

A DEVICE FOR MEASURING JAUNDICE LEVELS

FIELD OF INVENTION

- 5 The present invention relates to a portable hand held device, more particularly a portable hand held device for measuring jaundice levels in neonates.

BACKGROUND OF THE INVENTION

- 10 The medical profession is aware of the importance of determining the existence of jaundice immediately after the birth of a baby. A large number of new born children exhibit some degree of jaundice and frequently a jaundice test is performed as a regular routine in the delivery room. The degree of jaundice can range from a physiologically permissible level which will disappear within a short period of time after the birth to
- 15 various severe degree of jaundice, progressing to nuclear jaundice which can result in the death of a newborn or cerebral palsy as sequela even when the child is saved from death. Generally, medical professionals have made a visual observation of the colour of the newborn's skin and then decided if there was any necessity to take a blood specimen for measurement of the bilirubin value of the blood serum. It is commonly known that
- 20 errors may occur in skin colour observation when determining the jaundice levels in newborns. Hence, a portable and non-invasive device should provide an alternative means for reducing said errors. Further, this could save time and address logistic issues due to parents not having access to transportation to clinics and/or hospitals.
- 25 Many technologies related to measuring jaundice levels have been proposed to further improve the device. For example, an international publication WO2014006827A1 discloses an icterus meter with a probe provided on the end face at one end in one direction of a box-shaped case, in addition to a display unit and a direction-establishing protruding section being provided on respective, mutually opposite surfaces of the case.

A United States patent with publication no. US9934589B2 discloses a system and method for determining bilirubin levels in an individual based on skin coloration using a smartphone or other personal device and an attached ancillary apparatus. The device is capable of storing and running software, and is also coupled to both a camera and
5 light source to obtain data regarding the skin's coloration. Said software is installed on the device to control the light source and calculate bilirubin levels in the individual based on the input received from the camera. Another United States patent with publication no. US4267844A recites an electro-optical medical instrument for measuring the presence of bilirubin in skin tissue. The instrument is preferably hand-
10 held and self-contained and utilizes a source of flash light to provide sufficient energy in the desired wavelength spectrums. Further, the instrument can be automatically activated at a predetermined pressure against a patient's skin to provide a pair of measurement electrical signals, in which these electrical signals can be processed to provide an output signal representative of the bilirubin value which can be conveniently
15 displayed. A technology as disclosed in another United States patent with publication no. US9173603B2 recites a transcutaneous non-invasive device and method for measuring bilirubin levels, the device utilizing optical, electrical, and mechanical means in communication with a processing means to calculate the serum bilirubin concentration. Blanching pressure is applied to the tissue, whose thickness is measured.
20 Further, the level of bilirubin is then calculated from the thickness of the tissue and the detected and measured values of radiation transmitted through the living tissue.

There exists a need to provide a device to overcome these problems, particularly utilising a singular light source with a substantially small contact area to reduce any
25 gaps between the device and the inspected product, generally allowing a greater consistency of light to be emitted and received by the device for jaundice levels measurement.

SUMMARY OF INVENTION

It is an object of the present invention to provide a non-invasive device for measuring jaundice levels, particularly for neonates, whereby early detection of jaundice is essential to prevent future health complications. It is also an object of the present invention to provide a means for wirelessly connecting the device to other devices through internet-of-things to enable ease of analysis of results. It is a further object of the present invention to provide mapping of a data landscape of jaundice levels based on data collected by the device.

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In one aspect of the present invention, there is provided a device for measuring jaundice levels, the device comprising a body accommodating a light transmitting means for emitting light at a predetermined wavelength, a light receiving means for receiving reflected light, means to activate the device so that upon contact between the device and a surface of a target area, light is emitted and received by the device, in which the received light is processed by a means for determining jaundice levels, wherein said means for determining jaundice levels is incorporated with a means for transmitting information elsewhere from the device.

20 Preferably, the device further comprises a fibre optic bundle incorporated to the light transmitting means and the light receiving means for channelling the emitted and received light.

Preferably, the light transmitting means emits light at a wavelength range from substantially 340nm to substantially 850nm.

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Preferably, the device further comprising means for converting the reflected light into electronic signals to be process by the means for determining jaundice levels.

Preferably, the means for determining jaundice levels is a machine learning module.

