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IoT Based Capnography Device

E Gowtham
S J C Institute of Technology, Chickballapur, Bangalore

Abstract- The Capnography design which is hand held has a great demand due to its practical applications and effective usefulness in resuscitations of cardiac arrest, this is according to the American heart association. This proposed handheld capnography device which can used in a clinical place and also in any home environment is reported. The device which is will be developed with an infrared CO2 sensor, a very high resolution display. In addition to that, there are two rechargeable batteries of 7.6v, 0.99A, it is also attached with secure digital card having a capacity of 16GB which is incorporated to increase the usability and also portability of the device. A LCD monitors the CO2 values.

Keywords- IOT Based, Arduino, SCD30 - Carbon Dioxide CO2 and RH/T Sensor Module

I. INTRODUCTION

The continuous measurement of human respiratory CO2 by using a capnograph provides valuable information about cardiopulmonary resuscitation, endotracheal tube placement, pulmonary embolism, and procedural sedation, along with the information about the air pollution effect on cardiopulmonary characteristics and effectiveness of this is a treatment for any particular person or patient with respiratory distress (specifically with chronic obstruction, asthma, or any other lung diseases and congestive heart failure).Existing CO2 measurement devices, such as arterial blood gas, arterialized capillary blood gas, and venous blood gas analysis devices, are considered to be the gold standard in clinical practice.

However, these devices are invasive, require the recurrent collection of blood samples for CO2 measurement, and possess several limitations.

Their use requires expertise and skills, they cause pain to the patient and blood loss; and they involve time consuming processes that pose hazards and inflict damage to tissue, nerves, and vessels. Moreover, they measure only the current respiratory rate, which may change drastically within a short period. These demerits may be overcome by the use of a non-invasive and continuous CO2 measurement device, such as a capnograph.

The currently available capnograph device is bulky and expensive. Hence, a strong need exists for an inexpensive and light-weight device that is similar to a capnograph which can be used in any clinical environment and also in any kind of home environment by measuring a minimal set of parameters, such as CO2(ICO2), end-tidal CO2 (EtCO2), and the rate of respiratory.

Since over several years, a few attempts have also been conducted to develop time-based capnography by using diverting and non-diverting techniques. In 2013, Santoso and Dalu Setiaji presented a diverting capnograph that uses a nondispersive infrared (NDIR) CO2 sensor, ATmega8535, and display modules (an organic light-emitting diode [LED] seven-segment display to measure EtCO2, RR, and CO2 signals. The device was tested only on five sub- jects. Hence, the used sensor has insufficient efficiency in detecting human respiratory CO2.

II. LITERATURE SURVEY

A study by A. B. Sanders et al. suggest that the carbon dioxide exertion may be useful and also a non invasive form of indicating resuscitation from cardiac arrest. A very particular or specific case has done a prospective clinical study weather it can determined the carbon dioxide monitoring during a cardiopulmonary resuscitation which could be applicable as an indicator of survival and resuscitation. During this case study 34 patients out of 35 patients with cardia arrest were monitored during cardiopulmonary with capnometry with the duration of one year. The information which are obtained can indicate that monitoring carbon dioxide during cardiopulmonary are correlated with survival and resuscitation of cardiac arrest.

Similarly, a study by K. Z. Lukic et al. shows and it determines the stability and repeatability of a capnography which is interfaced with human exposure facility. The signals of a capnograph wave samples from the device with respect to the patients after they have been exposed to particle or filtered air in five minutes of consecutive intervals, and with several times of minutes differ with each volunteer within the operational human exposure facility.

They used a customized capnograph which is comprised of microchip ordion of a portable capnograph. This process of converter and AD card, these signals are acquired in which all are saved as a processing for subsequent ASCII. After monitoring all the volunteers every minute of the ventilation, tidal volume of expiratory and the rate of respiratory all these are recorded after and before the capnograph recordings in which all are averaged.

