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(71) Applicant: **IBRUM TECHNOLOGIES** [IN/IN]; Site No.15 Top Floor, 2nd Cross, Vinayaka Layout, Opposite SGR Dental College, Munnekolala, Marathalli Post, Bengaluru 560037 (IN).

(72) Inventor: **DEY, Nibedit**; Site No.15 Top Floor, 2nd Cross, Vinayaka Layout, Opposite SGR Dental College, Munnekolala, Marathalli Post, Bengaluru 560037 (IN).

(74) Agent: **KANNAN P, Ramesh** et al.; Quadriga, 'MANAS', Plot 47 & 48, Krishnaveni Nagar, North Street, Mugalivakkam, Chennai 600125 (IN).

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(54) **Title:** AN INTELLIGENT CARDIO-PULMONARY SCREENING DEVICE FOR TELEMEDICINE APPLICATIONS

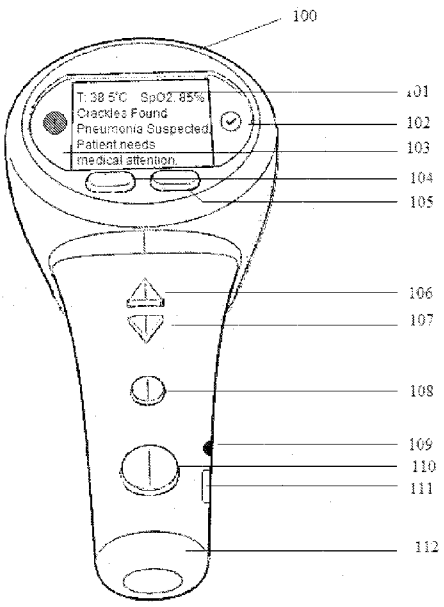

Figure 1

(57) **Abstract:** An intelligent and real-time cardio-pulmonary screening device (100) is disclosed. The device comprises a housing that encloses a body, said body comprising: a display unit (101); a plurality of light emitting diode (LED) indicators (102, 103); a first toggle switch (104); a second toggle switch (105); a plurality of volume controls (106, 107); a third toggle switch; an output port (109); a switch (110); a charging port (111); a temperature sensor; a transducer unit (112); and an artificial intelligence module. The artificial intelligence module analyses the sounds received in real-time and presents the results in the display unit (101), as well as in the plurality of the LED indicators (102, 103); it comprises an artificial intelligence processor that is configured to run machine learning algorithms on the device (100), with said artificial intelligence module syncing from and to the cloud when connected to internet. The disclosed device (100) is an easy to use, affordable, point of care screening device that classifies underlying cardio-pulmonary diseases within a minute.

WO 2020/075190 A1

[Continued on next page]

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TITLE OF THE INVENTION: AN INTELLIGENT CARDIO-PULMONARY SCREENING DEVICE FOR TELEMEDICINE APPLICATIONS

FIELD OF THE INVENTION

The present disclosure is generally related to a device for the screening of cardio-pulmonary conditions. Particularly, it is related to an intelligent cardio-pulmonary screening device, said monitoring occurring in a real-time basis.

BACKGROUND OF THE INVENTION

Infections of the lower respiratory tract are among the leading causes of childhood death worldwide. To diagnose such infections, doctors use the traditional stethoscope to listen to the chest sounds of a patient and recommend subsequent treatment. However, such a method of diagnosis is challenging due to noisy atmosphere and lack of familiarity with all types of sounds. Further, due to lack of specialists in primary care centres and lack of time per patient, patients sometimes remain undiagnosed, which leads to the disease becoming chronic.

The pulmonary examination consists of inspection, palpation, percussion, and auscultation. The inspection process initiates and continues throughout the patient encounter. Palpation, confirmed by percussion, assesses for tenderness and degree of chest expansion. Auscultation, a more sensitive process, confirms earlier findings and may help to identify specific pathologic processes not previously recognized.

The problem is worse for babies suffering from pneumonia, where any delayed diagnosis can be fatal. In a crowded and noisy atmosphere, it is extremely difficult to hear a baby's congested lungs through a normal stethoscope. As per research, physical observation and auscultation are not effective ways to diagnose a baby suffering from pneumonia. Similarly, finding a cardiac abnormality or foetal heart sound is a challenging task.

With the recent development of technologies, a new category of stethoscopes called smart stethoscope has entered the market. Unlike traditional acoustic or electronic stethoscopes, the smart stethoscopes have microphones inside a transducer unit that

collects the chest sounds. However, they do not have facilities to analyse the current condition of a patient and provide an immediate result. They only amplify sounds and provide an interface to visualize the waveform on a computer or a mobile phone.