Preferably, the machine learning module incorporates a series of predetermined jaundice level values to be compared with the converted electronic signals from the reflected light.

Preferably, the determined jaundice levels are displayed on a displaying means incorporated in the device.

Preferably, the means for transmitting information is capable of sending information to means for printing the determined jaundice levels for further analysis.

Preferably, the device further includes a means for locating said device via global positioning system (GPS).

Preferably, the means for locating the device further comprises a Global System for Mobile Communications (GSM) module for transmitting data across Internet of Things (IoT) applications.

In another aspect of the present invention, there is provided a method for non-invasive measurement of jaundice levels comprising the steps of emitting light at a predetermined wavelength to a target area, receiving reflected light from the target area, converting the reflected light to electronic signals, and processing the converted electronic signals with a series of predetermined jaundice level values.

In yet another aspect of the present invention, there is provided a system for mapping a data landscape of jaundice levels based on information received from one or more devices, wherein the landscape is generated based on a collection of jaundice levels and location of patients.

One skilled in the art will readily appreciate that the present invention is well adapted to carry out the objects and obtain the ends and advantages mentioned, as well as those inherent therein. The embodiment described herein is not intended as limitations on the
5 scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

For the purpose of facilitating an understanding of the invention, there is illustrated in
10 the accompanying drawing the preferred embodiments from an inspection of which when considered in connection with the following description, the invention, its construction and operation and many of its advantages would be readily understood and appreciated.

15 **FIG. 1** illustrates a preferred embodiment of a device for measuring jaundice levels.

FIG. 2 is a front sectional view of the device.

FIG. 3 is a side sectional view of the device.

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FIG. 4 is a block diagram illustrating a preferred embodiment of a system architecture for the device.

FIG. 5 illustrates a flow chart of a measurement process for determining jaundice
25 levels.

DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, the invention shall be described according to the preferred embodiments of the present invention and by referring to the accompanying description and drawings.

5 However, it is to be understood that limiting the description to the preferred embodiments of the invention is merely to facilitate discussion of the present invention and it is envisioned that those skilled in the art may devise various modifications without departing from the scope of the appended claim.

10 **FIG. 1 to FIG. 3** illustrates preferred embodiments of a device **1** for measuring jaundice levels, the device **1** comprising a body **2** accommodating a light transmitting means **6** for emitting light at a predetermined wavelength, a light receiving means for receiving reflected light, means to activate the device **1** so that upon contact between the device **1** and a surface of a targeted area, light is emitted and received by the device **1**, in which
15 the received light is processed by a means for determining jaundice levels, wherein said means for determining jaundice levels is incorporated with a means for transmitting information elsewhere from the device **1**. The body **2** of the device **1** may be made out of composite materials such as plastic or a combination of plastic with metal which may be manufactured by current technologies. The body **2** may also be designed with a grip
20 lateral to a user's hand with a head of the device **1** slightly angled downwards away from the body **2**. In a preferred embodiment, a top portion of the device **1** comprises a displaying means **3** incorporated in the device **1** and the means **4** for activating said device **1**.

25 Preferably, the displaying means **3** may be a liquid crystal display (LCD) panel or a light emitting diode (LED) display panel, which would provide feedback to users about an outcome of inspected jaundice levels within a predetermined time period, preferably within approximately three seconds upon activation of the device **1**. The means **4** for activating said device **1** may include one or more buttons **401** which for either powering

up the device **1** via a bootloader or serial bridge **407**, or for navigating through its user interface. In a preferred embodiment, the device **1** functions by measuring an amount of bilirubin and its unit of measurement is in milligrams per decilitre (mg/dL), but may also be measured in micromole per litre ($\mu\text{mol/L}$). Besides that, the target area may
 5 include any part of a skin on neonates or newborn babies, as jaundice is a common occurrence in neonates which may lead to various health complications if jaundice levels are too high.

