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Heart rate measurement and electrical pulse signal analysis for subjects span of 20–80 years

Q1 Neramitr Chirakanphaisarn [a], Thadsanee Thongkanluang [b], Yuwathida Chiwpreechar [c]

[a] *Faculty of Science and Technology, Huachiew Chalermprakiet University, Km. 18/18, Bangna-Trad Rd. Bangchalong, Bangplee, Samutprakarn 10540, Thailand*

[b] *Program in Materials Technology and Manufacturing, Faculty of Science and Technology, Suratthani Rajabhat University, Suratthani 84100, Thailand*

[c] *Faculty of Science and Technology, Huachiew Chalermprakiet University Km. 18/18, Bangna-Trad Rd. Bangchalong, Bangplee, Samutprakarn 10540, Thailand*

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Abstract

The preliminary research constructs the heart beat or pulse measurement for medical science. The electrical pulse signal analysis that supports one significant clinical study. The research prototype focuses the pulse rate and analysis system which consist of hardware and software parts. The hardware uses the ATMEGA 2560 ADK R3 for processing the input optical sensors, output result to LCD, and record data into SD memory card. The software as embedded algorithm is designed for controlling the input/output parts. Research techniques are applied in term of analog to digital converter, I2C, and data grouping.

The 40 subjects are informed consent and measured with ethical research. Experimental result explains the subject behaviors with maximum/minimum pulse values, patterns, and similarity three groups. The distinctive point of medical and health science prototype is accuracy, durability, low power consumption, and cheaper price.

Keywords: Heart beat; Electrical pulse analysis; ADK R3 micro-controller; Optical sensor

1. Introduction

This research is a fundamental principle of the tools and programs to contribute to the development of health science. The initial focus on the pulse, which is one of the four vital signs (Puongthong Kraipiboon, 2014) with a significant indicator of the performance of the heart. Pulse caused by the compression of the heart (Lalita Achanuphab, 2014) to send blood around the body, causing pressure on the walls of the arteries as a result, blood vessel contraction and

E-mail addresses: Mit9bkk@gmail.com (N. Chirakanphaisarn), Thad2007@gmail.com (T. Thongkanluang), Yuwathida@hotmail.com (Y. Chiwpreechar).

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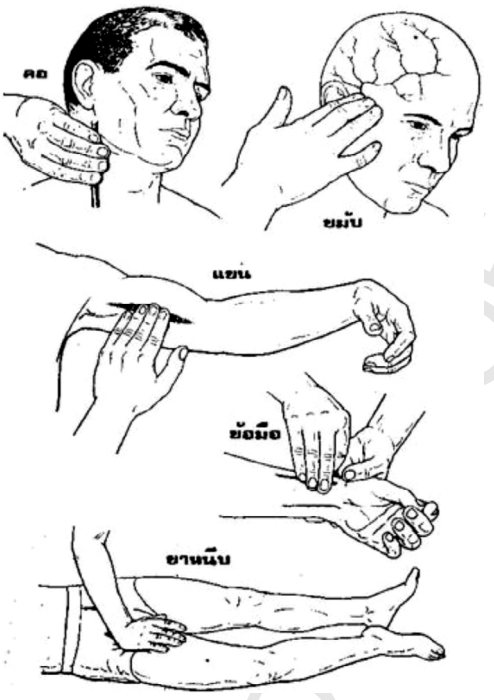

Fig. 1. Body pulse position (Lalita Achanuphab, 2014).