The problem with the smart stethoscope is that doctors are used to working with traditional stethoscope sounds. So, amplification holds little value for them. Apart from this, the user needs to have technical knowledge to interpret the plots. Therefore, the smart or electronic stethoscopes are not suitable for an average healthcare user like paramedical staff. Further, there is no pulmonary specific device which uses lung sounds for automatic analysis of a patient's condition.

There is, therefore, a need in the art for a device that monitors cardio-pulmonary activity in real-time, which overcomes the aforementioned drawbacks and shortcomings.

SUMMARY OF THE INVENTION

An intelligent and real-time cardio-pulmonary screening device is disclosed. The device comprises a housing that encloses a body.

The body comprises: a display unit; a plurality of light emitting diode (LED) indicators; a first toggle switch; a second toggle switch; a plurality of volume controls; a third toggle switch; an output port; a switch; a charging port; a temperature sensor; and a transducer unit.

The plurality of light emitting diode (LED) indicators visually indicates the results of cardio-pulmonary analysis.

The first toggle switch is configured to enable the toggling of the device between a heart monitoring mode and a lung monitoring mode, while the second toggle switch is configured to enable the toggling of the device between an adult mode and a paediatric mode. The third toggle switch is configured to enable the connecting or disconnecting of the device with an application on a handheld device or a wearable device or an application that is installable on a computing device.

The plurality of volume controls facilitate the increasing or decreasing of the volume of an audio output from the device.

The output port facilitates the connecting of an audio playback device; the switch powers the device on or off; the charging port facilities the charging of a rechargeable battery; the temperature sensor facilitates the measuring of the body temperature of a patient; and the transducer unit is configured to enable the device to receive sound from the chest or the lungs of the patient, said transducer unit being removably attached with the device.

An artificial intelligence module analyses the sounds received in real-time and presents the results in the display unit, as well as in the plurality of the LED indicators, said artificial intelligence module comprising an artificial intelligence processor that is configured to run machine learning algorithms on the device, with said artificial intelligence module syncing from and to the cloud when connected to internet; it comprises an artificial intelligence processor that is configured to run machine learning algorithms on the device.

The disclosed device is an easy to use, affordable, point of care screening device that classifies underlying cardio-pulmonary diseases within a minute.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates an intelligent cardio-pulmonary screening device, in accordance with the present disclosure.

Figure 2 illustrates a side view of an intelligent cardio-pulmonary screening device, in accordance with the present disclosure.

Figure 3 depicts a flowchart of the functioning of an intelligent cardio-pulmonary screening device, in accordance with the present disclosure.

Figure 4 illustrates an intelligent cardio-pulmonary screening device, in which a binaural with tube is attached to the device, in accordance with the present disclosure.

Figure 5 depicts another flowchart of the functioning of an intelligent cardio-pulmonary screening device, in accordance with the present disclosure.

DETAILED DESCRIPTION OF THE INVENTION

Throughout this specification, the use of the word "comprise" and “include” and variations such as "comprises "comprising", “includes”, and “including” implies the inclusion of an element or elements not specifically recited.

Throughout this specification, the user of the phrase ‘handheld device’, and its variations are to be construed as ‘any computing or electronic device that is compact and portable enough to be held and used in one or both hands, such as a smartphone, a tablet computer, or a personal digital assistant.

An intelligent and real-time cardio-pulmonary screening device (100) is disclosed. As shown in Figure 1 and Figure 2, the intelligent and real-time cardio-pulmonary screening device (100) comprises a housing that encloses a body.

The body comprises: a display unit (101); a plurality of light emitting diode (LED) indicators (102, 103); a first toggle switch (104); a second toggle switch (105); a plurality of volume controls (106, 107); a third toggle switch (108); an output port (109); a switch (110); a charging port (111); a temperature sensor (not shown) and an oxygen saturation sensor (not shown); and a transducer unit (112).

The plurality of light emitting diode (LED) indicators (102, 103) visually indicates the results of cardio-pulmonary analysis.

The first toggle switch (104) is configured to enable the toggling of the device (100) between a heart monitoring mode and a lung monitoring mode, while the second toggle switch (105) is configured to enable the toggling of the device (100) between an adult mode and a paediatric mode. The third toggle switch (108) is configured to enable the connecting or disconnecting of the device (100) with an application on a handheld device or a wearable device or an application that is installable on a computing device.

The computing device includes, but is not limited to, laptop computers, desktop computers, mobile phones, smart phones, tablets, phablets, and smart watches.

The plurality of volume controls (106, 107) facilitate the increasing or decreasing of the volume of an audio output from the device (100).

