ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 14, Issue, 07, pp.21868-21873, July, 2022
DOI: https://doi.org/10.24941/ijcr.43760.07.2022

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

REVIEW ARTICLE

IMPROVING HEALTH CARE WITH MEDICAL SENSORS INTEGRATED WITH INTERNET OF THINGS (IOT)

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ARTICLE INFO

Article History:
Received 19th April, 2022
Received in revised form
05th May, 2022
Accepted 14th June, 2022
Published online 26th July, 2022

Key words:

IOT, Vital signs,
Thinger, Temperature,
ECG, Heart rate,
SPO2, bpm, Led.

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ABSTRACT

Background: Patient who's health condition is stable but needs to be monitored throughout the day enforced to stay at hospital, which is something uncomfortable and Psychologically annoying, but each day medicine and technology is being developed, so how can we help these patients in making life easier!. **Objective:** The goal of this project is to invest the internet by using IOT (internet of things)to provide alow-cost device that can monitor patient's vital signs and displaying the results on screen of the device near the patient in his home without the need to go to the hospital and sending real time results of patient health via Wi-Fi module to the "Thinger" platform which can be used by a doctor. **Method:** Design and development of an integrated device for measuring heart rate, SPO2, temperature and ECG signal using sensors (ECG electrodes are connected to ECG board AD8232, ds18b20 for measuring temperature, MAX30100 sensor for measuring SPO2 and heart rate). The system also has an alarm (LEDs on the "Thinger" platform), this will help the doctor to notify the abnormality in the patient vital signs measurements. The technology we used, which is IOT using ESP8266 Wi-Fi board have many advantages such as inexpensive price and unlimited distance the data can be sent, then the "Thinger" platform that provide so many features for displaying any type of data. **Results:** The data that was displayed at device's screen and at IOT platform was an accurate real time data and fast alarm system in which the patient, his family and the doctor can feel safe about patient's health. **Conclusion:** In this thesis, we presented the design and development of an integrated device for measuring heart rate, SPO2, temperature and ECG signal using sensors, for monitoring, displaying the results on the screen of the device near the patient in his home without the need to go to the hospitaland sending the results of patient health via Wi-Fi module to the internet cloud platform using IOT which can be used by a doctor. The system also has an alarm system to notify the doctor of the abnormality in the patient vital signs measurements. This device deserves to be known and applicable because of its low cost and its ability to provides easy reached information of patient for easy health care.

Citation: ***Hiba Basman Shaker, Saif Ali Raheel and 3Fatima Rabeea Abd Ali.*** **2022**. "Improving health care with medical sensors integrated with internet of things (iot)*". International Journal of Current Research*, 14, (07), 21868-21873.

INTRODUCTION

This project is a small system that gather several information from the patient by using sensors that represent some vital signs, display data and sending it to the physician using IoT, also it providesan alarm system to alerts the doctor or his/ her family even him/herself if there is a problem with the health of the patient. Vital sign monitoring is becoming increasingly important for securing independent lives as the population of aged people increases. It is used for patients who need continuous monitoring especially for cardiac patients. Online, long-term monitoring plays a pivotal role, those cardiac problems that occur frequently during normal daily activities may disappear the moment the patient is hospitalized, causing diagnostic difficulties and consequently possible therapeutic errors.

In this sense, continuous and ambulatory monitoring systems are needed to detect the traits (Sokwoo Rhee, 2001). Also, the patient can check their health status anytime from the comfort of their homes and visit hospitals only when they really need to (Shubham Banka1). The information taken from the body is sent to the cloud 'Thinger' for displaying data to be monitored by the physician and to be stored. Storing purpose can act as a medical history for the future (Hari Kishore).This project will also provide an alert system, if the heartbeat,temperature,SPO2) is abnormal through a buzzer and also through led for each one on thinger (Hari Kishore). The Internet of Things (IoT) describes the network of physical objects "things" that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet.

These devices range from ordinary household objects to sophisticated industrial tools. With more than 7 billion connected IoT devices today, experts are expecting this number to grow to 10 billion by 2020 and 22 billion by 2025. The distinguishing characteristic of Internet of Things in the healthcare system is the constant monitoring a patient through checking various parameters and also infers a good result from the history of such constant monitoring (Shubham Banka).

