Original Article

# LabVIEW based Non-Invasive prototype device for cardiac diagnosis using Nadi Shastra

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## Abstract

In a country like India where there is a huge population suffering from cardiovascular disorders, Atherosclerosis is one of the reasons leading to high chances of occurrence of cardiac related deaths. Hence there is a severe need for introduction of non invasive technology which can help in early diagnostics of Atherosclerosis. Hence the main aim of this research is to design a non invasive technique to detect Atherosclerosis using Nadi Shashtra. Nadi Shashtra is one of the ancient medical technologies, which was originated in India. It has been derived from Ayurveda. The instrument so designed to diagnose Atherosclerosis is based on two basic parameters i.e. Pulse Wave Velocity (PWV) and Cardio Ankle Vascular Index (CAVI). The basic workflow of this device would be non-invasive calculation of PWV and CAVI using software LabVIEW and then the values so obtained will be compared to the standard prescribed range and the chances of occurrence of Atherosclerosis would be displayed in LabVIEW. To get more accurate analysis the test is done twice, once on upper limb and once on lower limb and the mean values are considered for calculations.

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## INTRODUCTION

Ayurveda is one of the oldest forms of medical diagnosis and treatment which originated in India. The basic principle of diagnosis and treatment in it is Prakruti, and the method of diagnosis is known as Prakruti Nidana. For this, the technique used is called Nadi Parikshan. This is done on the basis of three doshas or Tridosha namely Vata, Pitta, and Kapha.[1] Nadi Parikshan is done to know about these parameters by Nadi Shashtra scholars. Nadi Parikshan involves checking the radial artery with three fingers as shown in Figure1.

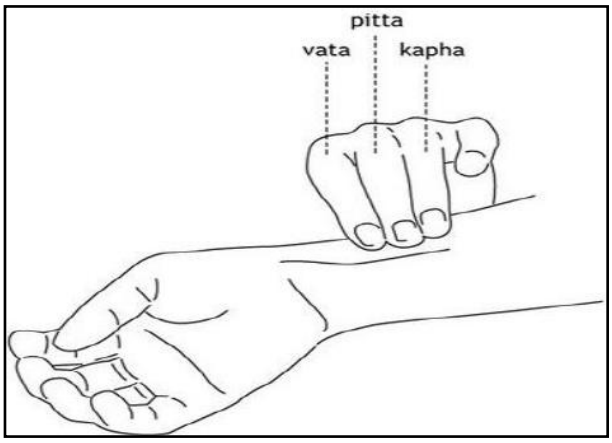


**Figure 1 : Nadi- Parikshan measurement method in Ayurveda [2]**

To design a non-invasive device to detect Arthrosclerosis the first task would involve the study of basic blood lipid profile and blood pressure. Further there needs to be an analysis of Pulse Pressure waveform to calculate Pulse Wave Velocity which can in turn help in calculating Cardio Ankle Vascular Index. Also a study of a wide range of Indian subject both suffering from Atherosclerosis and normal subjects is required to be performed to generalize the ranges to be used for calibration of prototype device so designed.

## PARAMETERS TO BE CONSIDERED

### Blood Lipid Profile:

Blood lipid profiling is used to detect the different levels of High Density Lipid (HDL), Low Density Lipid (LDL), triglycerides, cholesterol content whose increased concentrations are primary markers for Arthrosclerosis.[3,4]

### Blood Pressure:

Blood pressure is the pressure exerted by the blood on the arteries. Normal blood pressure 120/80mmHg.Changes in blood pressure can act as a first indicator of cardiac related disorders. [3,4]

### Pulse Wave Velocity (PWV):

Pulse Wave Velocity is one of the major parameters used to detect the extent of blockage in arteries. With the increase in deposition of cholesterol in the arteries PWV increases. [4,5]

The technique used to measure PWV includes measurement of distance between two places in between which the PWV is calculated and the Transit Time Delay involved in the pressure wave to reach the second point from first point. Formula for Pulse Wave Velocity is given as:

PWV = Distance/Transit Time Delay [6]

A study was done to calculate the range of pulse wave velocity in both normal and diseased patient. 150 subjects were tested. The graph shown in Figure 2 shows the analysis of PWV performed.