The output port (109) facilitates the connecting of an audio playback device; the switch (110) powers the device (100) on or off; the charging port (111) facilities the charging of a rechargeable battery (not shown); the temperature sensor (not shown) facilitates the measuring of the body temperature of a patient; the oxygen saturation sensor facilitates the measuring of the oxygen level of the patient; and the transducer unit (112) is configured to enable the device (100) to receive sound from the chest or the lungs of the patient, said transducer unit (112) being removably attached with the device (100).

The transducer unit (112) receives the chest sound or the sound of the lungs of the patient. Then, the sound is filtered and amplified in real-time. The device (100) has an adaptive noise cancellation system which eliminates ambient noises in the received sound.

The transducer unit (112) comprises: a microelectromechanical (MEMS) based sensor that picks up chest sound, and an acoustic sensor which picks ambient noise. The ambient noise is removed through filters and adaptive noise cancellation techniques. The sound collected by the chest sensor is amplified and processed through a processing unit.

The second toggle switch (105) allows the device (100) to toggle between an adult mode and paediatric mode during use. Depending on the selected mode, the device (100) filters high frequency sounds or low frequency sounds.

In an embodiment of the present disclosure, the device (100) comprises an in-built artificial intelligence module that analyses the sounds received and presents the results in the display unit (101) as well as in the plurality of the LED indicators (102, 103).

Traditional dual head stethoscope is designed to allow the user to be able to listen to different sound frequencies. The bell, or round side of the drum, is better for hearing low-pitched sounds. Children have thinner chest walls than adults and, therefore, louder breath sounds. Respiratory assessment of a paediatric patient requires age-appropriate alterations. Based on the selected mode, appropriate filters for frequencies are selected. Thus, the device (100) gets optimised for the suitable demography. This also tags the data collected by the device (100) with the type of patient. When the data is synced with the cloud, the previous data gets updated with new data. Similarly, the device (100) syncs the updated data with the on-device local data. This facilitates offline diagnosis with better accuracy. With time, the accuracy and efficiency improve with new data and more classification categories may be added.

The artificial intelligence module comprises an on-board artificial intelligence processor that is configured to run machine learning algorithms on the device (100). This module adds assistive intelligence to the users and ensures that the device (100) can be used by semi-skilled healthcare users and also in remote places, where there is no internet access. Hence there is disadvantage with cloud-based artificial intelligence classification. The on-board artificial intelligence module helps in offline diagnosis. The module syncs from and to the cloud when connected to internet. So, it reduces the dependency on the cloud and internet connectivity.

In another embodiment of the present disclosure, the temperature measured using the temperature sensor is displayed in the display unit (101).

Based on the degree of severity, the device (100) may also send out one or more alerts to a user. The alert may be any type of alert known in the art and includes, but is not limited to, visual alerts, text messages, and sound alerts.

As shown in Figure 3, the device (100) receives the chest sound patterns, lung sound patterns, and body temperature in real-time and transmits them to an application on a handheld device, or a wearable device through a communications module. The artificial intelligence module in the device (100) analyses the data in real-time and sends the results to the display unit (101) and to the plurality of LED indicators (102,

103). Further, the data in the application is synced with a server where it may be viewed by one or more healthcare professionals, who provide feedback. The feedback from the one or more healthcare professionals is updated in the artificial intelligence module of the device (100).

The transmission of the data through the communications module may occur through any wired or wireless technology known in the art, including, but not limited to, wireless internet, mobile data, Bluetooth Low Energy, Bluetooth 4.0, Near-Field Communication, LoRa, ZigBee, or the like. The device (100) may be remotely controlled through the application on a handheld device or a wearable device.

In yet another embodiment of the present disclosure, the device (100) may record and store the data in an internal storage and/or external storage. The recorded data can subsequently be streamed over the internet or any other telemedicine channel with a remote pulmonologist or cardiologist (remote clinical observation) for confirmation.

When the device (100) is connected to the application on a handheld device or a wearable device, the application is an interface between the user and expert(s) in remote locations. The application streams the chest sounds with other body parameters, such as temperature, oxygen, and respiratory rate to the expert(s). The application is also configured to allow the user to show the patient through a video channel or interface to the expert(s). The application also allows user to export the plotted data onto a printable format, which can be shared offline for further consultation.

In yet another embodiment of the present disclosure, the data from the application on a handheld device or a wearable device may also be transmitted to the cloud for storage and/or backup purposes.

The handheld device or the wearable device includes, but is not limited to, mobile phones, smart phones, tablets, phablets, and smart watches. The transmission of the real-time data from the device (100) may occur through wireless internet, mobile data, Bluetooth Low Energy, LoRa, ZigBee, or the like.

The device (100) is powered by a rechargeable battery that allows the device (100) to be used for several days without need of charging and can also be charged through a magnetic charger or wireless charger.

In yet another embodiment of the present disclosure, as shown in Figure 4, a binaural with tube (113) is attached to the device (100) to enable a user to use earpieces and a cap is placed when the tube is detached from the device (100).