In a preferred embodiment, the light transmitting means **6** may include a light source
 10 **405** configured to emit light at a predetermined wavelength range of substantially 340nm to substantially 850nm. Power is diverted to the light source via a light source driver **404** which enables the light to be emitted at a predetermined intensity with the aforementioned wavelength range. The light transmitting means **6** may be a broadband light emitting diode (LED). In a preferred embodiment, the light receiving means may
 15 include a spectrometer **409** which is capable of capturing light which are reflected from below the surface of the target area back into the device **1**. The bilirubin inside a patient's bloodstream absorbs light at a wavelength of between 460nm to 470nm, and the emitted light that is not of this wavelength may be absorbed by other blood cells, such as melanin and haemoglobin, for light with wavelengths of substantially 340nm
 20 to less than or equal to substantially 460nm, and wavelengths of substantially more than 470nm to substantially 850nm, with a predetermined amount of light reflected back into the device **1**, whereby the spectrometer **409** may then measure properties of the reflected light such as light intensity, wavelengths and many more.

25 In another preferred embodiment, the emitted light travels through a light guide from the light source **405** to an optical probe **410** such as illustrated in **FIG. 4**, the light guide comprising of a fibre optic bundle, whereby the fibre optic bundle channels the emitted light out from the device **1** and channels the received light into the device **1** respectively and back into the spectrometer **409**. The optical probe **410** may be disposed within a

recess in a front portion 7 of the body 2, whereby the front portion 7 of the body 2 of the device 1 is a contact area which is directly contacted with the surface of the target area. The recess may function to isolate unwanted signals from external surroundings into the device 1 to prevent interference during operation. Further, a shape of the target area in contact will have negligible effects on the accuracy of measurements when the device 1 is directly contacted to the surface of the target area.

In a particular embodiment, the device 1 further comprising means for converting the reflected light into electronic signals to be processed by the means for determining jaundice level, in which said means for converting the reflected light is preferably the spectrometer 409. The spectrometer 409 operates by sampling an analogue waveform of the reflected light at uniform time intervals and assigns a digital value for each sample. The reflected light may be received by the spectrometer 409 through by way of example, but not limited to, reflective concave blazed grating, grating chip and high-sensitivity complementary metal-oxide-semiconductor (CMOS) linear image sensor or the likes, incorporated into the spectrometer 409. Further, the digital value then appears on the spectrometer's 409 output in an analogue coded format by way of performing sampling and quantization on the reflected light received by the device 1, wherein said analogue coded format may subsequently be converted to binary coded format using an Analog-to-Digital Converter (ADC) 408, in which the binary coded format represents the voltage value of the received reflected light.

In another preferred embodiment, the means for determining jaundice levels may be a machine learning module, wherein the machine learning module incorporates a series of predetermined jaundice level values to be compared with the converted electronic signals from the reflected light. The machine learning module may be incorporated with an Artificial Neural Network (ANN) module for enhancing the capabilities of the device in measuring jaundice levels. Advantageously, the machine learning module is further enhanced by utilizing a means for transmitting information to either or both interaction

and communication with wireless devices such as printers, servers, personal computers, databases or the likes. These predetermined jaundice level values may be obtained from databases provided by clinical research. It shall be understood that the machine learning module and ANN module are incorporated into the System on a Chip (SOC) module

5 **417** in the device **1**.

Referring to **FIG. 4**, the device further comprises means **5** for charging a lithium polymer battery **411** in the device **1** in which the battery **411** may be monitored for its current or remaining charge via a batter monitoring module **412** which provides

10 indication to be displayed on the displaying means **3**. The means **5** for charging the battery **411** may be a Universal Serial Bus (USB) Port **406**, preferably either a micro-USB port or a USB Type-C port with fast-charging capabilities. Further, a power management integrated circuit (PMIC) **413** may be incorporated into the device **1** for battery **411** management, voltage regulation and charging functions. In addition, the

15 device **1** further comprises a means for locating said device **1** via Global Positioning System (GPS) **415** antennas **416** incorporated in the device **1**, enabling features such as geo-tagging when the device **1** is in operation. The GPS **415** is operable by utilizing a mobile phone SIM card **414** with wireless network capabilities utilizing mobile data such as Global System for Mobile Communications (GSM) **415'**, Enhanced Data for

20 Global Evolution (EDGE), 3G, 4G or the likes. Further included on the device are a buzzer **402**, which provides audio feedback upon activation of the device, and an antenna **403**.

