

AUTOMATED BLOOD FLOW ALERTING SYSTEM FOR NPWT

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Abstract— Blood in the human body should be pure enough for the body to function properly. There might be several reasons by which the blood in human body become impure. Negative pressure wound therapy is used for severe cases. Conventional NPWT method of draining off blood does not have an alerting system. Thus, it requires continuous observation of draining process until the impure blood is removed. Manual observation is quiet time consuming as well as inefficient, making it a tedious task for health practitioners. Risks of monitoring manually are fairly high and need for an automated real time alerting system as proposed can be considered relevant. The proposed system employs an automated system for the continuous observation of blood flow. The system methodology is based on analyzing color of the blood. Color would be the most effective parameter that can give information on several pathologies in this diagnosis. Hence, the use of color sensor is a need. The Real Time signal processing to monitor blood stream in correlation with its natural color and alert the staff in charge when the infected blood ends and pure blood starts to flow.

Keywords—NPWT, Catheter, PDA, Sepsis.

I. INTRODUCTION

One of the hallmarks of modern medicine is the availability of large volumes of patient information including both physiologic measurements and laboratory data. Systems that analyze these data and report unexpected or abnormal conditions back to a clinician at or near the moment that these data are available are known as real-time alert systems. Real-time alert systems are found throughout healthcare and can be classified as simple or complex. Real-time alerts would be expected to be most useful in clinical situations where patient conditions are anticipated to change on a second-to-second or minute-to-minute basis. One of the first real-time alert systems described was a wireless PDA-based system triggered by a critical alert or by vital sign data using thresholds. Parameters were set such that approximately one alert per day was generated. Interestingly, and perhaps not unexpectedly, the PDA user was almost always the first clinician to become aware of the abnormality. This observation demonstrates both the effectiveness of an impetus for the further development of this technology. Today's best medical devices for measuring blood flow require patients to first show up at a clinic or hospital, then stay very still during the imaging procedure. But an experimental sensor that clings to the skin like a temporary tattoo could enable 24-hour monitoring of blood flow wherever a patient goes.

Related Works

A. Manual blood culture systems

Conventional manual systems and media are available from many commercial sources. Aerobic blood culture bottles and anaerobic blood culture bottles are inoculated with blood and usually incubated for 7 days. Each bottle is examined daily for macroscopic evidence of microbial growth (e.g., hemolysis, turbidity of the media, gas production, or formation of discrete colonies). An aliquot of the contents of the aerobic bottle is gram stained and sub cultured after the first overnight incubation. A terminal subculture is usually done at the end of the incubation period. Conventional manual systems are flexible and require no purchase of expensive instruments, but they are labor intensive.

B. PCS Method

Fast and accurate detection of pathogens from patients with BSI can be limited by a technology's ability to detect low levels of microorganisms. NanoMR has developed a PCS as a clinical sample concentrator method to boost the sensitivity of molecular identification and resistance testing for whole blood specimens enabling detection of BSI in 3.5 hours. Since positivity rates of blood cultures (BC) are relatively low (<10%), blood collection from patients with known BSI is targeted and evaluated the performance of PCS and downstream molecular testing with BC. A total of 34 patients were tested by PCS and species-specific PCR. Classification was determined by a standardized algorithm. Overall concordance with BC was 94%, including 2 indeterminate calls (table). The possibility of either case being the result of contamination during blood draw could not be discounted, yielding an indeterminate designation.

C. BACTEC Method

BACTEC blood culture system (Becton Dickinson Diagnostic Instrument Systems) is compared with conventional culture methods for recovery and time to detection of significant isolates from normally sterile body fluids. A total of 412 specimens were included in the study. Half of the specimens were inoculated directly into the automated blood culture system. The remaining specimens were centrifuged at 3000 rpm for 10 min and were inoculated onto conventional media. Clinically significant microorganisms were isolated from 41 specimens (10%) by both culture systems; however, for 62 specimens (14.9%), growth was detected only with the BACTEC system. No isolates were detected with only conventional culture methods. A significant difference was noted between the blood culture system and routine culture methods for recovery of pathogenic microorganisms that were from sterile body fluids.

D. Continuous-monitoring blood culture systems

With changes in health care financing, including the recognition that labor costs need to be better controlled, manufacturers are increasingly looking to the use of automation in clinical microbiology. The early-generation BACTEC instruments had the following disadvantages: culture bottles had to be manually manipulated, gas canisters were needed for every instrument; detection needles had to be changed periodically; sterilization of the needle devices occasionally failed, resulting in a false diagnosis of bacteremia, cultures were sometimes instrument false-positive; and bottle throughput was relatively slow (35-60 seconds per bottle). Continuous-monitoring blood culture systems were developed in an effort to address these problems. All comparative studies to date have shown that the continuous-monitoring blood culture systems have detected growth sooner than earlier-generation BACTEC instruments and manual systems. These systems have been found to be comparable in terms of performance.