The disclosed device (100) is an easy to use, affordable, point of care screening device that records sounds from digital auscultation examinations and uses artificial intelligence to classify underlying cardio-pulmonary diseases within a minute. The results of the classification can be confirmed by healthcare experts by sharing the results. The device (100) is suitable to be used by medical as well as paramedical staff. The device (100) can also be used for detecting abnormal foetal heart sounds, Temporomandibular joint (TMJ) sounds, and cardiac murmurs.

Auscultation of the lung is an important part of the respiratory examination and is helpful in diagnosing various respiratory disorders. Auscultation assesses airflow through the trachea-bronchial tree. It is important to distinguish normal respiratory sounds from abnormal ones, for example crackles, rhonchi, wheezes, stridor, and pleural rub, in order to make correct diagnosis. Abnormal breath sounds are usually indicators of problems in the lungs or airways. The most common causes of abnormal breath sounds are pneumonia, heart failure, chronic obstructive pulmonary disease (COPD), such as emphysema, asthma, bronchitis, foreign body in the lungs or airways.

As shown in Figure 5, the device (100) analyses and classifies sounds acquired from different chest points during examination. The classification is done by on-board artificial intelligence module. The device (100) gives one or more alerts if the patient needs further medical attention. For example, if there is crackle pattern found in the lungs sound with abnormal temperature and low oxygen, the device may classify the condition as suspected pneumonia and warn user to refer the baby to a paediatrician. This procedure can happen without any internet connectivity.

The display unit (101) displays the classification determined by the device (100). If the user is a semi-skilled user, then the patient is referred to the suitable specialist for further diagnosis, in case of an abnormal pattern (for example, displayed through a red LED). If the user is an advanced user, such as researcher or pulmonologist or paediatrician, then they can use the displayed information to investigate further.

The device (100) can be a hand held one or a wearable one. In wearable form, the device (100) is worn by the patient or wrapped properly as instructed. In wearable form, the device (100) also determines respiratory rate as an additional parameter. The wearable device (100) can be used for long-term, continuous respiratory health monitoring of bed-bound patients.

It will be apparent to a person skilled in the art that the above description is for illustrative purposes only and should not be considered as limiting. Various modifications, additions, alterations and improvements without deviating from the spirit and the scope of the disclosure may be made by a person skilled in the art. Such modifications, additions, alterations and improvements should be construed as being within the scope of this disclosure.

LIST OF REFERENCE NUMERALS:

100 – An Intelligent Cardio-Pulmonary Screening Device

101 – Display Unit

102, 103 – Plurality of LED Indicators

104 – First Toggle Switch

105 – Second Toggle Switch

106, 107 - Volume Controls

108 – Third Toggle Switch

109 – Output Port

110 - Switch

111 - Charging Port

112 – Transducer Unit

113 – Binaural with Tube

CLAIMS

We Claim:

1. An intelligent and real-time cardio-pulmonary screening device (100), comprising:

a housing that encloses a body, said body comprising:

a display unit (101);

a plurality of light emitting diode (LED) indicators (102, 103) that visually indicates the results of cardio-pulmonary analysis;

a first toggle switch (104) that is configured to enable the toggling of the device (100) between a heart monitoring mode and a lung monitoring mode;

a second toggle switch (105) that is configured to enable the toggling of the device (100) between an adult mode and a paediatric mode;

a plurality of volume controls (106, 107) that facilitate the increasing or decreasing of the volume of an audio output from the device (100);

a third toggle switch (108) that is configured to enable the connecting or disconnecting of the device (100) with an application on a handheld device or a wearable device, said application on a handheld device or wearable device being configured to facilitate remote clinical observation through a video interface;

an output port (109) that facilitates the connecting of an audio playback device;

a switch (110) that powers the device (100) on or off;

a charging port (111) that facilities the charging of a rechargeable battery;

a temperature sensor that facilitates the measuring of the body temperature of a patient;

an oxygen saturation sensor that measures the oxygen level of the patient;

a transducer unit (112) that is removably attached to the device (100), said transducer unit (112) receiving the chest sound or the sound of the lungs of the patient, said sound being: filtered through an adaptive noise cancellation system, amplified through a processor, and transmitted to the application on a handheld device or a wearable device through a communications module; and

an artificial intelligence module that analyses the sounds received in real-time and presents the results in the display unit (101), as well as in the plurality of the LED indicators (102, 103), said artificial intelligence module comprising an artificial intelligence processor that is configured to run machine learning algorithms on the device (100), with said artificial intelligence module syncing from and to the cloud when connected to internet,

said device (100) being capable of auto-analysing and classifying the condition of the patient.

