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Design of Radial Pulse Detector

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Abstract - *Ayurvedic and other ancient alternative medical sciences viz. Chinese, Korean, Yunani etc. practitioners throughout world have been using pulse diagnosis to diagnose the disease and the organ at by feeling the palpations at their close yet precise positions of the radial artery. In this paper, there is consideration of some technical and clinical issues to achieve the development of a pulse diagnostic device according to various fields of study: literature studies, sensors, amplifiers, systems, physical quantity studies, and make estimated design of system. This device should be appropriate both technically and in terms of Indian Ayurvedic medicine. The purpose of this project is to help medical practitioner to diagnose different diseases in accordance with changes in various parameters of pulse signal of radial artery. These parameters are calculated by using different sensors. We have pointed out some problems occurred in previous methods of pulse diagnosis and have tried to overcome them. And we have proposed a new method for radial pulse diagnosis.*

Key Words: **Radial artery, Pulse diagnosis, Pressure Sensors,**

1. INTRODUCTION

From the past decades, pulse diagnosis was done from the three precise locations on the wrist at the radial artery, like vata, pitta, and kapha. This science was very important in the Traditional Ayurveda & Chinese. The signals obtained from these locations are not only due to the contraction and relaxation of blood vessel but also a result of movement of blood through the artery and change in their diameter. [1]

1.1 What is Pulse Examination?

Pulse Examination is an ancient ayurvedic technique of diagnosis through the pulse. It can accurately diagnose physical, mental and emotional imbalances as well as diseases. The pulse, when examined, reveals both physical & mental characteristics of the patient.

1.2 History of Radial Pulse Diagnosis:

The science of Ayurveda is depends on three pulse signals, which are vata, pitta and kapha. In Traditional Chinese Medicine these radial artery named as cun, guan and chi respectively. But the basic for these systems are same. The Pulse experts using their better experience and skill feel this signal by means of diagnosis of disease. [1]

The different waveforms obtained from vata, pitta and kapha pulses have shape as that of movement of cobra, frog and swan respectively as shown in fig. 1[1] below.

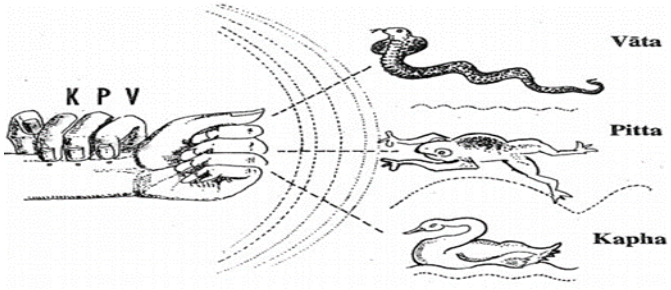


Fig. 1 Shapes of waveform of vata, pitta and kapha pulses [1]

These pulses are felt at specific position on the wrist of the patient: vata on index finger, pitta on middle finger and kapha on the ring finger. The Pulse experts feel them by placing their hand in a specific orientation on the patient's wrist, as shown in Fig. 2 [1]

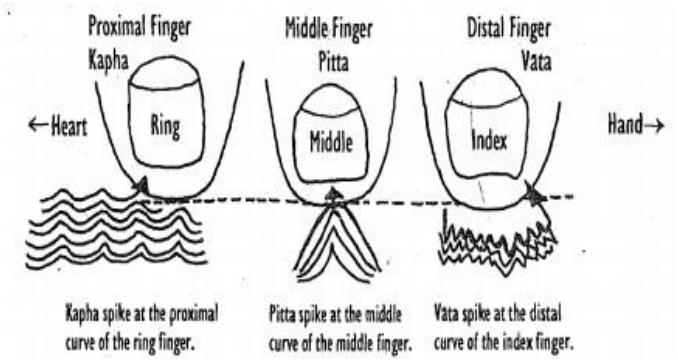
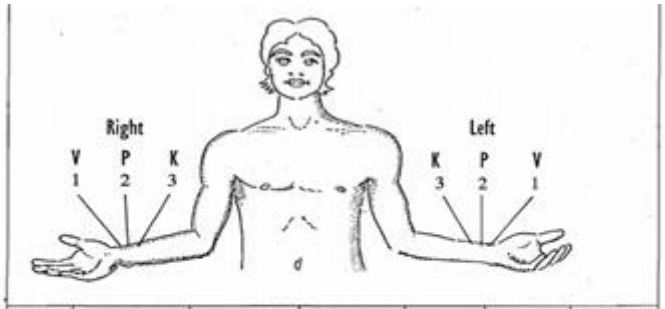