expansion of the cardiac rhythm. We can feel exactly where the artery running through or easy to understand. Pulse is the rhythm of the heart. Fig. 1 shows the location of a palpable pulse, the body will find that often are at the bone joints such as knees, wrists, arms, groin, head and neck. Pulse (Wannachart Kataichan, 2014) can be explained other words, the shock waves of blood flow caused by the compression of the left ventricular wall of the artery is expanded into a rhythm. The Pulse rate, heart rate or heart beat (Puongthong Kraipiboon, 2014) is called to convey the same meaning and reflect the pacing of the heart (beats per minute), by counting the beats of the artery within 1 min. We can take the pulse while measuring heart rate anytime factors influencing the pulse (Wannachart Kataichan, 2014), there are many factors which are important to the cardiovascular system and the issues which led to the creation of measurement parameters. The key questions such as age, the age of increased pulse rate will drop, sex after puberty, the average pulse rates of male to female is slightly lower. Exercise, the pulse rate increases with exercise, fever, increased pulse rate. To adjust to lower blood pressure, reduce the dose of certain medications, such as pulse, heart disease.

Q2 Fig. 2 shows a system of the heart and the pulse generator [12] described below.

1 Atrium begins to depolarize.
2 Atrium depolarizes.
3 Ventricles begin to depolarize at apex.
4 Ventricles depolarize.
5 Ventricles begin to re polarize at apex.
6 Ventricles re polarize.

2. Background

To explore the issue, and the importance of the issue of the rate of heartbeat is normal or abnormal, and it is an important issue that needs to be researched. The heart rate measurement error may lead to subsequent damage. This research is creating a measurement system to values that are more accurate, the rate of heartbeat or pulse, the number Q3 of times the feeling of the waves on the arteries of an inch at a time, 1 min (bpm: beat. per minute) (Table 1).

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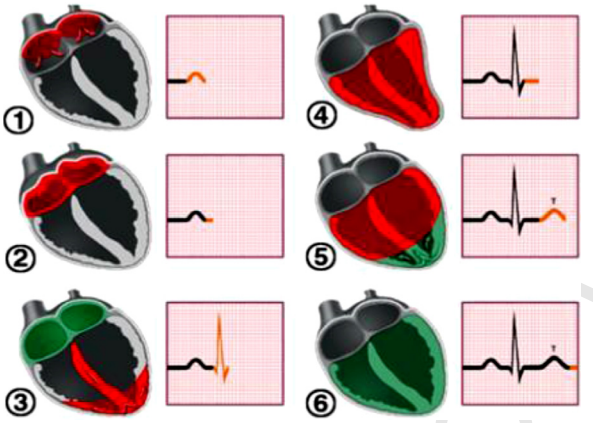

Fig. 2. Heart behavior and part of the generated signal (Wannachart Kataichan, 2014).

Table 1
Pulse rate by age span.

Age span	Heart rate (bpm)
Less than 1 month	120–160
1–12 months	80–140
12 months – 2 years	80–130
2–6 years	75–120
6–12 years	75–110
More than 12 years	60–100

Abnormal pulse rate environment (Lalita Achanuphab, 2014) by Tachycardia: a condition in which the heart rate in adults than 100 bpm, Bradycardia: a condition in which the heart rate in adults less than 60 bpm. The information shown is the importance of the issue, the researchers make weight and focus on creating a quality and precision in order to show or tell the heart rate is normal or abnormal. The importance of the research may be divided by topic below.

- Reading the rate of the heartbeat, irregular pulse, causing a crash and damage.
- Commercial tool can measure your heart rate, but without analysis.
- Acquisition of the pulse and could not be estimated.
- Measurement of heart rate is generally expensive.

3. Literature review

The research involved a literature review or research presenting data in a consistent theoretical basis for the analysis, design, research results, and comparisons. To obtain a summary of each report. Therefore, the acquisition of new knowledge to new research, it may be relevant to the further development oriented research for them. The research has a positive impact on research development, which we have divided the important topics such as pulse, pulse rate measurements, and supports research, experimentation, analysis and comparison, to develop further.