2. An intelligent and real-time cardio-pulmonary screening device (100) as claimed in claim 1, wherein the device (100) sends out one or more alerts to a user.

3. An intelligent and real-time cardio-pulmonary screening device (100) as claimed in claim 1, wherein data in the application is synced with a

server, where it may be viewed by one or more healthcare professionals, who provide feedback, said feedback being updated in the artificial intelligence module of the device (100).

4. An intelligent and real-time cardio-pulmonary screening device (100) as claimed in claim 1, wherein the device (100) is charged through a magnetic charger or wireless charger.

5. An intelligent and real-time cardio-pulmonary screening device (100) as claimed in claim 1, wherein the device (100) is worn by the patient or wrapped around the body of the patient.

6. An intelligent and real-time cardio-pulmonary screening device (100) as claimed in claim 5, wherein the device (100) also determines respiratory rate as an additional parameter.

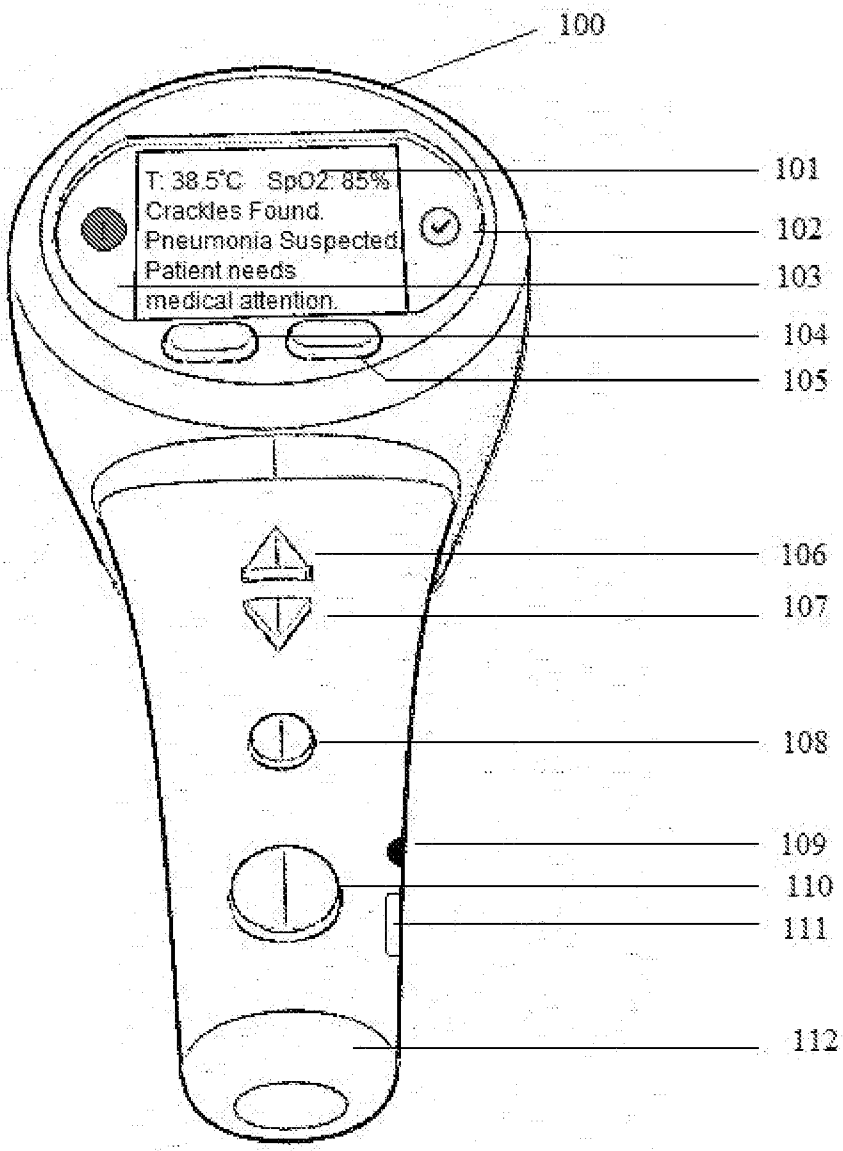

100
T: 38.5°C SpO2: 85%
Crackles Found.
Pneumonia Suspected.
Patient needs
medical attention.
101
102
103
104
105
106
107
108
109
110
111
112