II. SYSTEM DESCRIPTION

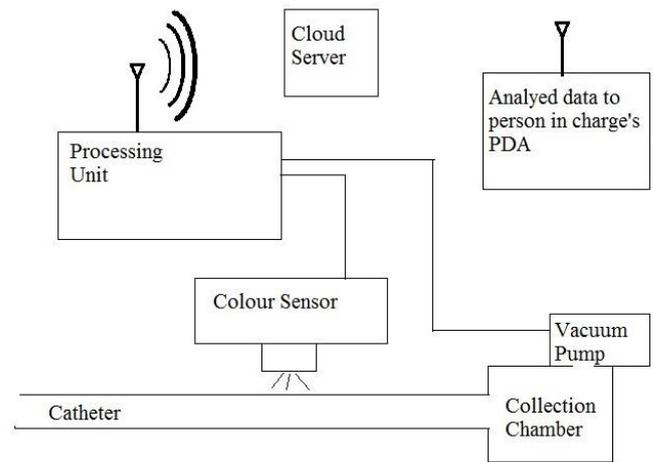
A. PRINCIPLE

The propose a robust method for controlling the flow of blood onset of automated detection. The method, which can be the basis of automated analysis technology with references from NPWT is likely to be used in various fields such as medical diagnosis and so on. NPWT is a widely used non-invasive wound therapy method. Negative pressure wound therapy has been extensively applied to accelerate wound healing in chronic, acute and complex wounds. The technique includes negative pressure and an airtight wound, and the suction force created by the NPWT equipment that helps to drain excess fluid, leading to the alleviation of wound edema and bacterial count reduction, thus promoting granulation tissue formation, as well as affecting blood flow perfusion in the wound.

The diagram above explains the working of the suggested system. The catheter is the tube through which the infected blood flows which is continually monitored with use of a color sensor and the data gained is sent to processing unit which distinguish between pure blood and impure blood, the analyzed date i.e., continuous result whether its pure blood or not decides the further working of the vacuum pump which creates the negative pressure to remove the infected blood. Along with this this data is sent to cloud which is then sent to the PDA of the person in charge of observation. If some undefined activity is observed the authority is alerted. All the data about the flow is stored in cloud which can any time be taken.

Presently no automated NPWT is used and continuous observation of the NPWT manually is not an efficient process. The proposed method is relevant in the fact that the risks of manually observing this is fairly high. The proposed system not only does observe the blood stream but also stops the suction pump when the pure blood starts to flow along with alerting the person in charge and also logging the data about blood flow in cloud and the PDA of the observer. Remote login is also possible generating the scope for observation from anywhere.

B. BLOCK DIAGRAM



Component Description

1. Arduino Mega

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560 (datasheet). It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, 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. The Mega is compatible with most shields designed for the Arduino Duemilanove or Diecimila.

1.1 Power

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

- VIN. The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). Supply voltage can be given through this pin, or, if supplying voltage via the power jack, access it through this pin.
- 5V. The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.
- 3V3. A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- GND. Ground pins.

1.2 Memory

The ATmega2560 has 256 KB of flash memory for storing code (of which 8 KB is used for the bootloader), 8 KB of SRAM and 4 KB of EEPROM (which can be read and written with the EEPROM library).

Input and Output

Each of the 54 digital pins on the Mega can be used as an input or output, using pinMode(), digitalWrite() and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

- Serial: 0 (RX) and 1 (TX); Serial 1: 19 (RX) and 18 (TX); Serial 2: 17 (RX) and 16 (TX); Serial 3: 15 (RX) and 14 (TX). Used to receive (RX) and transmit (TX) TTL serial data. Pins 0 and 1 are also connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.

- External Interrupts: 2 (interrupt 0), 3 (interrupt 1), 18 (interrupt 5), 19 (interrupt 4), 20 (interrupt 3), and 21 (interrupt 2). These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.

- PWM: 0 to 13. Provide 8-bit PWM output with the analogWrite() function.

- SPI: 50 (MISO), 51 (MOSI), 52 (SCK), 53 (SS). These pins support SPI communication using the SPI library. The SPI pins are also broken out on the ICSP header, which is physically compatible with the Uno, Duemilanove and Diecimila.

- LED: 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

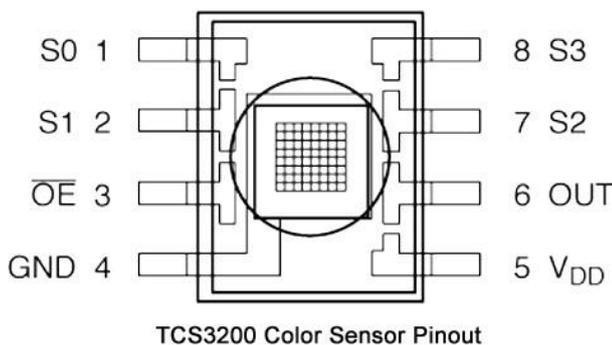
- I2C: 20 (SDA) and 21 (SCL). Support I2C (TWI) communication using the Wire library (documentation on the Wiring website). Note that these pins are not in the same location as the I2C pins on the Duemilanove or Diecimila. The Mega2560 has 16 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values).

By default they measure from ground to 5 volts, though it is possible to change the upper end of their range using the AREF pin and analogReference() function. There are a couple of other pins on the board:

- AREF. Reference voltage for the analog inputs. Used with analogReference().