Pulse; (Wannachart Kataichan, 2014) caused by the compression of the heart (Lalita Achanuphab, 2014) to send blood around the body, including the classification of age, pulse rate (Puongthong Kraipiboon, 2014). The research system to measure the pulse (Hashem et al., 2010) the development of a device for measuring the heart rate measured at the end of a finger and a light sensor to monitor the circulation of the blood and into the processing system. To display the rates measured techniques such as (Yang et al., 2014) fiber optic sensor development for detection of textile heartbeat and breathing by detecting the optical fiber sandwiched between parallel plates can be bent a little. Microfiber design, textile sensor, the interesting part about measuring your heart rate (Carrara et al., 2014) is the classification of the rhythm of the heart from signs electrocardiogram (EKG). In general, the value may not be covered because the results of the measurement are multiple. Interesting issues and the measurement system (Li, 2010) The proposed

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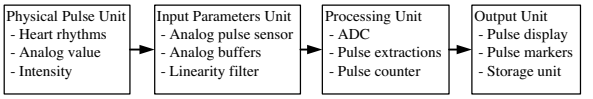

Fig. 3. Principle research methodology.

research protocols MAC: multiple access based on the design BSN: body sensor network is labeled H-MAC. This can help improve the efficiency of the energy used in the body sensor, which is a technique that helps reduce energy consumption and increase the efficiency of the overall system. The important issues of the measurement system (Obeid et al., 2010) will help detect heart rate with touch-less and modeling pulse which such research is a case study that can be applied in the research that needs optimization. Another sensor technology systems that (Ho et al., 2010) explains how the heart and respiratory rate monitoring system using an air pressure sensor and ultrasonic.

Result analysis, conclusion, comparison; Experiments and analysis (Hashem et al., 2010) was a pulse for one person tested 90 people who had concluded that the measure was consistent with the commercial tools (HRM devices with Electrocardiogram. report) and pulse rate measurements using pulse techniques, instrumentation, measurement systems etc. Position and posture measurements (Yang et al., 2014) can be used to measure cardiac and respiratory rate simultaneously during standing and sitting and measured continuously and have relation and comparison with commercial systems (Carrara et al., 2014). Dynamic measurements using the techniques identified by the RR base which can output normal rhythm (NSR: Normal sinus rhythm) with an accuracy of 99% and atrial. Fibrillation (AF) is accurate 77% within 10 min, which was created in the University of Virginia (UVA) on Holter database. Another interesting technique that systems (Li, 2010) result of the rhythmic pulse signal synchronized with each other. Development of biosensor in BSN can beat heart disease by detecting the highest point of the electrical signals for each system energy efficiency which research has used simulation on OMNet++ simulator. The results show the value of heart rate on H-MAC good stability in the analysis (Obeid et al., 2010). Analysis VNA: Vector network of microwave systems are tested to check for signs of heart at 1 m proposed system demonstrated its ability to detect signs of heart is possible to adjust the frequency and transmit power. The frequencies of 2.4, 5.8, 10, 16, and 60 GHz. Levels were between 0 and −27 dBm signal level meter supports respiration and heart rate and heart rate variability occurred. The output of the model using wavelet techniques and classic filter to find the SNR: signal to noise ratio between 0 and −20 dB.

4. Research methodology

This methodology explains the practical solutions which compose as follows:
Principle research methodology; To explain as follows

- Physical pulse
- Input parameters
- Central processing units
- Output parameters
- Storage units

Fig. 3 shows how the research study describes the first research, First step; Physical pulse is defined pulse (Lalita Achanuphab, 2014) that represents the heartbeat rhythm is defined as the number of beats per minute. Second step; Input derived parameters are parameters which are then used to make physical linearity filter by buffer circuit to forward it to the central processing unit. Third step; Central processing unit serves as calculation algorithm to analyze the results transmitted to the output. Fourth step; Output parameters such as the amount of pulse rate, dynamic number of pulse signal, and stored into memory.