Figure 1

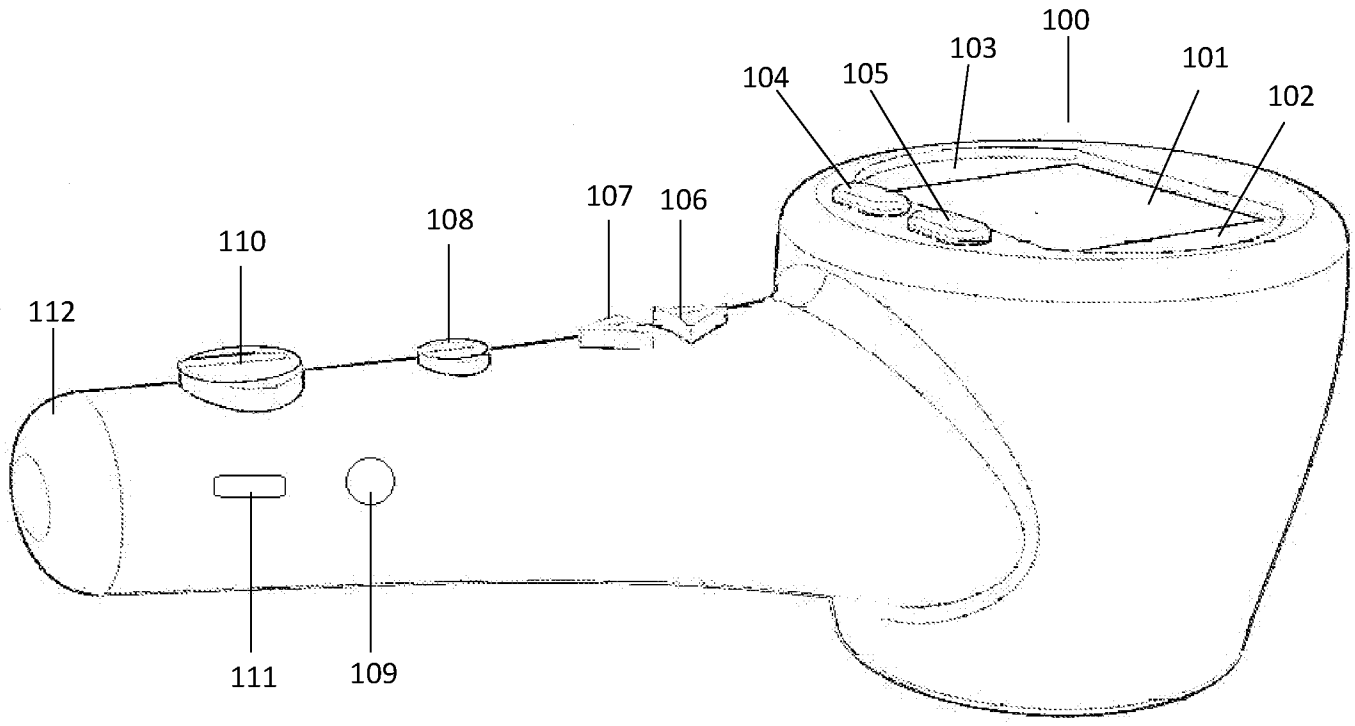
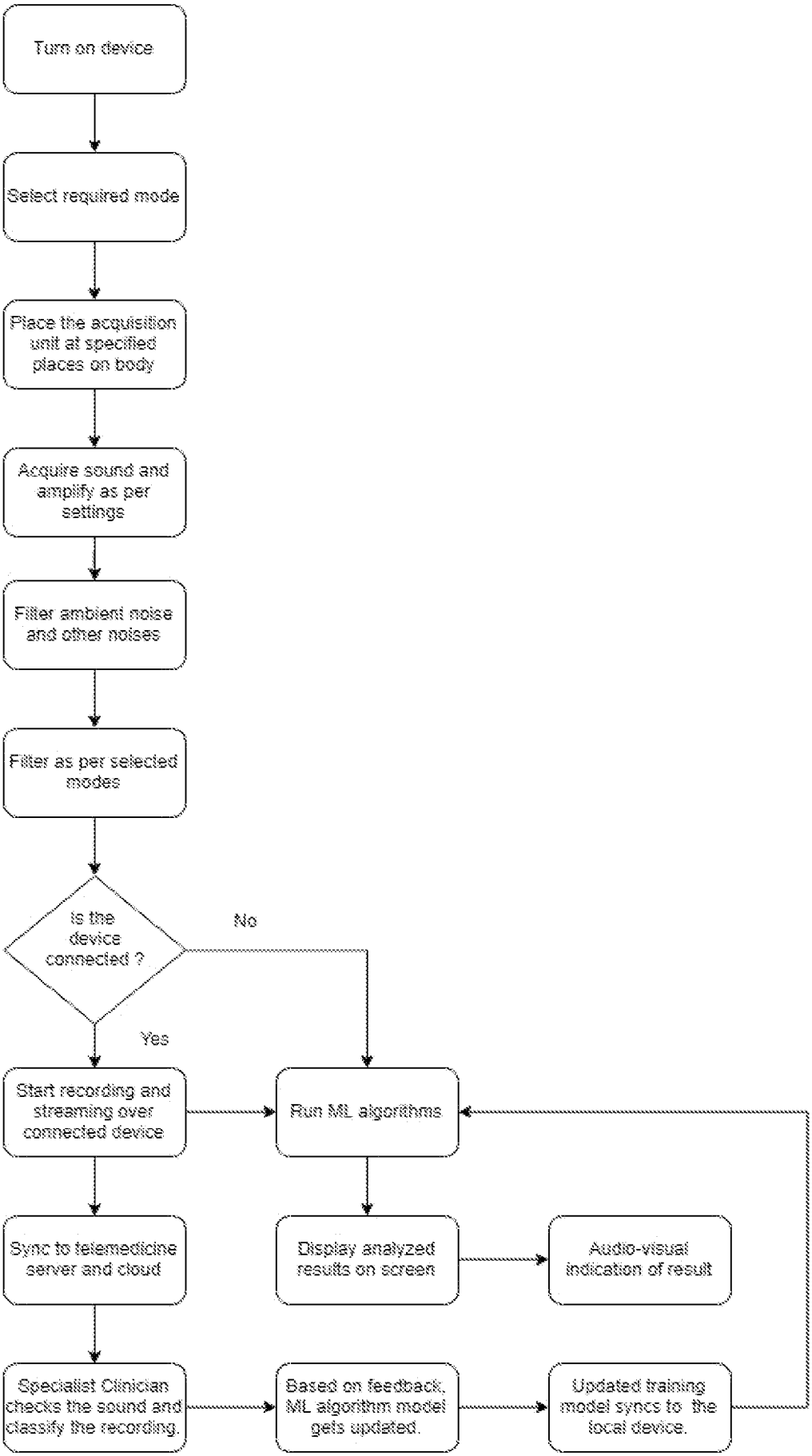