Problem Statements

The major aim applied in this smart health monitoring device is summarized as.

- To Understand and get the output data of pulse rate in the real time environment with accuracy via IOT, and allow to be accessed by medical stuff (Hari Kishore)
- Is to make an online self-monitoring, portable device which can be used at home or outside. easy to use for the patients to regularly monitor their conditions and send them to the doctor without the necessity to actually go to the hospital
- Providing low cost, low power consumption, portable and reliable method for monitoring patients in developing countries.
- Data storage of the patient vital signs on the IOT platform (Hari Kishore)
- For patients who need continuous monitoring such as elderly or cardiac patients, those cardiac problems that occur frequently during normal daily activities may disappear the moment the patient is hospitalized, causing diagnostic difficulties and consequently possible therapeutic errors. In this sense, continuous and ambulatory monitoring systems are needed to detect the traits.

Project scopes: In order to achieve the project objectives, there are two main parts of the scopes which are hardware and software. For the hardware part, the scope of this project is a circuit of IOT board (NodeMCU) with small size one lead ECG board, temperature sensor, SPO2 sensor (that measures spo2 and heart rate), and microcontroller with touchscreen LCD. To determine the ECG signal, heart rate, temperature and blood oxygen level, and display the results on the screen and online website… the software codes will do it.

MATERIALS AND METHODS

Hardware Components

ECG board (Spark Fun Single Lead Heart Rate Monitor - AD8232) (https://www.sparkfun.com/products/12650)

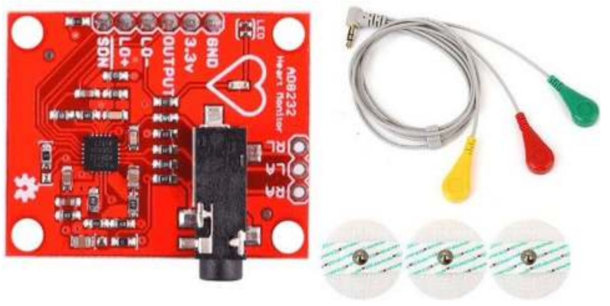


Fig.(2.1). ECG board (https://how2electronics.com/ecg-monitoring-with-ad8232-ecg-sensor-arduino/)

The AD8232 Spark Fun Single Lead Heart Rate Monitor is a cost-effective board used to measure the electrical activity of the heart. This electrical activity can be charted as an ECG or Electrocardiogram and output as an analog reading. ECGs can be extremely noisy, the AD8232 Single Lead Heart Rate Monitor acts as an op amp to help obtain a clear signal from the PR and QT Intervals easily. The AD8232 is an integrated signal conditioning block for ECG and other bio potential measurement applications.

It is designed to extract, amplify, and filter small bio potential signals in the presence of noisy conditions, such as those created by motion or remote electrode placement. The AD8232 Heart Rate Monitor breaks out nine connections from the IC that you can solder pins, wires, or other connectors to. SDN, LO+, LO-, OUTPUT, 3.3V, GND provide essential pins for operating this monitor with an Arduino or other development board. Also provided on this board are RA (Right Arm), LA (Left Arm), and RL (Right Leg) pins to attach and use your own custom sensors. Additionally, there is an LED indicator light that will pulsate to the rhythm of a heartbeat.

Features:

- Operating Voltage - 3.3V
- Analog Output
- Leads-Off Detection
- Shutdown Pin
- LED Indicator
- 3.5mm Jack for Biomedical Pad Connection

MAX30100sensor(https://datasheets.maximintegrated.com/en/ds/MAX30100.pdf)

Fig.(2.2): MAX30100 sensor

The MAX30100 is an integrated pulse oximetry and heart rate monitor sensor solution. It combines two LEDs, a photo detector, optimized optics, and low-noise analog signal processing to detect pulse oximetry and heart-rate signals. The MAX30100 operates from 1.8V and 3.3V power supplies and can be powered down through software with negligible standby current, permitting the power supply to remain connected at all times.