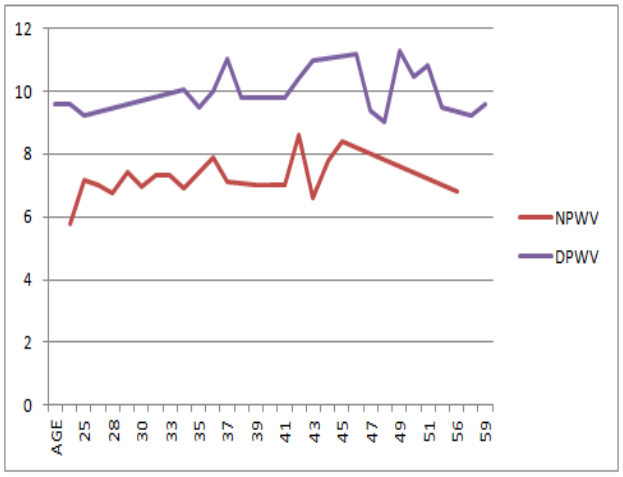


Figure2. Analysis of PWV study performed.

The above analysis shows the PWV of normal subjects in red colour and the diseased patients in blue colour. It was found that the range of normal PWV is around 6.0 to 9.0 m/s and for diseased patients it is in the range of 10.0 to 12.0 m/s or more.

### Cardio-Ankle Vascular Index (CAVI):

CAVI is the parameter used to measure the amount of stiffness of any artery. [4] CAVI basically depends on Pulse Wave Velocity and Blood Pressure vales. [7]

CAVI is calculated by formula given by Bramwell-Hill's equation: [8] and is derived from the stiffness parameter β first proposed by a group of scientist working under Hayashi in 1980. [9,10]

$$CAVI = \frac{2 \times \text{Blood Density}}{\text{Pulse Pressure}} \left[ \ln \frac{\text{Systolic Blood Pressure}}{\text{Diastolic Blood Pressure}} \right] \times \text{Pulse Wave Velocity}^2$$

Figure3. Formula for CAVI [8]

Where:
Pulse Pressure = Systolic Blood Pressure – Diastolic Blood Pressure.[4]
A study was done to calculate the range of CAVI in both normal and diseased patient. 150 subjects were tested and there data for all of the above parameters were recorded and analysed. Figure 4 shows the data analysis of CAVI of the data acquired from the subjects.

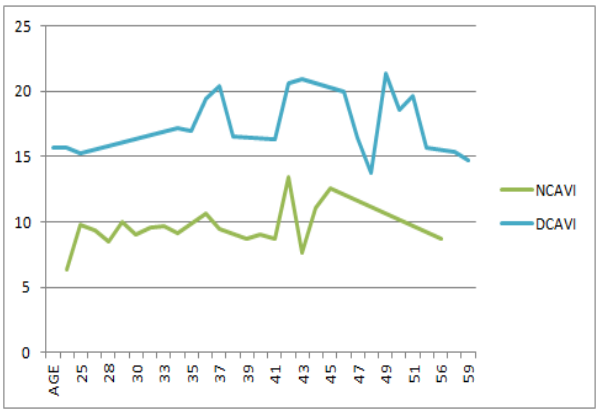


Figure 4. Analysis of CAVI study performed

The above analysis shows the CAVI of normal subjects in green colour and the diseased patients in blue colour. It was found that the range of normal CAVI is around 7-12 and for diseased patients it is in the range of 14-21. Hence it was decided in our studies to set 3 ranges for CAVI:

a. No Atherosclerosis- CAVI below 12.
b. Possible chances of Atherosclerosis- CAVI range between 12 to 14.
c. Atherosclerosis- CAVI above 14.