Process research methodology; Fig. 4 shows the algorithm consisted of hardware and software. The hardware used to control the input and output, which will receive an analog signal by using the voltage level that changes according to the light intensity. Buffer circuit is used to adjust the input signal level to be appropriate after a filtering signal from noise occurs. The balance of the control hardware we use electronic mechanisms to reduce the noise to the input that has the slightest mistake. The software uses algorithms to Al Gore, the control features such as adaptive pulse rate, calculated by the method of decision-making and information flow processes. The software receives the digital signal

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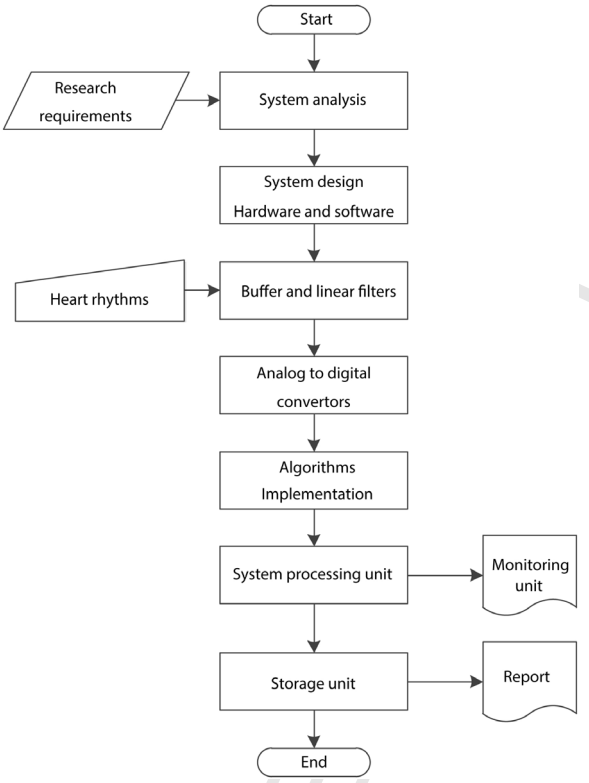

Fig. 4. Process research methodology.

in order to meet the conditions and logical interfaces such as I2C, SPI, USB. The storage unit is used for recording data in real time. The gait data will show in term of continuous signal as gait pattern.

5. Design and implementation

System design; the system consists (Fig. 5) of four sections: an overview. The first unit, input sensor value is the pulse rate by detecting the intensity of the light and into the calculation and processing. The second unit calculation and processing serve as a hub to receive and send information, including the calculation of the software.

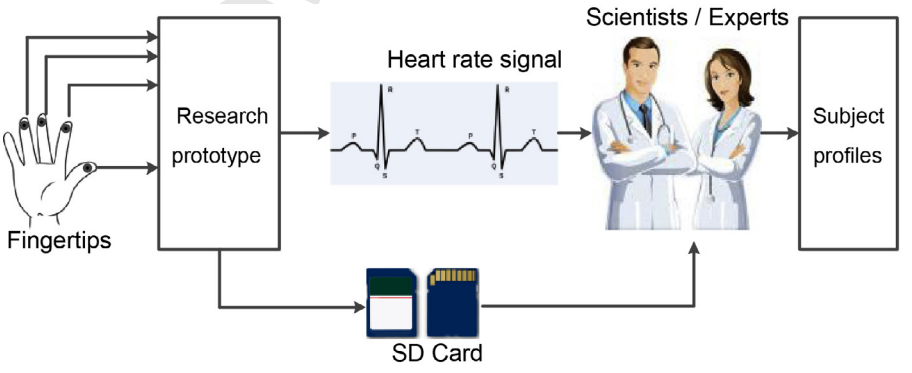

Fig. 5. System architecture.