Principle work of MAX30100 Pulse Oximeter and Heart-Rate Sensor: The device has two LEDs, one emitting red light, another emitting infrared light. For pulse rate, only the infrared light is needed. Both the red light and infrared light is used to measure oxygen levels in the blood. When the heart pumps blood, there is an increase in oxygenated blood as a result of having more blood. As the heart relaxes, the volume of oxygenated blood also decreases. By knowing the time between the increase and decrease of oxygenated blood, the pulse rate is determined. It turns out, oxygenated blood absorbs more infrared light and passes more red light while deoxygenated blood absorbs red light and passes more infrared light. This is the main function of the MAX30100: it reads the absorption levels for both light sources and stored them in a buffer that can be read via I2C.

Benefits and Features

- Complete Pulse Oximeter and Heart-Rate Sensor Solution Simplifies Design
  - Integrated LEDs, Photo Sensor, and High-Performance Analog Front –End
  - Tiny 5.6mm x 2.8mm x 1.2mm 14-Pin Optically Enhanced System-in-Package

- Ultra-Low-Power Operation Increases Battery Life for Wearable Devices
  - Programmable Sample Rate and LED Current for Power Savings
  - Ultra-Low Shutdown Current (0.7µA, typ)
- Advanced Functionality Improves Measurement Performance
  - High SNR Provides Robust Motion Artifact Resilience
  - Integrated Ambient Light Cancellation
  - High Sample Rate Capability
  - Fast Data Output Capability

Table (2.1):Pin outs(https://artofcircuits.com/product/max30100-pulse-oximeter-heart-rate-sensor-module-wearable-health)

Pin No.	Signal Name	Description
1	VIN	1.8V – 5.5V Power Input
2	SCL	I2C Serial Clock
3	SDA	I2C Serial Data
4	INT	MAX30100 Interrupt
5	IRD	IR LED Cathode and LED Driver Connection Point. Lea
6	RD	Red LED Cathode and LED Driver Connection Point. L
7	GND	0V / Reference Voltage

DS18B20 1-Wire Temperature Sensor (https:// lastminuteengineers.com/ds18b20-arduino-tutorial/): It's a waterproof probe style, requires only one digital pin for two-way communication with a microcontroller.DS18B20 temperature sensor is fairly precise and needs no external components to work, consist of three pins:

GND: Is a ground pin.

DQ: Is 1-Wire Data Bus should be connected to a digital pin or microcontroller.

VDD: Pin supplies power for the sensor which can be between 3.3 to 5V

Principle work of DS18B20 Temperature Sensor: The core functionality of the DS18B20 is its direct-to-digital temperature sensor. The resolution of the temperature sensor is user-configurable to 9, 10, 11, or 12 bits, corresponding to increments of 0.5°C, 0.25°C, 0.125°C, and 0.0625°C, respectively. The default resolution at power-up is 12-bit. The DS18B20 powers up in a low power idle state. To initiate a temperature measurement and A-to-D conversion, the master must issue a Convert T (44h) command. Following the conversion, the resulting thermal data is stored in the 2-byte temperature register in the scratchpad memory and the DS18B20 returns to its idle state. If the DS18B20 is powered by an external supply, the master can issue "read time slots" after the Convert T command and the DS18B20 will respond by transmitting 0 while the temperature conversion is in progress and 1 when the conversion is done.

Table (2.2). Specifications

Power Supply	3V to 5.5V
Current Consumption	1Ma
Temperature Range	-55 to 125°C
Accuracy	±0.5°C
Resolution	9 to 12 bit (selectable)
Conversion Time	< 750ms

ESP8266-NodeMCU: Node MCU is an open-source firmware and development kit that helps you to prototype or build IOT products. It supports serial communication protocols i.e. UART, SPI, I2C etc. It includes firmware that runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The firmware uses the Lua scripting language (https://cityos-air.readme.io/docs/esp8266-nodemcu). NodeMcu Development board is featured with Wi-Fi capability, analog pin, digital pins and serial communication protocols (https://www. electronicwings. com/nodemcu/introduction-to-nodemcu)

Fig.(2.3). ESP8266-NodeMCU (9)

Arduino Mega

Fig.(2.4). Arduino Mega(12)

Arduino MEGA 2560 is designed for projects that require more I/O lines, more sketch memory and more RAM. With 54 digital I/O pins, 16 analog inputs and a larger space. This gives your projects plenty of room and opportunities maintaining the simplicity and effectiveness of theArduino platform. This document explains how to connect your Mega2560 board to the Computer and upload your first Sketch. The Arduino Mega 2560 is programmed using the Arduino Software (IDE), our Integrated Development Environment common to all our boards and running both online and offline (https://www.arduino.cc/en/Guide/ArduinoMega2560)