## LabVIEW PROGRAMMING LOGIC

LabVIEW is a graphical programming language by National Instruments. LabVIEW was selected to be used because of its real time application and for compatibility with the Data Acquisition Card of National Instruments. Electrocardiogram (ECG) and Pulse waveform signals are feed to the LabVIEW program which is used to calculate the PWV. The standard value as per International standards for distance between heart and radial pulse calculating site is used as 0.85m. Transit Time Delay is calculated by detecting the peak values of ECG waveform's R peak and the peaks from Pulse waveform. [11,12] The logic for PWV calculation is shown in Figure 5. CAVI is calculated by using the formula as stated above and LED indicators are used to check the chances of Atherosclerosis as per the ranges stated above. The logic for checking this is shown in Figure 6. The ECG and Pulse waveforms are displayed using waveform recorders the coding for which is shown in Figure 7

## LabVIEW SIMULATION

Due to pending approval from Human Ethic Committee the LabVIEW design was simulated by using a set of sample waveforms acquired from database available of a well known website.

Case1. Normal Patient
Systolic Blood Pressure: 124 mmHg
Dystolic Blood Pressure: 86 mmHg

Figure8. Shows the output acquired on simulation of ECG and pulse pressure waveform of the patient.

Case2. Diseased Patient
Systolic Blood Pressure: 144mmHg
Dystolic Blood Pressure: 92 mmHg

Figure9. shows the output acquired on simulation of ECG and pulse pressure waveform of the patient.

## DISCUSSION:

The study was done on 150 normal and diseased subjects from an age group of 20 to 60 to detect the normal and diseased range of PWV and CAVI and accordingly a virtual device was made in software LabVIEW to check for the chances of Atherosclerosis data acquired.
It was found that normal range for PWV was 6-8m/sec and normal range for CAVI was around 7-12. The diseased range for PWV was found to be around 10-12m/s and CAVI was 14-21. Primary testing of the prototype design with waveforms from standard databases shows promising results. After getting clearance from Human Ethic Committee, clinical testing can be performed on human subjects, the device design can be accordingly modified to achieve more accurate results