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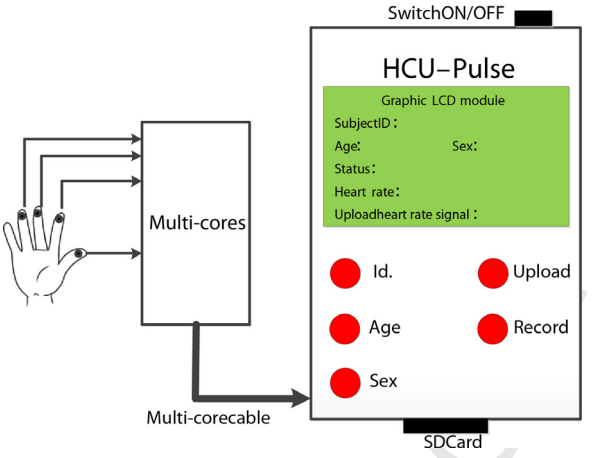

Fig. 6. Research prototype.

The third unit, display unit is used to represent data obtained from measurement through LCD display. The fourth unit, analysis is analyzing or classification of information to group the symptoms of subjects. The fifth unit, storage unit stores the information into the SD card to store data records of subjects (Fig. 6).

Algorithm implementation; the system implementation in term of software control consists of functions such as pin_Mode, lcd.begin, analog_Value, and interrupt_Setup, etc. This preliminary study composes optical sensor input and then process unit for calculation and monitor to display unit. The algorithm shown in below:

```
# Algorithm design and implementation
//Include preprocessor
//Variables of Pulse sensor
//The interrupt service routine
     data type ;            //initialization the variable
// Programming procedure
void setup() {

  File dataFile = SD.open("neramitr.csv", FILE_WRITE);
                                  //  open head file of SD card
  {
   pinMode(data_type, INPUT);     //define PIN status
   pinMode(data_type, OUTPUT);    //define PIN status
   Serial.begin(bit rate);          //define data bit rate
   lcd.begin(x,y);                  //define display unit
                                 //Subject_ID, SEX, AGE calibration
       analogValue = analogRead(data type);
    clear();                                  // clear temporary
    interruptSetup();                  // sets up to read Pulse Sensor
   }
   dataFile.close();                  // close file of SD card
}

void loop() {
  analogValue = analogRead(data type);
                                          //ID,SEX,AGE set calibration
  reading=digitalRead(IN_PIN);          //read from Digital PIN
  sendDataToProcessing('S', Signal);
                                 //send Processing the raw Pulse Sensor data
  }
```

The practical prototype; ankle motion measurement is constructed with hardware design and software algorithms. The prototype is implemented via various interfaces such as SPI, I2C, and bus system. Practical prototype can be used measured the heartbeat, pulse, and recording into SD card. The master prototype as shown in Fig. 7.

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Fig. 7. Practical prototype.

6. Experimental results and analysis

The ethical research in term of experiment is benefit for right process. This research is supported with ethical research. The results are displayed with research prototype as shown in Fig. 1 for evaluation in term of pulse signals or patterns. The pulse sensor gives good result when wire connection occurs low noise signal. The 40 subjects given the different patterns however, we can data analysis of heartbeat value (BPM) and maximum or minimum value of