LCD 3.5TFT shield

Fig.(2.5). 3.5tft LCD shield(14)

This 3.5″ color TFT display as mentioned above, is based on the ILI9481 TFT display driver. The module offers a resolution of 480×320 pixels, clear display, and support for touch function. It comes with an SD card slot through which an SD card loaded with graphics and UI can be attached to the display. The module is also pre-soldered with pins for easy mount (like a shield) on either of the Arduino Mega and Uno, which is nice since there are not many big TFT displays that work with the Arduino Uno (https://www.electronics-lab.com/project/ using-ili9481-3-5-color-tft-display-arduino/)

Arduino pro mini

Fig.(2.6). Arduinopro Mini (https://store.roboticsbd.com/arduino-shield/1219-35inch-arduino-display-uno-robotics-bangladesh.html)

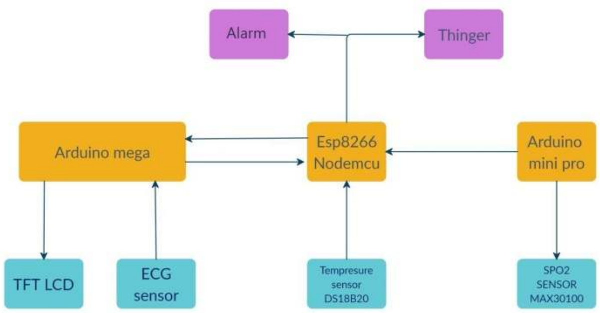
The Arduino Mini is a small microcontroller board originally based on the ATmega328P intended for use on breadboards and when space is at a premium. Because of its small size, connecting the Arduino Mini is a bit more complicated than a regular Arduino board (see below for instructions and photos) (https://www.arduino.cc/en/Guide/ArduinoMini). Arduino Mini is programmed using the Arduino Software (IDE), our Integrated Development Environment common to all our boards and running both online and offline.

Software Components

Arduino IDE: We used the Arduino IDE for programming the microcontrollers, it offers easy-to-use interface software with wide number of boards to program with it, also adding libraries is so easy.

Thinger.io: Thinger.io is a cloud IOT Platform that provides every needed tool to prototype, scale and manage connected products in a very simple way, we added its library to the Arduino IDE and some information such as (USERNAME, DEVICE_ID, DEVICE_CREDENTIAL) to complete the connection process between the website and our IOT board (NodeMCU).

PROJECT BLOCK DIGRAM



Procedure

Connection process: Arduino mini, Arduino mega and ESP8266NodeMCUare a microcontroller boards which are used here to read analog data from all the sensors and convert that data into digital form using mathematical algorithms. The micro-controller boards will also control the series of sensors and sequence of their functioning; in a way that data from SpO2 sensor, temperature sensor and ECG sensor are continuously read by the controller boards.the data will be sent to the "thinger" website through ESP8266NodeMCUwhich is connected with these boards,the data will be sent also to 3.5 TFT touch screen LCD shield through Arduino mega to be displayed. Interfacing of sensors with "thinger" website via Wi-Fi is carried out by connecting micro-controller board (ESP8266NodeMCU). 7volts supply is needed to switch on the microcontroller boards. Power adapter with12 volt can be used for this purpose. Once the circuit is on, it starts monitoring the data of patient's vital signs and displaying it on both LCD touch screen by sendthem through Arduino mega and "thinger" website by sendingthe data throughWi-Fimodule.