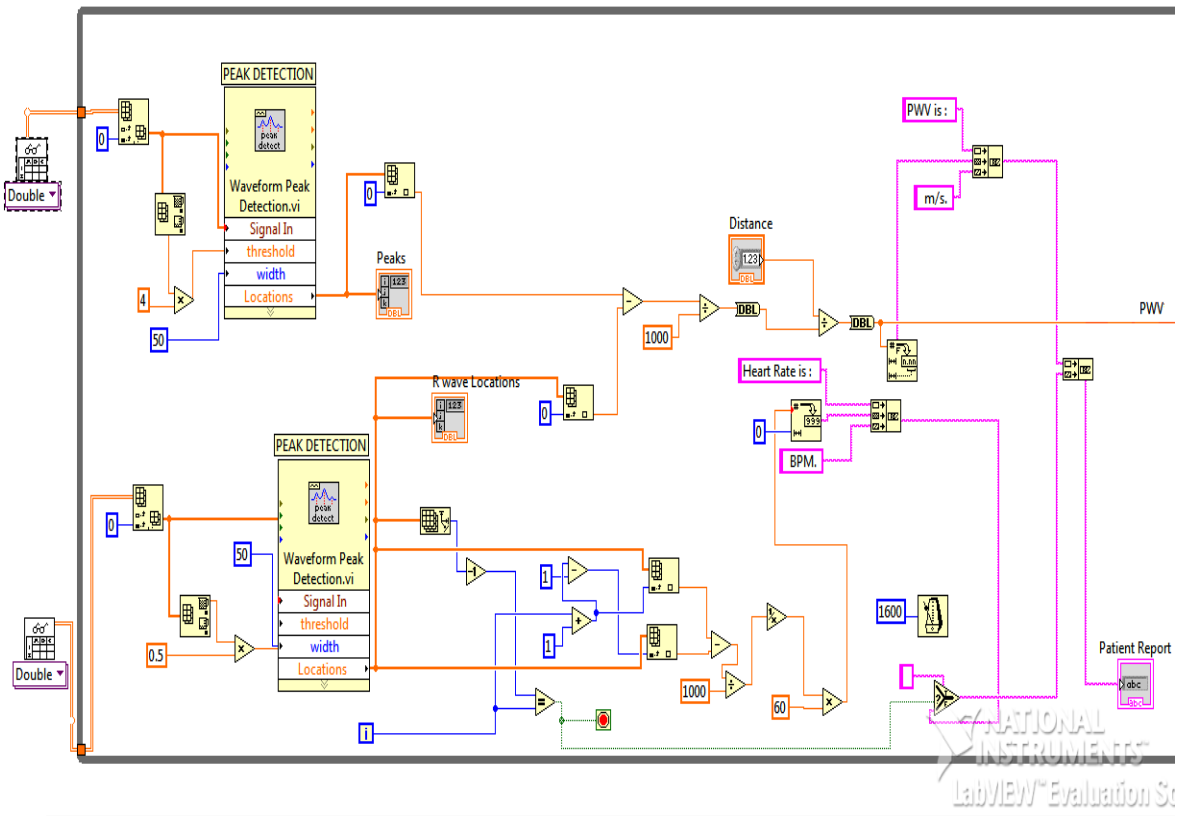


Figure 5. Logic for calculation of Pulse Wave Velocity.

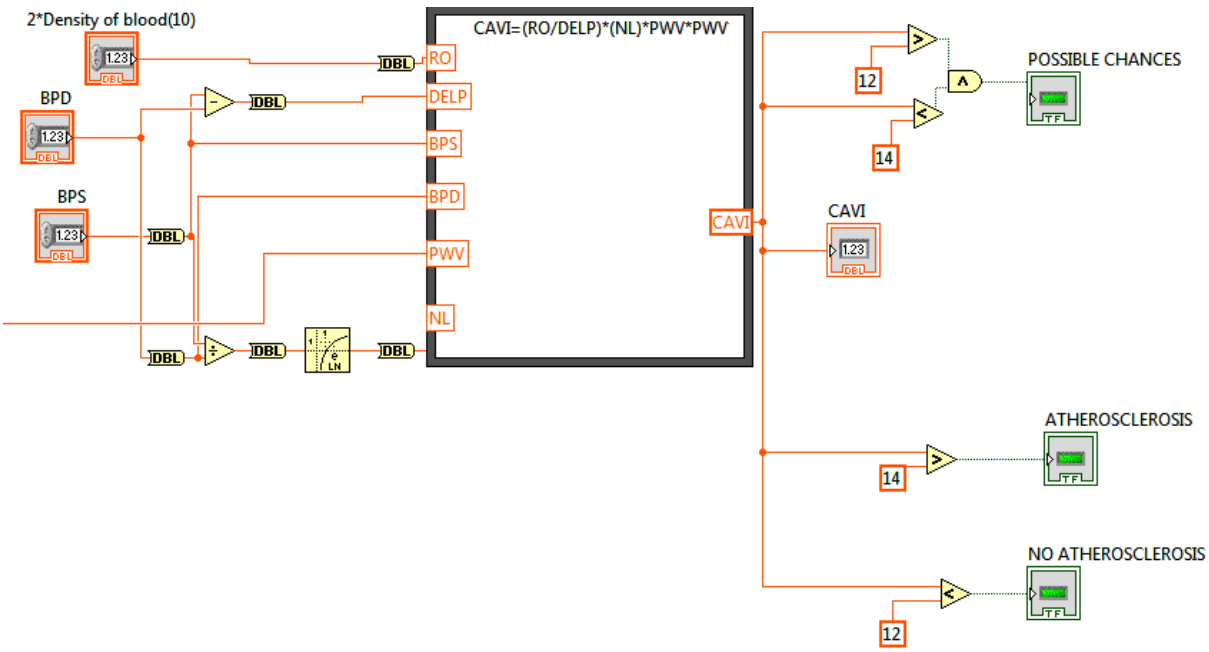


Figure6. Logic for detecting chances or occurrence of Atherosclerosis.

