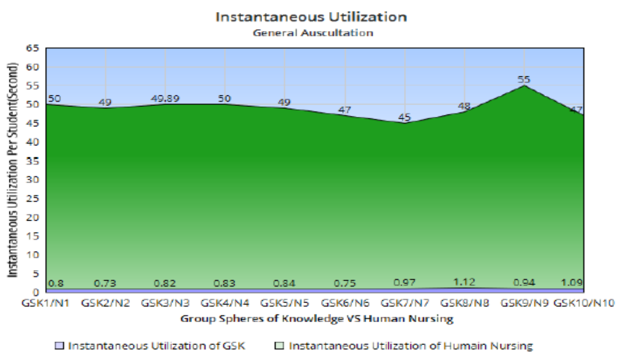

Figure 12. AI Auscultation model scenario

### 4.2.1. General Auscultation Process

Based on the initial auscultation simulation, we notice that the instantaneous diagnosis per student (St) of DNNst takes an average time not exceeding 0.8 s, while the auscultation of human nursing takes 49 s. this indicates that the AI general auscultation solution takes less time to confirm a suspected or healthy case (Figure 13).

### 4.2.2. Specific Auscultation Process

According to the configuration of the two environments on the detection of the five diseases (Covid19, Bradycardia, Hypothermia, ASTHMA and Tachycardia) [15, 16, 17], we see that AI Auscultation takes an average duration of 2.5 s/st as instantaneous use to specify the type of the disease, based on the basic references of the physiological values associated with each disease, this gives a rapid protocol intervention for the treatment and hospitalization of the patient. However, Classical Auscultation takes a long time compared to AI Auscultation, which varies according to disease (Figure 14), the following table summarizes the results of experience on classic auscultation by analogy with existing detection tools [18, 19, 20].




$GSK_{ith}$: Group Sphere of knowledge entity / $N_{ith}$: Human Nursing entity

Figure 13. Comparative study AI / classic System of the general auscultation procedure

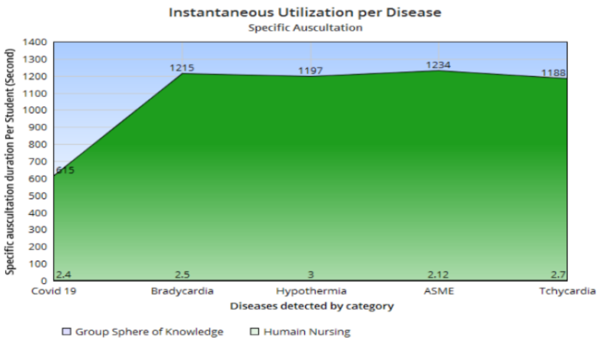



Figure 14. Comparative study AI / classic System of the specific auscultation procedure

Table 3. Experimental results of the instantaneous duration of the specific diagnosis for classic auscultation

| Type of disease | Instantaneous Experimental Specification Duration/St |
|---|---|
| Covid19 (RST) | 615s/st ~10 min /st |
| Hypothermia (TH) | 1197s/st ~19min /st |
| ASTHMA (PF) | 1234s/st ~ 21min/st |
| Tachycardia (CRP) | 1188s/st ~19min/st |
| Bradycardia (CRP) | 1215s/st ~ 20min/st |
| Indication | RST: Rapid serological test/TH: Thermometer/PF: Peak Flow/CRP: Rapid semi-quantitative CRP test: blood / serum /plasma |

From these results the AI Auscultation has brought an enormous saving of time compared to the classic diagnosis, which makes it possible to intervene quickly to give an adequate treatment and to block any evolution of the patient's disease, or possibility contamination in the campus. To represent the overall duration of AI and classic auscultation for the detection of Covid-19, We take a sample of 600 students contained for the two simulations, we find that the overall duration of AI Auscultation according to the number of students, is very short compared to the classic auscultation (Figure 15).