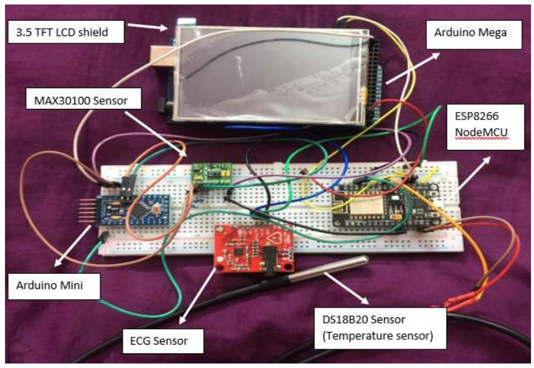


Fig.(2.7). Picture showing the components of thedevice

Programming the Arduino pro mini for reading the output from the MAX30100 sensor and transmit signals via serial pin TX

- Connect 3.3v and GND pins of the MAX30100 sensor to the VCC and GND pins in the Arduino pro mini.
- Connect SCLand SDA pins of the MAX30100 sensor to the A4 and A5 pins in the Arduino pro mini.
- Connect the Arduino pro mini pin TX to the D2 pin in ESP8266-NodeMCU (for transmitting the signals to IOT board).
- In the Arduino IDE upload the sketch in (Wemos_D1_mini_Spo2_Serial) to the Arduino.

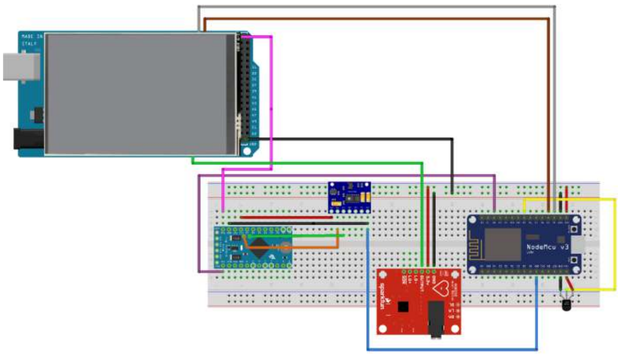
Programming theArduino Mega for reading the output from the ECG sensor and receive the data from the temperature sensor & MAX30100 sensor to display all the data of the 3 sensors in 3.5tft LCD Screen

- Connect 3.3v and GND pins of the ECG board to the 3.3v and GND pins in the ESP8266-NodeMCU.
- Connect output pin of the ECG board to A8 pin in the Arduino Mega.
- Connect the 3.5tft LCD screen pins to Arduino Mega pins.
- Connect the ESP8266-NodeMcu pin TX to the RX pin in Arduino Mega and RX pins of ESP8266-NodeMcu to TX of the Arduino mega (for sending the ECG signal to the ESP8266-NodeMcu,and receiving the temperature, MAX30100 sensors signals from ESP8266-NodeMCU to displayall values on touch screen).
- In the Arduino IDE upload the sketch in (3.5inch_TFT_Chart_Data_print_serial) to the Arduino.

Programming the ESP8266-NodeMCU for reading the output from the temperature sensor, and receive the data from ECG sensor & MAX30100 sensor to send all the data of the 3 transmit signal via Wi-Fi to the thinger website

- Connect 5v and GND pins of the temperature sensor to the Vin and GND pins in the ESP8266-NodeMCU.
- Connect output pin of the temperature sensor to D5 pin in the ESP8266-NodeMCU.

- Connect the ESP8266-NodeMcu pin TX to the RX pin in Arduino Mega and RX pin of ESP8266-NodeMcu to TX of the Arduino mega. (send the temperature signal from ESP8266-NodeMCU and (SPO2&HR)to Arduino Mega to display them on touch screenand receive the ECG signal from Arduino Mega tosend all the data of the 3sensors via Wi-Fi to the thinger website).
- IntheArduinoIDEuploadthesketchin(Nodemcu_ECG_THINGER_SERIAL_SERIAL2_MAX30100_DS18B20) to the Arduino.



Creatingthinger profile

- Open the website (https://thinger.io/)
- Sign up (fill your information)
- Add device (fill the details)
- Add dashboard (fill the details)
- Add widget (each one represent a value you want to display, in our case: temperature, bpm and Spo2) by choosing text/value type.
- For alarm system, also add widget (We added three LEDs for three parameters (temperature, SPO2 and Heart rate), whereas when one of the three parameters is normal, it‘s led will be green, when it became abnormal, it‘s led will be red) by choosing Led indicator type.

Packaging of the project

•we redesigned the hardware in a suitable way for cosmetic needing, as shown in figure (2.8).