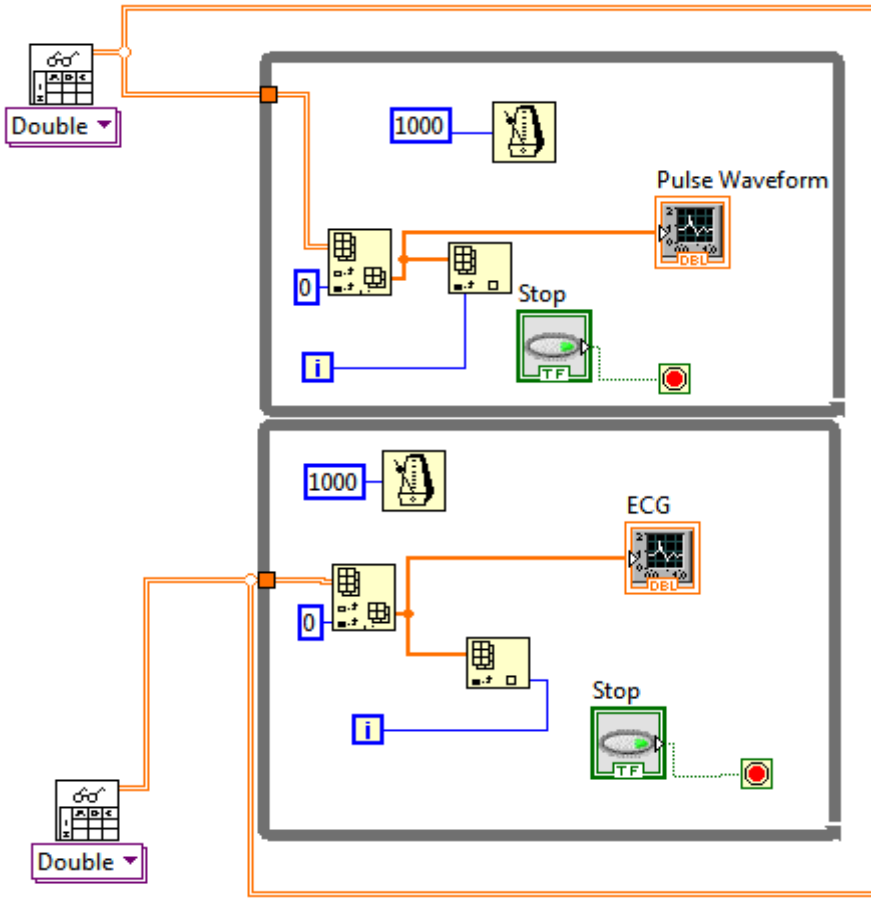


Figure 7: Logic to display the ECG and Pulse waveform

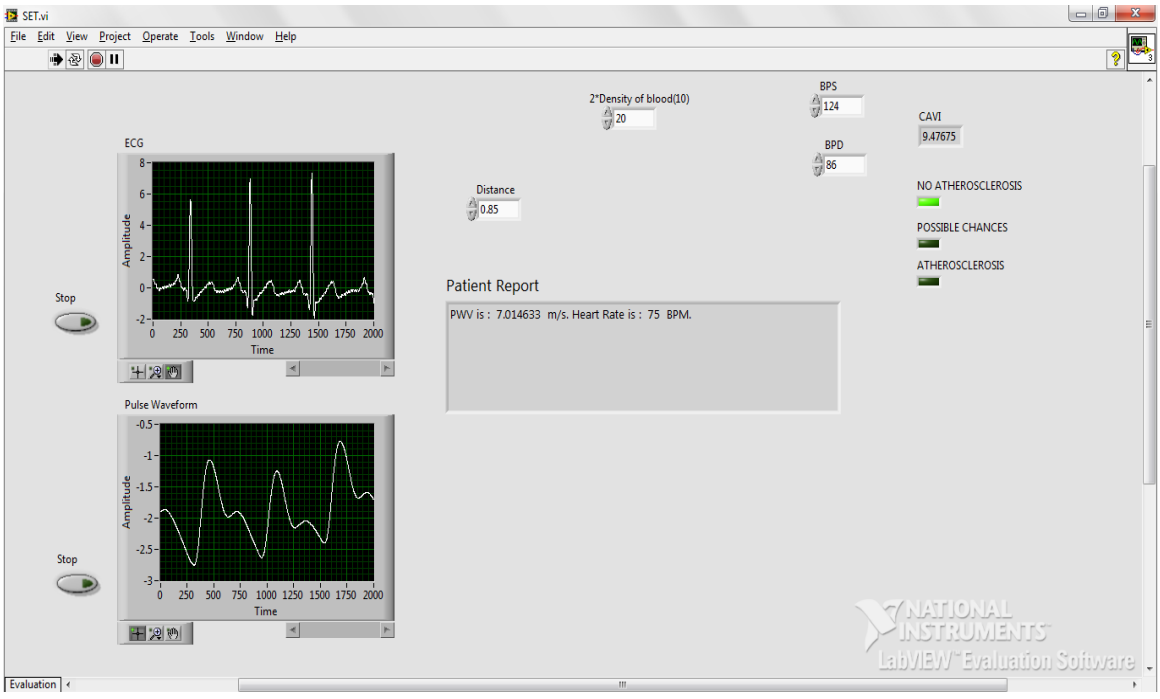


Figure8. Simulation of the design for Normal Patient.

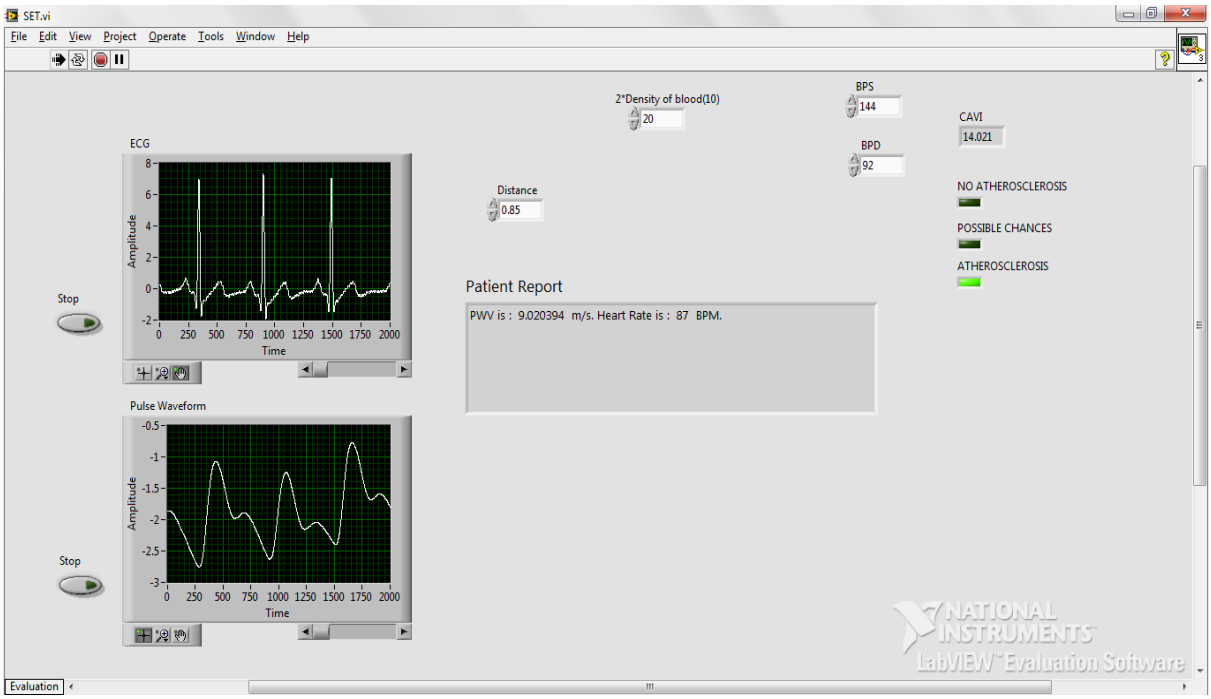


Figure 9. Simulation of the design for Diseased Patient.

## CONCLUSION:

Only a small group of people have knowledge about Nadi Shashtra. Development of such a device to detect Atherosclerosis can form a bridge between traditional Ayurvedic knowledge and modern instrumentation techniques which can further start a new domain of possible research. Such a non-invasive device can help cardiac specialist and doctors to easily diagnose Atherosclerosis which plays an instrumental role in detection of occurrences of other severe cardiac diseases.

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## Competing Interests

None declared.

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