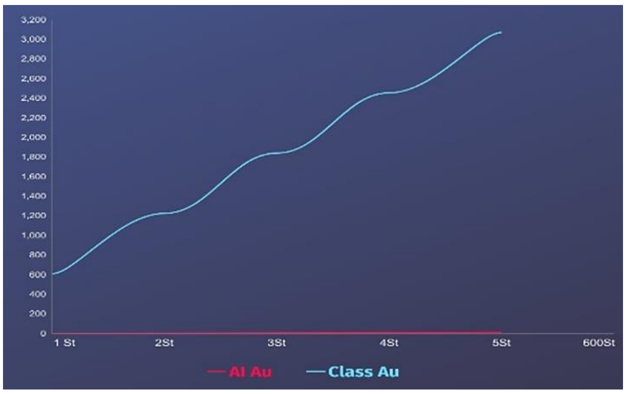



Figure 15. AI and Classic global auscultation for detection of Covid-19

## 5. CONCLUSIONS

The AI Auscultation system compared to the classical solution in this project has several advantages in the general and specific detection of a disease in the campus, such as the cancellation of the contact between the patient and the nurse during the diagnostic phase, switch in a short duration of AI auscultation to the protocol phase of the treatment, in goal to avoid any complications or contamination. This smart system also informs the campus about the GPS_Android red areas of infection for more precautions. As prospects for this work, we will manage the time occupancy of beds and material resources, for patients who require special treatment in the campus health center, in order to balance the use with the availability of resources.

## REFERENCES

[1] A. Bellat, Kh. Mansouri, A. Raihani, "Implementation of artificial neural network for optimization of a wind farm", International Journal on Technical and Physical Problems of Engineering, Issue 47, Vol. 13, No. 2, pp. 35-39, June 2021.
[2] A. Kocak, M.C. Taplamacioglu, H. Gozde, "General overview of area networks and communication technologies in smart grid applications", International Journal on Technical and Physical Problems of Engineering, Issue 46, Vol. 13, No. 1, pp. 103-110, March 2021.
[3] M. Gavaghan, "Examination: Cardiac Anatomy and Physiology", A Review, AORN Journal, Vol. 67, Issue 4, pp. 824-828, Department of Nursing, Bloomsburg University Pa, USA, 01 April 1998.
[4] B. Karnath, M.C. Boyars, "Pulmonary Auscultation - Hospital Physician", Vol. 38, No. 1, pp. 22-26, Annual International Conference of IEEE Engineering in Medicine and Biology Society, USA, January 2002.
[5] B. Ozdemir, S.S. Yalcıın, "The role of body temperature on respiratory rate in children with acute respiratory infections", African Health Sciences, Vol. 21, No. 2, pp. 640-646, Makhanda, South Africa, August 2021.
[6] V. Oliynik, "Enhanced Frame-Similarity Technique for Detection of Respiratory and Cardiac Rhythms in Auscultation Records", IEEE 40th International Conference on Electronics and Nanotechnology (ELNANO), pp. 419-424, Kiev, Ukraine, April 22-24 2020.
[7] M.S. Wibawa, I.M.D. Maysanjaya, N.K.D.P. Novianti, P.N. Crisnapati, "Abnormal Heart Rhythm Detection Based on Spectrogram of Heart Sound using Convolutional Neural Network", The 6th International Conference on Cyber and IT Service Management (CITSM), pp. 1-4, Parapat Nort Sumatera, Indonesia, 7-9 Aug. 2018.
[8] D. Perna, A. Tagarelli, "Deep Auscultation: Predicting Respiratory Anomalies and Diseases via Recurrent Neural Networks", IEEE 32nd International Symposium on Computer-Based Medical Systems (CBMS), pp. 50-55, Cordoba, Spain, 5-7 June 2019.
[9] R. Liu, S. Cai, K. Zhang, N. Hu, "Detection of Adventitious Respiratory Sounds based on Convolutional Neural Network", International Conference on Intelligent Informatics and Biomedical Sciences (ICIIBMS), pp. 298-303, Shanghai, China, 21-24 November 2019.
[10] R. Song, H. Chen, J. Cheng, C. Li, Y. Liu, X. Chen, "PulseGAN: Learning to generate realistic pulse waveforms in remote photoplethysmography", IEEE