FIG. 5 illustrates an exemplary embodiment of a process flow of the measurement of

25 the reflected light received by the device **1**. At Step **501**, the front portion **7** of the body **2** of the device **1** is directly contacted with the surface of the target area and ensured that no gap exists or there is an insignificant gap between the target area and the device **1**. At Step **502**, the device **1** is then activated by pushing the button **401** and light is emitted from the light source **405** in the light transmitting means **6** to the target area by

means of diffusion through the surface of the target area. The emitted light which is diffused into the target area will reflect off the internals of the target area, in which an amount of light will be absorbed and an amount of reflected light may then be able to diffuse through the surface of the target area back into the device **1**. At Step **503**, the reflected light will then be received and guided through the fibre optic bundle to the light receiving means. At Step **504**, the reflected light is then processed by the Analog-to-Digital Converter (ADC) **408** and the spectrometer **409** to be converted into electronic signals, which is subsequently processed further by the machine learning module. At Step **505**, the processed electronic signals may then be compared with a set of predetermined jaundice level values to determine the current jaundice level of the patient, which is subsequently displayed on the displaying means **3**. The displaying means **3** will then provide jaundice level measurements in a desired measurement unit, either in mg/dL or $\mu\text{mol/L}$, such as illustrated in Step **506**. Optionally, this information may be transmitted to the means for printing said information in a wireless configuration, whereby said information may be stored for future inspection purposes or further analysis so necessary treatment may be performed accordingly.

In a further embodiment, the device **1** further comprising of a system for mapping a data landscape based information received from one or more devices **1** connected to the system. The data landscape is an integrated view of all data entities within and outside an organization, in which it captures a larger and deeper view of data and its data technologies, processes and capabilities both within and outside the organization. The information comprises of location of the device **1**, which is obtained from using the GPS **415**, and condition of patients detected by the device **1**, which includes the jaundice levels of neonates. In this further embodiment, the system utilizes the capabilities of the machine learning module by compiling all of the aforementioned information for a predetermined number of patients and subsequently generating the data landscape, wherein the generated landscape may be able to provide further insight into a current state of affairs regarding jaundice levels in neonates.

The present disclosure includes as contained in the appended claims, as well as that of the foregoing description. Although this invention has been described in its preferred form with a degree of particularity, it is understood that the present disclosure of the
5 preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangements of parts may be resorted to without departing from the scope of the invention.

CLAIMS

1. A device (1) which is portable for measuring jaundice levels, the device (1) comprising
5 a body (2) accommodating a light transmitting means (6) for emitting light at a predetermined wavelength;
a light receiving means for receiving reflected light;
means (4) to activate the device (1);
means to determine jaundice levels that is incorporated into a System on a Chip
10 module (417) in the device (1); and
a global positioning system (415);
wherein the device (1), upon contact with a surface of a target area, light is emitted and received by the device (1), in which the received light is converted into electronic signals to be processed by the means for determining jaundice levels that
15 is incorporated with a series of predetermined jaundice level values to be compared with the converted electronic signals from the reflected light through machine learning, which is then output in combination with a location of the device (1) obtained via the global positioning system (415) for mapping of a data landscape.
- 20 2. The device (1) according to claim 1 further comprises a fibre optic bundle incorporated to the light transmitting means (6) and light receiving means for channelling the emitted and received light.
3. The device (1) according to claims 1 or 2, wherein the light transmitting means (6)
25 emits light at a wavelength range of 340nm to 850nm.

4. The device (1) according to any one of the preceding claims, wherein the determined jaundice levels are displayed on a displaying means (3) incorporated in the device (1).
- 5 5. The device (1) according to any one of the preceding claims, wherein the means for transmitting information is capable of sending information to means for printing the determined jaundice levels for further analysis.
- 10 6. The device (1) according to any one of the preceding claims, further comprising a Global System for Mobile Communications (GSM) (415') module for transmitting data across Internet of Things (IoT) applications.
- 15 7. A method for non-invasive measurement of jaundice level using a portable device (1) based on any one of the preceding claims, the method comprising the steps of:
 - emitting light of a predetermined wavelength to a target area by a light transmitting means (6) of the device (1);
 - receiving reflected light from the target area;
 - converting the reflected light received by a light receiving means to electronic
 - 20 signals; and
 - determining the jaundice level by processing the converted electronic signals for comparison with a series of predetermined jaundice level values through machine learning by a means for determining jaundice level that is incorporated into a System on a Chip module (417) in the device (1);
 - 25 wherein the determined jaundice level is then output in combination with a location of the device (1) obtained via a global positioning system (415) for mapping of a data landscape.