Figure 2


Turn on device
Select required mode
Place the acquisition unit at specified places on body
Acquire sound and amplify as per settings
Filter ambient noise and other noises
Filter as per selected modes
Is the device connected ?
No
Yes
Start recording and streaming over connected device
Run ML algorithms
Sync to telemedicine server and cloud
Display analyzed results on screen
Audio-visual indication of result
Specialist Clinician checks the sound and classify the recording.
Based on feedback, ML algorithm model gets updated.
Updated training model syncs to the local device.

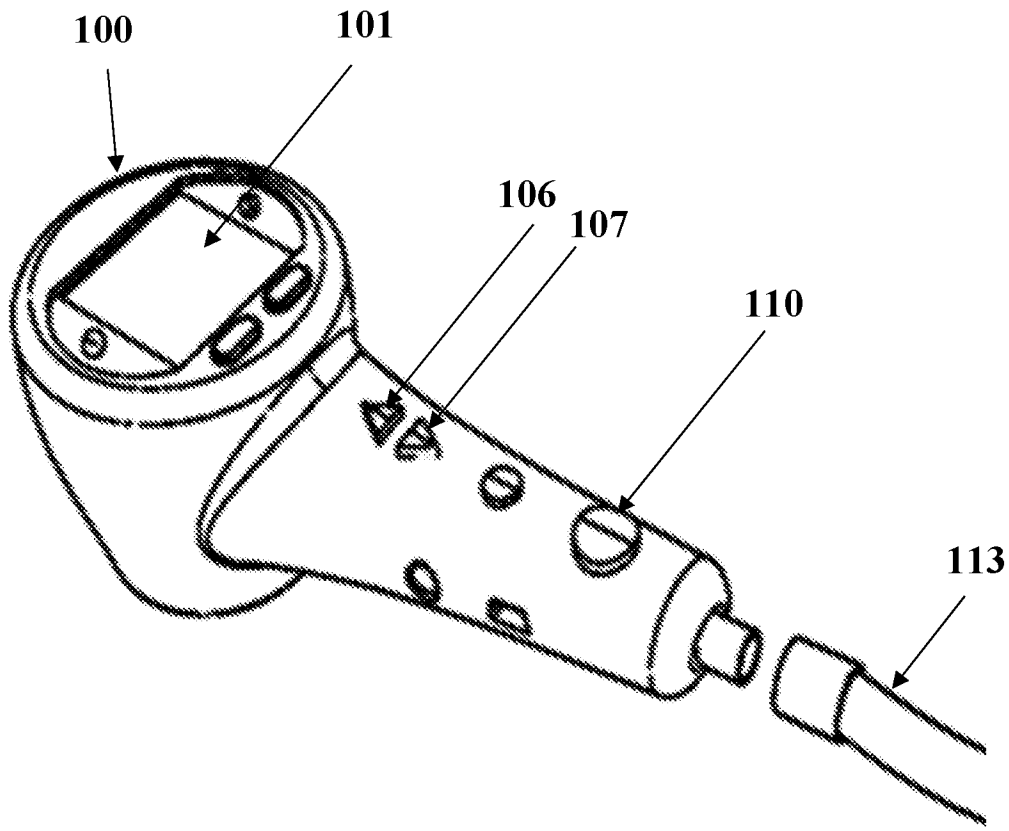


Figure 4

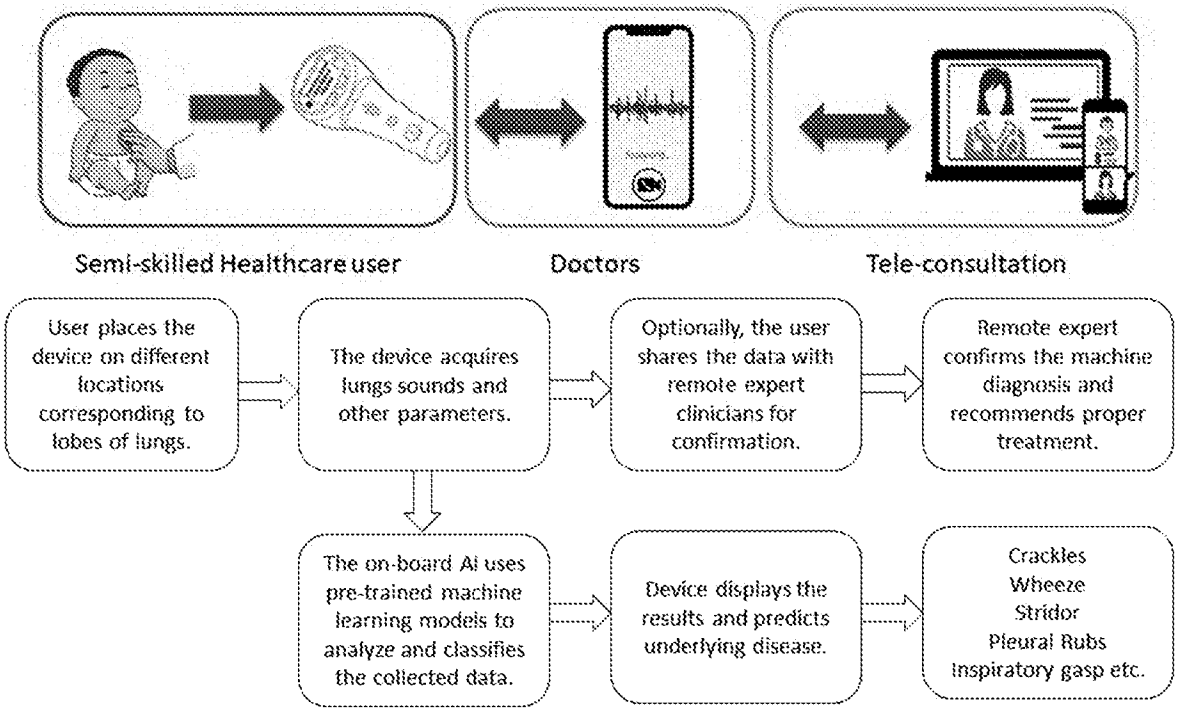

Semi-skilled Healthcare user
Doctors
Tele-consultation
User places the device on different locations corresponding to lobes of lungs.
The device acquires lungs sounds and other parameters.
Optionally, the user shares the data with remote expert clinicians for confirmation.
Remote expert confirms the machine diagnosis and recommends proper treatment.
The on-board AI uses pre-trained machine learning models to analyze and classifies the collected data.
Device displays the results and predicts underlying disease.
Crackles
Wheeze
Stridor
Pleural Rubs
Inspiratory gasp etc.

Figure 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IN2019/050747

A. CLASSIFICATION OF SUBJECT MATTER
A61B5/087,A61B5/024,G06F3/01 Version=2020.01

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A61B,G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Databases: Total Patent One, IPO Internal Database
Keywords: sensor,noninvasive,cardiopulmonary,wearable, wrist

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US6676600B1(TENSYS MEDICAL, INC.)13 January 2004 (13-01-2004)Whole document	1-6
Y	CN105962949A (UNIV SHANGHAI SCIENCE & TECH)28 September 2016 (28-09-2016) Whole document	1-6

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06-01-2020	06-01-2020
Name and mailing address of the ISA/ Indian Patent Office Plot No.32, Sector 14,Dwarka,New Delhi-110075 Facsimile No.	Authorized officer Devendra Kumar Deshmukh Telephone No. +91-1125300200

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IN2019/050747

Citation	Pub.Date	Family	Pub.Date
US 6676600 B1	13-01-2004	US 2005049501 A1	03-03-2005