Designing a System for Detection of Osteoporosis Using Virtual Instrumentation

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Abstract: Osteoporosis, decreasing bone density is a serious disease and its early diagnosis is very important at the right time. The conventionally available method for the assessment of bone mineral density and its related disease is through DEXA SCAN and cost of this machine is more for every scan, which is not affordable for all people. Here, proposed an inexpensive technique, which diagnoses osteoporosis using ADXL335 vibration sensor on tibia bone and gives frequency response in virtual instrumentation LabVIEW.

Index Terms **- Bone Mineral Density(BMD), Osteoporosis, FFT, Natural Frequency.**

I. INTRODUCTION

Bone mineral density (BMD) is the amount of calcium & other minerals in bone tissue. Osteoporosis is silent chronic, progressive condition in which bone density gradually decreases. At this stage bone becomes porous & fragile & may break even by minor injuries as for example if a person falls down, even then bone breaks[1]. There are various factors affect bone mineral loss such as aging, menopause.

Figure 1. Osteoporotic Bone

In current years, it had been found that more than 200 million of individuals affected by osteoporosis all over the world, because of that awareness related to osteoporosis is increasing. In spite of that, above 75% of these not known that they have osteoporosis and they are not subjected to proper medical care. In the group of three female, one female and in a group of five male, one male is affected by osteoporosis over the age of 50. In the United Kingdom, 536,000 fractures are occurred due to this disease. So, it's very important to early detection of this disease.

The response of bone at high strain loading cannot be same as predicted by static analysis because the bone has the property of a viscoelastic material. This implies it should be subjected to dynamic tests to study dynamic behaviour under illness and stable condition.

II. LITERATURE REVIEW

Conventionally osteoporosis diagnosed by measuring an amount of bone mineral density. There are various techniques used for the diagnostic purpose of osteoporosis in which DEXA scan is traditional techniques and also known as a golden standard method to measure bone mineral density because of its high accuracy.

In 1987, Dual Energy X-ray Absorptiometry (DEXA) technique was presented after the successful result of DPA (Dual Photon Absorptiometry)[2]. DEXA technique based on X-ray generator which gives two distinct energy levels of X-ray beams. Depends on the tissues nature, these beams are attenuated by it. On the basis of attenuation of energy BMD measured[3].

System development of quantitative ultrasonic detection for osteoporosis

In this paper , two probes coaxial fixed at both sides of the bone to be tested, one as a transmitter and the other as a receiver, & adopt transversal propagation quantitative ultrasonic technology, using gel as a coupler to be contacted with the subjects' skin, and employ pulse transmission to measure Broadband Ultrasonic Attenuation (BUA) and Speed of Sound (SOS)[4].

Development and Implementation of Instrumentation System for Diagnosing Bone Quality using Vibration Technique

This work is based on vibration analysis from impulse input on the human leg bone. Two commercial MEMS accelerometers are attached to the shaft (long vertical leg bone) at appropriate locations where vibrations are predominant. The proposed system consists of a MEMS accelerometer sensor ADXL335 from Analog Devices is used as a detection sensor that measures vibrations in terms of acceleration produced by the mild impulsive force applied on the diaphysis of left tibia, interfaced with Data Acquisition Card (DAQ), and displayed in the PC. In this study, 25 subjects had participated with different sex and age group between 18-20[5].

Detection of Osteoporosis and Osteopenia by Stress wave generation Method

The impulse response technique for monitoring the stress wave propagation in tibia bone has been effectively used in the assessment of osteoporosis. The technique gives a better understanding of the dynamic behaviour of bone under impact force, and the natural frequency of stress wave Signal is a clear indication of mechanical stiffness of the bone under investigation.

The experimental setup comprises an impulse force hammer and two ceramic shear type accelerometers (ADXL 345) within built charge, amplifiers. The coupler provides constant current excitation required by accelerometers and decouples the DC bias voltage from the output signal. Storage oscilloscope is used for online observation of impulse and stress wave signal. High-speed PIC 16F877A is used to digitize and acquire the impulse response data into a personal computer for further processing and analysis[6].

Osteoporosis Detection by Impulse Response Technique

In this paper, a portable and simple device is implemented using impulse response technique to determine osteoporosis is presented. It is a non-invasive technique that considers the natural frequency of the tibia. The natural frequency is found to be positively correlated to the standard osteoporosis index (stiffness index)[7].