Fig. 2 Location of fingers on wrist to feel vata, pitta and kapha pulses [1]

Also, the analysis of hollow organs and semi-solid organs is done by feeling the nature of pulse at the deep and superficial layers of the wrist radial artery by applying external pressure. The location of organ pulses on both hand is as shown in Fig. 3[1]



1	2	3	3	2	1	Pulse
Colon	Gallbladder	Pericardium	Bladder	Stomach	Small Intestine	1st Level
Lung	Liver	*Vāta, Pitta, Kapha* Circulation	Kidney	Spleen	Heart	7th Level

Fig. 3 Location of organ pulses [1]

1.3 Development in Analysis Technology:

For this old technique of radial pulse analysis there is a requirement of years of experience and knowledge and can vary from person to person. Thus the recent trend follows to replicate this system in terms of a device which will be smart enough to diagnose disease by capturing the signals from wrist using various types of sensors like pressure sensors, temperature sensors etc. [1]

2. OBJECTIVES

The problem statement indicates the need of development of pulse analysis technique to diagnose the disease. In ancient technology of radial pulse diagnosis i.e. Palpation method requires good yogic powers like mind concentration and many years of experience in pulse diagnosis. Also the pulse signal of radial artery varies person to person and makes the diagnosis of disease difficult. So the main aim of this project is to study about location of organ pulses, to select different types of sensors used to calculate different parameters of pulse signals by using ECU. The objectives of this project are as below:

1) To help the medical practitioners for diagnosing the various diseases accurately and precisely.
2) To reduce the time required for checking the pulse signal for diagnosis of disease.
3) To store the pulse variation data for diseases other than heart disease such as pitta, vatta, diabetics, asthma etc. for further treatment on it.

3. METHODOLOGY

1) Study of basics of radial pulse diagnosis.
2) Study of location of organ pulses.
3) Designing of model of ECU (Electronic Control Unit) to display different waveforms.
4) Selection of suitable sensors.
5) Designing and Analysis of sensors.
6) Selection of other components of ECU.
7) Construction of ECU.
8) Evaluation of expected results & Experimental results.

4. PULSE DIAGNOSIS

4.1 Characteristics of Pulse:

Rate: - Normal pulse rates at rest, in beats per minute (BPM).

Volume: - The degree of expansion displayed by artery during diastolic and systolic state is called volume.

Table-1: Characteristics of pulses [2]

newborn (from 0–3 months)	Infants (from 3–6 months)	Infants (from 6–12 months)	Children (from 1 – 10 years)	Children over age 10 years & adults, including seniors	well-trained adult athletes
100-150	90-120	80-120	70-130	60-100	40-60

Force: - It is the approximate measure of the systolic pressure.

(Systolic Pressure: The top no. refers to amount of pressure in your arteries during contraction of your heart muscle. = 60 mm of Hg to 220 mm of Hg

Diastolic Pressure: The bottom no. refers to your B.P. when your heart is between beats. = 30 mm of Hg to 120 mm of Hg)

Rhythm: - A normal pulse is regular in rhythm and force. It indicates whether the beats are equidistant or not. Two types of rhythms are

1. Regularly irregular
2. Irregularly irregular

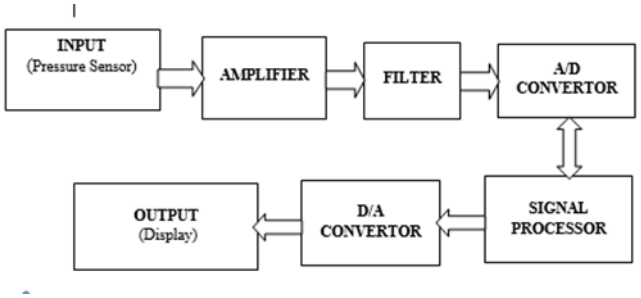
4.2 Effect of Various Diseases on Pulse:

Pulse plays an important role in the diagnosis of the disease. Pulse alters in every disease and at different stages of the same disease. In all the medical sciences lot many description is found on this topic. Few examples are:-

Table-2: Effect of Various diseases on Pulse [2]

Malaria	Slow pulse.
Sunstroke	Rapid full pulse
Perforated Peptic ulcers	Strong pulse increasing steadily
Hepatic disease	Rapid pulse.
Goiter	Slow pulse.
Bronchial Asthma	Small, Rapid, Irregular and intermittent pulse.
Typhoid	Slow compared to other febrile conditions, infrequent, slow pulse during post febrile conditions

5. ESTIMATED DESIGN



5.1 Components of System:

1. Input:

Pressure Sensors are required for picking up the radial pulses from the wrist. The physical fundamentals of sensors determine the dimensions of measured signal and calculating the pulse rate.