- Reset. Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

2. TCS3200 Color Sensor Module



This Arduino compatible TCS3200 color sensor module consist of a TAOS TCS3200 RGB sensor chip and 4 white LEDs. The main part of the module is the TCS3200 chip which is a Color Light-to-Frequency Converter. The white LEDs are used for providing proper lighting for the sensor to detect the object color correctly. This chip can sense a wide variety of colors and it gives the output in the form of corresponding frequency. The TCS3200 chip consist of an 8 x 8 array of photodiodes. Each photodiode have either a red, green, or blue filter, or no filter. The filters of each color are distributed evenly throughout the array to

eliminate location bias among the colors. Internal circuits includes an oscillator which produces a square-wave output whose frequency is proportional to the intensity of the chosen color.

Specification and Features

- i. Input voltage: (2.7V to 5.5V)
- ii. Interface: Digital TTL
- iii. High-resolution conversion of light intensity to frequency
- iv. Programmable colour and full-scale output frequency
- v. No need of ADC (can be directly connected to the digital pins of the microcontroller).
- vi. Power down feature
- vii. Working temperature: -40oC to 85oC
- viii. Size: 28.4x28.4mm(1.12x1.12")

To determine the color of an object, it is needed to measure the frequency from 6th pin when each filter is activated. Set both S2 and S3 to LOW, measure the frequency. Now we get the intensity of RED component in the object. Set S2 to LOW and S3 to HIGH in order to get the intensity of BLUE component in the object. Set both S2 and S3 to HIGH and get the intensity of GREEN component in the object. Compare the frequencies of the three components to get the actual color of the object.

```
e.g.:
digitalWrite(S2, LOW);
digitalWrite(S3, LOW); //Activating photodiode with red filter
red = pulseIn(outpin, LOW);
```

This is to get the value corresponding to the red color component of the object color.

RESULT

Fig.1 shows the observed output while executing the calibration program. As the sensor is pointed to the calibration colour the following output is obtained. This include the RGB values of the colour shown to the sensor.

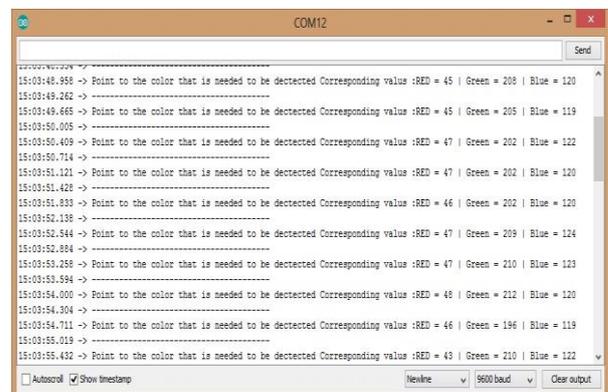
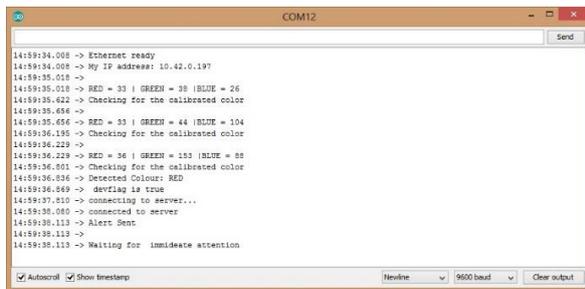


Fig.1 Output of calibration program

By the calibration of the sensor, red color is monitored and corresponding value is taken down.

Fig.2 depicts the output from the main program. The RGB values obtained from the calibration program is taken as

parameters for the main program which detects the color and sent an alert to the PDA of the user as shown in Fig.3



```

COM12
14:59:34.008 -> Ethernet ready
14:59:34.008 -> My IP address: 10.42.0.197
14:59:35.018 ->
14:59:35.018 -> RED = 33 | GREEN = 38 | BLUE = 26
14:59:35.622 -> Checking for the calibrated color
14:59:35.656 ->
14:59:35.656 -> RED = 33 | GREEN = 44 | BLUE = 104
14:59:36.195 -> Checking for the calibrated color
14:59:36.229 ->
14:59:36.229 -> RED = 36 | GREEN = 153 | BLUE = 88
14:59:36.801 -> Checking for the calibrated color
14:59:36.836 -> Detected colour: RED
14:59:36.869 -> setting as true
14:59:37.810 -> connecting to server...
14:59:38.080 -> connected to server
14:59:38.113 -> Alert: Stop
14:59:38.113 ->
14:59:38.113 -> Waiting for immediate attention
Autoscroll Show keystroke
Newline 9600 baud Clear output

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Fig.2 Output of main program which detect flow of blood

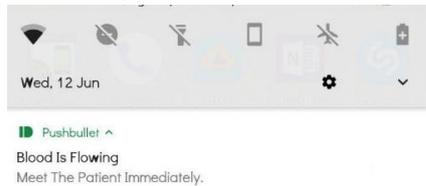


Fig.3 PDA notifying the blood flow

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