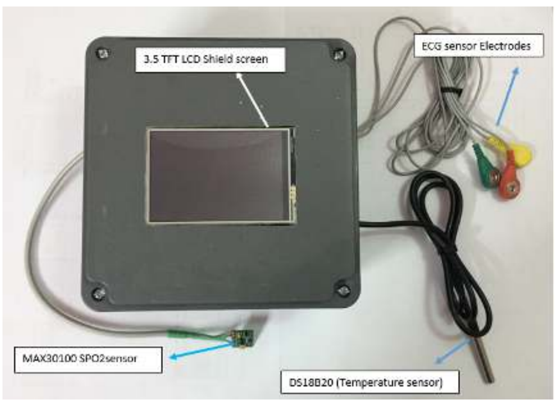


Figure (2.8): Project after packaging

SECTIONTHREE: RESULTS

Results

•Results from thinger platform showing ECG, Temperature, heart rate (bpm) and SPO2, as shown in figure (3.1)

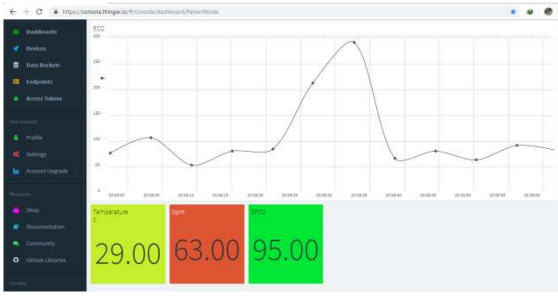


Figure (3.1): Photo showing theresultss from thingerplatform

Results displayed at 3.5 tft touchscreen LCD, as shown in Figure (3.2)

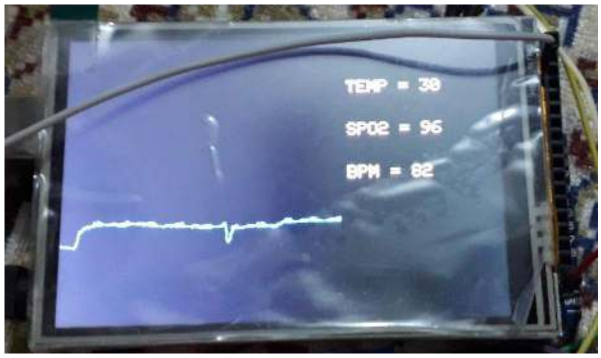


Figure (3.2). Screen shot showing the results displayed at 3.5 TFT touch screen LCD

SECTIONFOUR: DISCUSSION AND CONCLUSION

Problems we encountered by working on the project

1. (MAX30100) and (DS18B20) sensors didn't work when we connect them directly to (ESP8266 NodeMCU)
2. We use thinker instead of thing speak website which we used before because of (ECG sensor), thing speak website is slower than thinger so it is better to use it for fast ECG signal drawing.
3.ECG sensor didn't work correctly when we connect it directly with NodeMCU, We connect the ECG sensor with Arduino mega so its work correctly
4. Max30100 didn't work when there's anything else connect with its same microcontroller, we connected it with mini Arduino alone and send the data to the NodeMCU.
5.Because of number of pins of the screen it is better to use Arduino mega with it instead of Arduino mega.

CONCLUSION

According to the results, we found out that keeping eye on the patient and make sure of his health condition being monitored comfortably is something can be reached easily with the development of the technology. this device will be very useful for patient and doctor using IOT technology that enables the delivery of data anywhere in the world, we want to give Society the necessary tools in order to develop new e-Health applications and products.

Future work

In this part, we will talk about hardware and software that can be added to the system in the future in order to make the system more flexible and useful for the patient.

- Add more sensors give us more information about the patient vitalsign like pressure sensor.

- Add GSM Module in order to send a message to the authorized person about patient location through emergency situation.
- Make a network connection system so that the system will be used for more than one patient.
- Use a buzzer for system alarm.
- The data of all external sensors can be managed by a fully formed mobile app and other devices. Thus, the patient will get the notification regarding their current status and cloud stores their compact data.
- Strict security protocols like fingerprint scans and password protection can make the system more reliable so that it may not create any confusion.
- For better communication of the patient with the doctor, managing assistant and family members, a video call can be also provided in this system.
- Increase the flexibility by using batteries for power and change the packaging so that the device will be portable.

Conflict of interest statement

•None Declared

Funding statement

•Self Funding

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