Journal of Biomedical and Health Informatics, Vol. 25, No. 5, pp. 1373-1384, Ioannina, Greece, 4 June 2020.
[11] U.S. Pasaribu, U. Mukhaiyar, N.M. Huda, K.N. Sari, S.W. Indratno, "Modelling COVID-19 growth cases of provinces in java Island by modified spatial weight matrix GSTAR through railroad passenger's mobility", Heliyon, Vol. 7, Issue 2, pp. 06-25, United Kingdom, February 2021.
[12] G.W. Kirschen, D.D. Singer, H.C. Thode, A.J. Singer, "Relationship between body temperature and heart rate in adults and children - A local and national study", The American Journal of Emergency Medicine, Vol. 38, Issue 5, pp. 929-933, Virginia, United States of America, May 2020.
[13] M. Augustynek, D. Friedmannova, M. Cmielova, "Measuring of dependency between heart rate, respiratory rate and the human movement", IFAC Proceedings Volumes, Vol. 46, Issue 28, pp. 292-297, Osaka, Japan, December 2013.
[14] S.D. Roberts, D. Pegden, "The history of simulation modeling", Winter Simulation Conference (WSC), 2017, pp. 308-323, Las Vegas Nevada, USA, December 2017.
[15] G. Tse, T. Liu, K.H.C. Li, V. Laxton, A.O.T. Wong, Y.W.F. Chan, R.A. Li, "Tachycardia-bradycardia-syndrome: Electrophysiological mechanisms and future therapeutic approaches", International Journal of molecular medicine, Vol. 39, No. 3, 519-526, February 2017.
[16] T. Rothe, "Bronchial asthma in adults", IForum Medical Suisse, Vol. 17, No. 08, pp. 187-193, EMH Media, Switzerland, February 2017.
[17] P. Paal, L. Gordon, G. Strapazzon, M.B. Maeder, G. Putzer, B. Walpoth, H. Brugger, "Accidental hypothermia - An update", Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine", Vol. 24, No. 1, 1-20, Scandinavia, 15 September 2016.
[18] S. Su, G. Wong, W. Shi, et al., "Epidemiology, genetic recombination and pathogenesis of coronaviruses", Trends Microbiol, No. 24, pp. 490-502, Cambridge MA 02139, USA, 21 March 2016.
[19] HWTAi BioTec, "Rapid cardiovascular disease test CCR-402", Virtual Expo Group, Shizhong Zone, Jinan, Shandong Province, China, 2020.
[20] H.N. Hartman, P.E. North, "Respiratory Disease Evaluation Using Peak Flow Measurement and Environmental Exposure Analysis in Rural Peru", Journal of Allergy and Clinical Immunology, Vol. 137, Issue 2, Supplement Page AB203, Mosby, USA, 2016.

## BIOGRAPHIES

**Mohamed Mbida** was born in Settat, Morocco, 1986. received his Ph.D. degree in networks and Information Systems, from Faculty of Sciences and Technology, Hassan I University, Settat, Morocco in 2017. He received the B.Sc. degree in networks Information Systems and the M.Sc. degree in Network Computer engineering in 2012 and 2009. Currently, he is pursuing his research in Networks and Security Engineering, smart warehouse management and exploiting the sentimental bias between ratings and reviews with neural networks at the Laboratory of Emerging Technology (LAVETE), from Faculty of Sciences and Technology, Hassan I University, Settat, Morocco. His main research areas are how to use wireless sensor networks to secure and monitor mobile sensor networks, especially in Topology and Congestion of control. He is member of the National Smart Grid Committee Casablanca Morocco 2018.

**Abdellah Ezzati** received the Ph.D. degree in computer science from the Science Faculty, Rabat, Morocco, in 1997, where he was a member of the Computer Commission. He is currently a Professor with Hassan I University, Settat, Morocco, and he is also the Head of bachelor of computer science. He has participated in several works as the Palmes Project which elaborates a Moroccan Education Certification. His research interests include performance evaluation in WSN, VANET and the IoT, security, cloud computing, and big data.