Furthermore, a study by M. K. Demirel et al. shows how to evaluate the diagnostic contribution of alveolar dead space fraction (AVDSf) measured using capnography in the admitted people who might be having pulmonary embolism (PE). A total of 58 patients who were admitted to our hospital with suspected PE between October 2006 and January 2008 were included in this study. Every people or patients who then treated in Wells clinical score, capnography, computed tomographic pulmonary angiography, D-dimer measurement, lower-extremity venous Doppler ultrasonography, and V/Q scintigraphy. Forty patients (69%) had PE based on computed tomographic pulmonary angiography findings.

Another study written by N. David et al. may also show that multiple studies illustrate the benefits of waveform capnography in the non-intubated patient. This type of monitoring is routinely used by anesthesia providers to recognize ventilation issues. Its role is to administrate a deep sedation is well defined. Prehospital providers embrace the ease and benefit of monitoring capnography. Currently, few community-based emergency physicians utilize capnography with the non-intubated patient. This study shows that it will be possible to clinically identify areas where monitoring the carbon dioxide at its end is beneficial to the emergency provider and patient.

While adding another case with respect to the previous theories, another study by S. E. Huttmann et al. explains that the partial pressure between an elevated carbon dioxide and the relationship between pco2 and reduced ventilation which will be resulting from the failure of respiratory pump said to be recorded in Copenhagen polio epidemic during 1952.

A variety of methods are present to estimating pco2, blood gas analysis is one of the many, furthermore is transcutaneous measurement of pco2, in addition to that capnography have been developed for the assess of ventilation. The measurement of CO2 in a clinical setting is very much valuable that includes chronic and acute respiratory failure, cardiopulmonary resuscitation which also include controlled analgesia and procedural sedation. These variety of techniques which are available currently may differ respectively with respect to their accuracy and their capacity to provide continuous assessment without any side effects, also their availability and their poor ability to assess useful information regarding with the patient.

III. BLOCK DIAGRAM

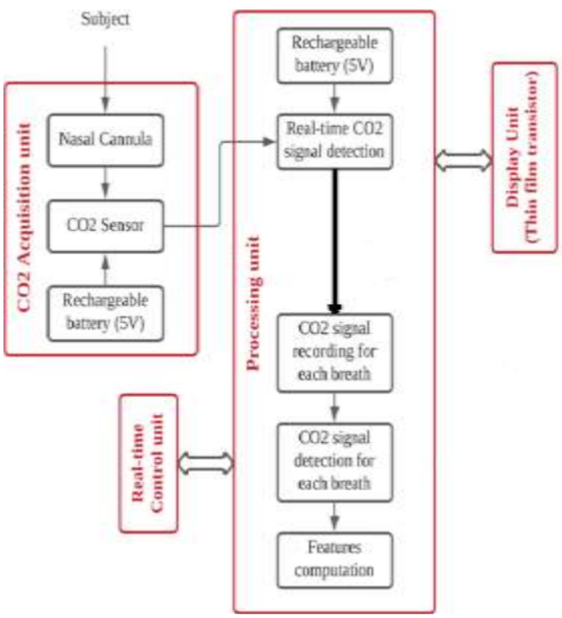

Figure 1: Block diagram of IOT based capnogram

1. Block Diagram Description

The block diagram of the proposed capnography device is shown in Fig 2.1. The SCD30 is a highly accurate CO2 sensor module based on our patented CMOS sensor Technology for IR detection that includes a best-in-class humidity and temperature sensor. This allows ambient humidity and temperature to be outputted through modeling and compensating of external heat sources without the requirement for any additional components. This allows ambient humidity and temperature to be outputted through modeling and compensating of external heat sources without the requirement for any additional components. Arduino UNO is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. A display is essential for providing real-time feedback on the measured CO2 levels. It can be an LED or LCD display, showing numerical values and waveforms. Moreover, the integration of an Arduino-controller will be displayed on the monitor CO2 values on OLED display.

The CO2 signal is attained from the subjects through a sampling tube and then diverted to the microcontroller unit for the purpose of computation and transmission. A high-resolution display is used to display the CO2 signal and other parameters, such as maximum and minimum CO2 concentrations, breathing rate, and activity through serial communication. The overall block diagram of the proposed prototype capnography device; the CO2 acquisition unit consists of a nasal cannula, and CO2 sensor, the pro- cessing unit (ATmega2560) elucidates the data transmission and computation, the display unit displays the CO2, ICO2, EtCO2.