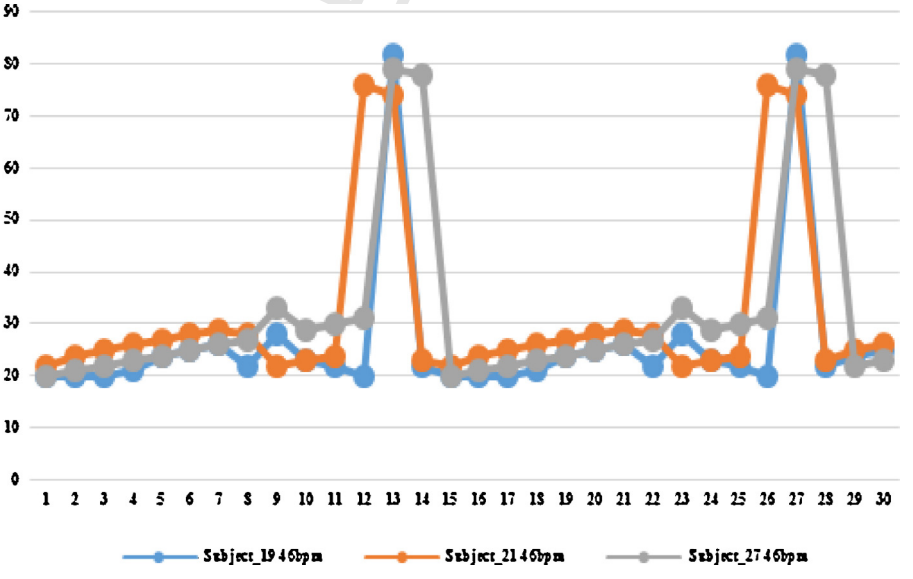

Fig. 8. shows pulse rate as the first group.

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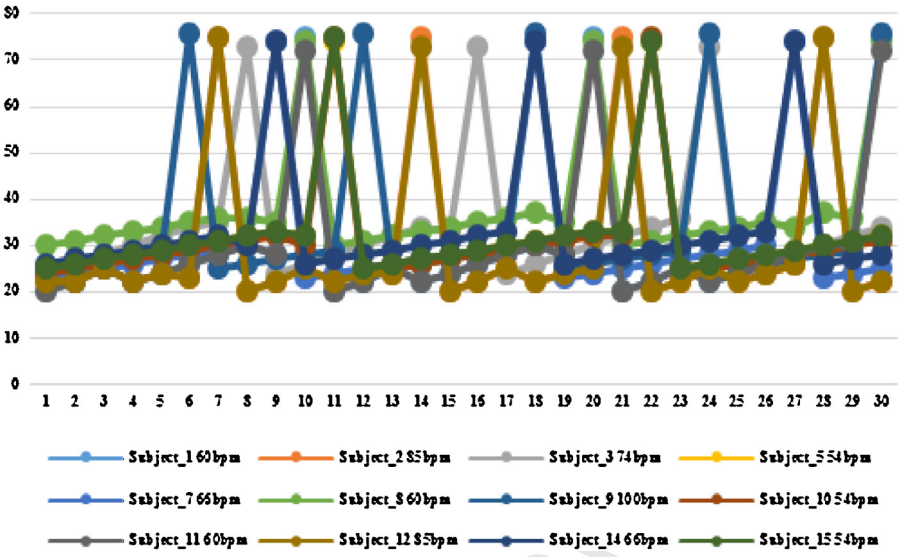

Fig. 9. shows pulse rate as the second group.

the electrical signal level. We choose eighteen subjects for testing with similar environment. Otherwise, the different environments still unstable for measuring parameter. Alter experimental result, we can classify the data signal as 3 groups.

The first group (Fig. 8) which shown in term of heartbeat (BPM unit) is ($0 < \text{BPM} < 50$) by Y axis represents the voltage (mV) and X axis represents time ($\times 10^{-1}$ s). The average voltage level is 75 mV. Three subjects are tested under similar environment. The subject results are irregular pattern because they are elderly subjects.

The second group (Fig. 9) that shown in term of heartbeat (BPM unit) is ($50 \leq \text{BPM} \leq 100$) by Y axis represents the voltage (mV) and X axis represents time ($\times 10^{-1}$ s). The average voltage level is 70 mV. Twelve subjects are experimented under similar environment. The subject results are regular pattern because they are normal subjects.

The third group (Fig. 10) which shown in term of heartbeat (BPM unit) is ($110 \leq \text{BPM} \leq 130$) by Y axis represents the voltage (mV) and X axis represents time ($\times 10^{-1}$ s). The average voltage level is 60 mV. Three subjects are tested under similar environment. The subject results are irregular pattern because they are sporting subjects.