2. Amplifier:

An amplifier takes a relatively small signal and increases its magnitude. For instance, the signal coming from pressure sensors does not have enough strength to give clear information of physical parameters of pulse and can't read by operator. But put an amplifier between input and output and the pulse waveform can be read.

3. Filter:

Electronic filters are circuits which perform signal processing functions, specifically to remove unwanted frequency components from the signal, to enhance wanted ones, or both.

4. A/D Converter:

In electronics, an analog-to-digital converter is a system that converts an analog signal, such as a pressure picked up by a pressure sensors into a digital signal. An ADC may also provide an isolated measurement such as an electronic device that converts an input analog signal to a digital number proportional to the magnitude of the signals.

5. Signal Processor:

Digital signal processing algorithms typically require a large number of mathematical operations to be performed quickly and repeatedly on a series of data samples. Signals are constantly converted from analog to digital, manipulated digitally, and then converted back to analog form.

6. D/A Converter:

In electronics, a digital-to-analog converter is a device that converts a digital signal into an analog signal.

7. Output:

A display device is an output device for presentation of information in visual form.

6. SELECTION OF SYSTEM COMPONENTS

6.1 Sensor Selection:

In this project we are presenting high sensitive sensor design for acquiring the three pulses from the radial artery along with a method of validating the sensor with a standard procedure. [9]

1. Three principal pulses are felt in the wrist region along the radial artery. The place for feeling the pulse is on the lateral aspect of the right forearm, 2cm up from wrist.
2. Based on the dominant pulse among the three and direction in which pulse motion is felt, we can identify our 350 different disease conditions.
3. Healthy human subjects have three pulse amplitudes in the ratio of 4:2:1 respectively.
4. However ratio is to follow seasonal variations and changes with parameters as time of day, temperature and humidity of the skin.
5. The right arm of male subjects and left arm of female is used to read the pulse.

By considering the above points there are different sensors present for pulse diagnosis. As many years ago infrared optical sensors have been used for cardiovascular pulse detection. But infrared sensors can't measure the pressure directly and also harmful to our body and expensive. Another one is Strain Gauge differential pressure sensor used in system where pressure cuff wrapped around the wrist and then pressure modulation in cuff caused by

pressure pulse was measured. But strain gauge pressure sensors are unable to provide lower range of pressure, also sensitive to environmental changes and contain long term drift [8].

Recently piezoelectric sensors used for measuring pulse pressure directly in which mechanical stimulus generated by pulse is converted into electrical signal. But in recent technology piezoelectric sensors are present with pressure sensitive material like Electro-Mechanical Film (EMFi) and Polyvinylidenefluoride (PVDF) for pulse detection in radial artery. The base material of EMFi is inexpensive which is applicable for large area sensors but piezoelectric sensors contain fluoride which is toxic substance therefore use of it is avoided in medical purpose. In PVDF material its sensitivity to force related to length and width i.e. area of membrane. This property of it creates many versatile applications for material.

From above discussion we observe that the piezoe

Electric sensor with PVDF membrane is suitable for our system hence we select it as input to our system

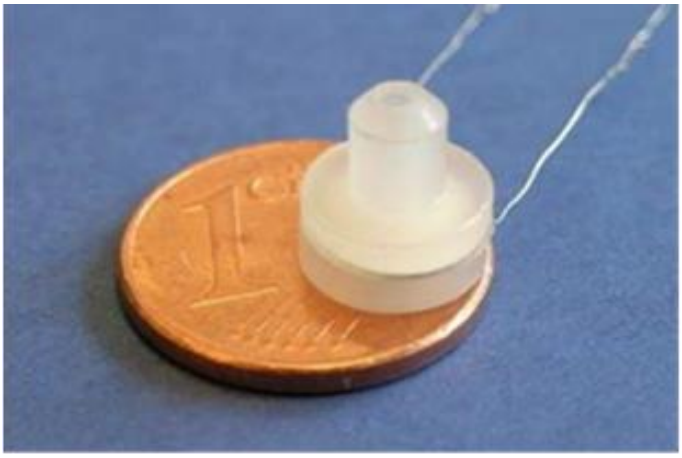


Fig. 3 Pressure sensor with a PVDF membrane.