2. Hardware Description

SCD 30

The SCD30 from Sensirion is a high quality Nondispersive Infrared (NDIR) based CO_2 sensor capable of detecting 400 to 10000ppm with an accuracy of (±30ppm+3%). In order to improve accuracy the SCD30 has temperature and humidity sensing built-in, as well as commands to set the current altitude. This allows ambient humidity and temperature to be outputted through modeling and compensating of external heat sources without the requirement for any additional components. The module's dual-channel principle enables excellent long-term stability by design, and its ultra-thin package size allows easy integration into even the most demanding applications.

The CO2 acquisition unit consists of five main com- ponents: a sampling tube, direct current (DC) motor, pump, moisture trapper and CO2 sensor. A nasal cannula, with a length of seven feet, is placed be- tween the water trap and subject to transport the CO2 samples. The incorporated water trap is highly sensitive and traps the moisture and patient secretions while maintaining the morphology of the CO2.

ATmega328P

This Arduino board which consists of the following they are, digital pins and analogue input/output pins, along with that it has shields and with that it contains other peripheral circuits. The 6 analogue pins includes 14 digital pins, with a connected usb connecter, an ICSP which stands for in circuit serial programming header, and also a power jack. This is also a IDE based programming device, which can be able to run in offline and online platforms.

The Arduino-Uno has a source which is an open and programmable microcontroller board developed as very less complicated version of Arduino mega 328. The board has mainly 14 digital input/output pins, analogue pins which can be programmable with the use of Arduino IDE which here stand for (integrated development environment). This Arduino will be programmed by using a simple programming language like C/C++ and by connecting this system or board by a USB cable.

The specifications of Arduino microcontroller. This system requires an Arduino which is an open source that will be programmable very easily, in which any program can be reprogrammed at any given interval of time. This is a simple microcontroller is a computing platform of an open source which is used for programming and constructing several electronic devices.

3. Software Description

This Arduino programmable IDE which is an open source, it is developed for the use of programming circuits efficiently and easily. The user will be able to write simple programs like LED turning on/off to a very complex programming operations like robots controlling. The user can tell the Arduino board to do any valuable operation the user desires to the Arduino board with the help of some set of programming instruction set up by the user.

This Arduino programmable IDE supports a specific languages like C, C++ with the help of some specific rules for constructing a code. This software library of the Arduino from the wiring project, this library provides a very similar or common output and input procedures. The user here will be required to write the codes for only two basic functions, to start the main program an the sketch loop which are also linked and all are compiled into an executive program with GNU which is a tool chain, this also include it in the IDE distribution. The program in the Arduino employs the program which coverts the code which is in executable format into a file text in hexadecimal format of encoding which is then loaded to the Arduino board from the loader program into the firmware.
IOT based capnography device which can perform all these kind of operations which the software called IDE Arduino IDE. Arduino IDE was used to program Arduino's official boards based on Atmel AVR Microcontrollers, but over time, once the popularity of Arduino grew and the availability of open-source compilers existed, many more platforms from PIC, STM32, TI MSP430, ESP32 can be coded with the help of IDEW Arduino.

Any program with embedded c normally requires an extension of c language of the nonstandard to support and enhanced microprocessor features such as fixed-point arithmetic, multiple distinct memory systems, with simple or basic output and input operations. A standards C language committee produced a Technical Report, most recently revised in 2008 and reviewed in 2013, which provides very common implementations to all of it. This also includes some of the features which are not available in normal c, it is a fixed in one point or fixed arithmetic. The address named space and also any input or output in simple or basic addressing hardware. This type of language which is embedded c will use syntax which is very much similar to that of c language like as follows, main() function, declaration of data type, defining the variable, if, switch and case statements in it, also while and for loop function, with strings and arrays, including with bit operations, also with macro like this there are many types of functions which is used in the embedded c programming language.