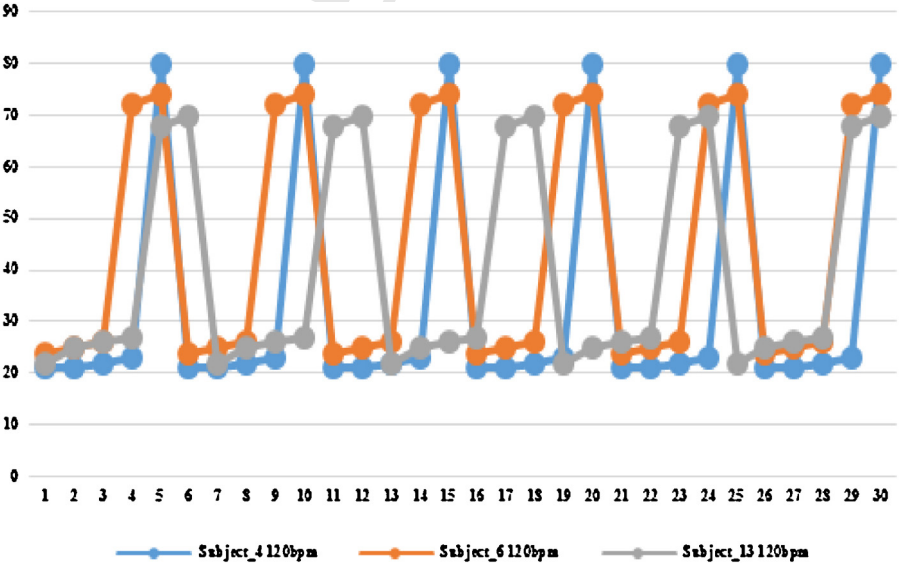

Fig. 10. shows pulse rate as the third group.

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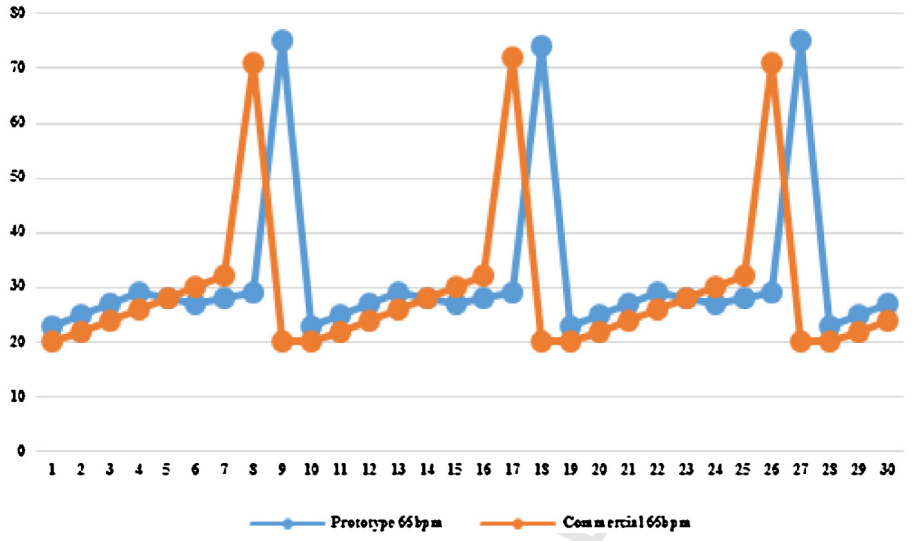

Fig. 11. shows the comparison of prototype and commercial

The experimental result can be shown of patterns. The comparison (Fig. 11) between our research prototype and commercial product by Y axis represents the voltage (mV) and X axis represents time ($\times 10^{-1}$ s). The tools are measured under same environment. The average values of heartbeat (BPM) are correlated value. The average of voltage (mV) difference of about 1.5 mV via practical comparison.

7. Conclusion

This research is to construct the heartbeat measurement, which used embedded system and pulse sensor techniques as shown in Fig. 5 system architecture. This preliminary study will be composed the system design, analysis, testing, implementation, and performance evaluation. The research illustrates the efficiency, accuracy, quantity of subjects, and good results. This prototype is accuracy 95% by comparison between our prototype and commercial. The master prototype can be developed the commercial product.

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