6.2 Design of PVDF based Pulse Sensor:

In PVDF material its sensitivity to force related to length and width i.e. area of membrane. The length of membrane decided based on following:

- The mean diameter of right and left radial artery was 2.35 ± 0.49 mm and 2.29 ± 0.48 mm respectively and including sheath it will come up to 3mm-5mm.
- The length of PVDF membrane is depends on age, height to weight ratio of the person. And mean value of length is 25mm.
- The length should be less than the distance between two tendons between which artery passes. This changes person to person from 45mm to 55mm hence length restricted to 50mm.
- The breadth based on placing of sensor. Since sensor are placed at three points where we require the three pulses are at a distance of 12.5mm center to center hence breath should be up to 20mm.
- High-quality Invitrolon PVDF membrane with 0.45 µm thickness is particularly suited for high sensitivity and low background immunoblotting.

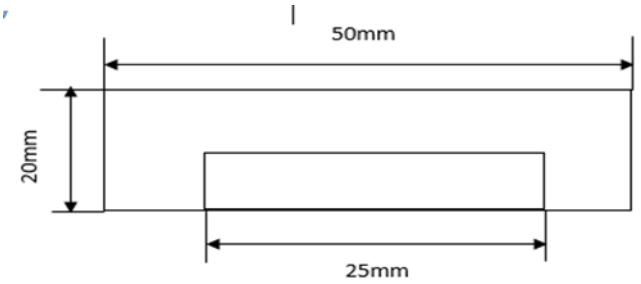


Fig. 4 Design of Pulse Sensor [9]

6.3 Sensitivity Analysis for the Sensor:

Sensor is considered as a simply supported beam as shown in fig. 5[9]

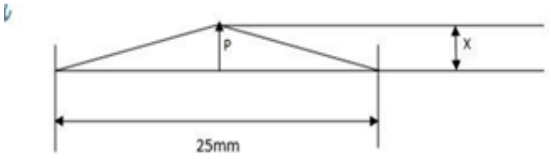


Fig. 5 Model of our sensor for sensitivity analysis [9]

Here P is load applied on PVDF at center which is pressure acting over the area of artery.

The piezoelectric element used for converting mechanical motion of pulse to electrical signals may be thought as charge generator. Mechanical deformation generates a charge and this charge appears as voltage to amplifier.

Voltage, E = Q/C Volt…… (i)

The magnitude and polarity of the induced surface charges are proportional to magnitude and direction of applied force, F. Polarity of induced charges depends on direction of applied force.

Charge, Q = d × F Coulomb…… (ii)

Where,

d = charge sensitivity of PVDF membrane C/N (Constant for given material)

$$d = g \times \varepsilon \quad \text{pC/N} \ldots\ldots\ldots \text{(a)}$$

d = -34pC/N for PVDF material

F = Applied force

F = p × aNewton ..... (b)

(p = Pressure applied by radial pulse in N/m^2, a = area of radial pulse = πr^2, m^2)
By taking the values of'd' and 'F' we get value of charge,

Q = -6.8 coulomb to -45.56 coulomb.

6.4 Pulse Measuring System:

Development of a signal conditioning unit to improve quality of signals such as amplification, filtering, common mode rejection is generated by PVDF sensor. This unit consists of amplifier, filter, A/D and D/A converter etc.

The components of system are selected for the above range of charge from standard parts available in market.

7. CONCLUSION AND FUTURE WORK

We have a lot of proven records in ancient literature that there is not a single disease in the human body which cannot be diagnosed by examining the pulse. However, ancient medical practitioners had to totally rely upon years of clinical experience in order to come to any conclusive diagnosis. Clinicians today have limited examination of the pulse to its rate, rhythm and volume by virtue of which they hardly come to a concrete diagnosis based upon pulse alone. If there could be a system by which the radial pulse could be critically examined just like the ancient Ayurveda practitioners and others, it could be one of the most useful tools in the field of non-invasive modern medical diagnosis of disease.

Thus there is need of development of system which has potential to objectively measure and display the changes occurring in the radial artery in accordance with ayurvedic principles without having to undergo subjective interpretations. The sensors used in such system are selected and design in this paper which help to select other component of ECU. Future research will concentrate on the development of system, vibration analysis of three pulses and diagnosis of disease like using improve version of equipment. And will hope that developing technique should help the medical practitioners to diagnose disease accurately and precisely.

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