IV. RESULT

This figure shows electronic arrangement of these components which are used in the proposed handheld capnography device. These components are placed on a double-sided PCB which is designed for the proposed prototype. The bottom layer of the PCB carries the CO2 sensor, pump, and DC motor, while the upper layer accommodates the micro-con troller and RTC unit. The display is fitted at the very top on the board as shown in Fig 5.2. A rechargeable battery of 7.4 V and 0.99 A will be used to provide constant supply of 5 V via the voltage regulator IC 7805. Two simple mechanical switches are used to deliver the constant power supply to the sensor and microcontroller.

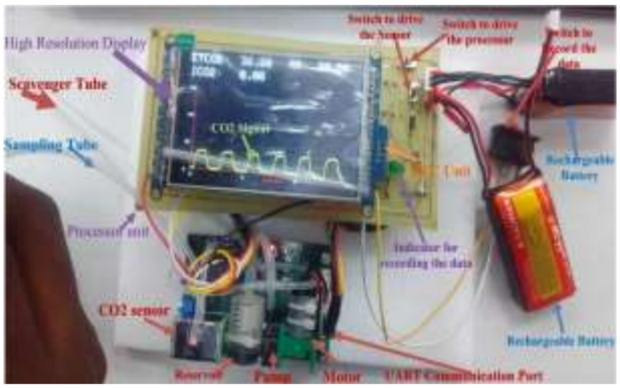

Figure 2: Hardware Implimentation

Illustration of the Subject

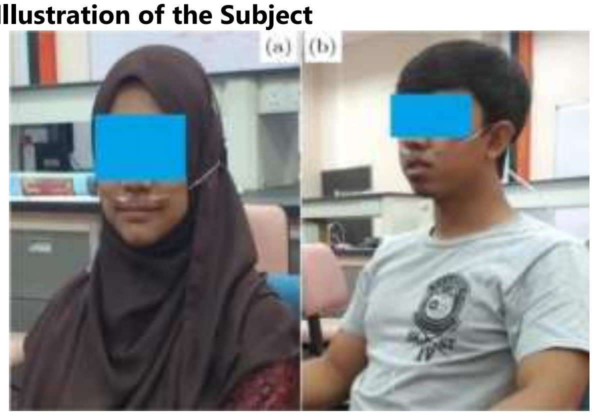

Figure 3: Illustration of the subject

The subjects are instructed to sit idly on a chair without any physical movement to avoid the change in the CO_2 signal and incorporated features during the recording. Thereafter, each subject is asked to breathe in and out comfortably after placing the sampling tube nearby his/her nose and inserting prongs into it, as shown in Fig 5.4, to avoid the alternation in the reading. The CO_2 data recording is conducted on 15 subjects, for 2 min each, using the standard capnography (Capnostream^{TM}20 Model CS08798) and proposed device as advocated by Zhang *et al.*, for further signal analysis. The sampling frequency (f_S) of the existing standard capnography is 20 Hz, while that of the proposed device is 100 Hz.

The accuracy of the proposed device is validated by using the Bland–Altman's plot (drawn using MATLAB R2015a, Version 8.5) with $p < 0{:}05$ and limits of agreement set to 10%–20%of the actual CO_2, $EtCO_2$, and RR values, respectively.

V. CONCLUSION

We present an inexpensive, light-weight, and handheld prototype capnography device based on diverting technology for application in clinical set-tings and the home environment. Compared with those of a previously reported device, the size and weight of the developed device have reduced by 67% and 30%, respectively, facilitating the handling of the device. The device computes and displays the CO2 signal, ICO2, EtCO2, and RR on a high-resolution display. In addition, this device provides smooth and sharp signals due to the integration of a noise reduction method that reduces the computational cost of the device.

Future Work

Capnography is increasingly being used by Emergency medical personnel to assist in their assessment and treatment of patients prior to transportation to hospital. These uses include verifying and monitoring the position of an ETT (endotracheal tube) or a blind insertion airway device. A misplaced tube in the oesophagus will lead to a patient's death if it goes undetected.

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