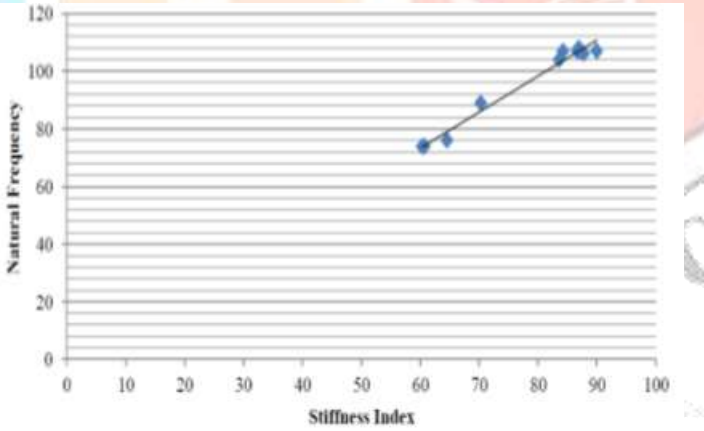


Figure 2.5 Natural frequency vs Stiffness index

The output is the natural frequency of the bone in consideration. Standard value ranges of frequency that indicated normal bone, osteopenia or osteoporosis are found. Depending upon the output of the device the patient can be diagnosed with normal bone, osteopenia or osteoporosis.

III PROPOSED SYSTEM

In this study, an easy first line method has been proposed to detect osteoporosis. Impulse response test was carried out on the tibia bone for the detection of osteoporosis with the help of LabVIEW. The experimental setup comprises of the surgical hammer, ADXL 335 accelerometer, Arduino. ADXL 335 is a 3-axis accelerometer with signal conditioned voltage outputs. The sensor captures acceleration with a full-scale range of ±3g. It can be used in tilt-sensing applications, as well as dynamic acceleration resulting from shock or vibrations.

The tibial shin bone was located on the human leg and the sensor was placed at a distance of 3 finger space from the tibial tuberosity. Periodic impulses were generated using a surgical hammer which was impacted at a distance of 2-3 cm from the spot where the sensor was placed. ADXL 335 captures the vibrations which were generated due to the impact of the surgical hammer. The output of the

sensor which is in the form of voltage was acquired with the help of Arduino Uno board. The acquired signals were then analyzed in LabVIEW which is an application software.

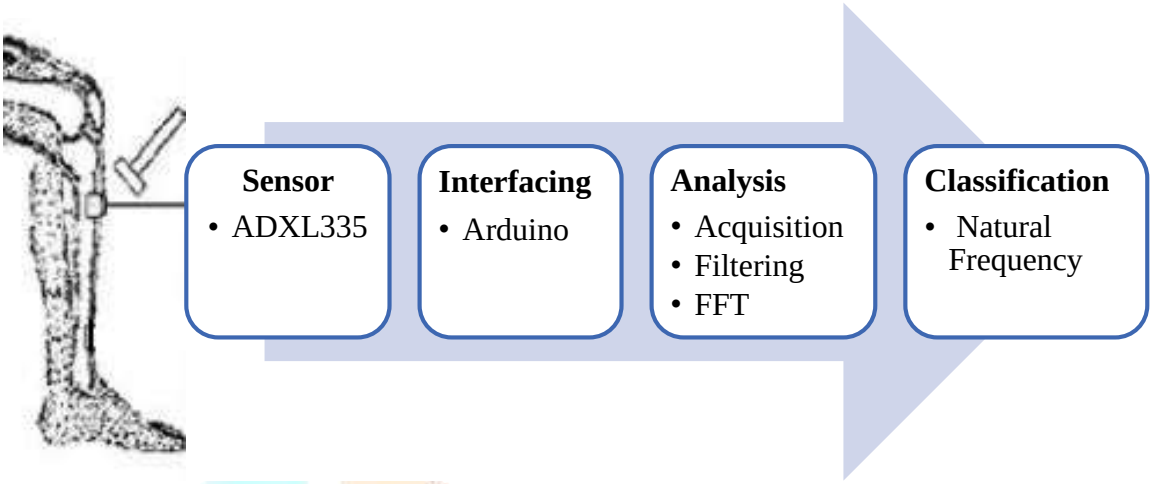


Figure 3.1 Proposed Idea Block Diagram

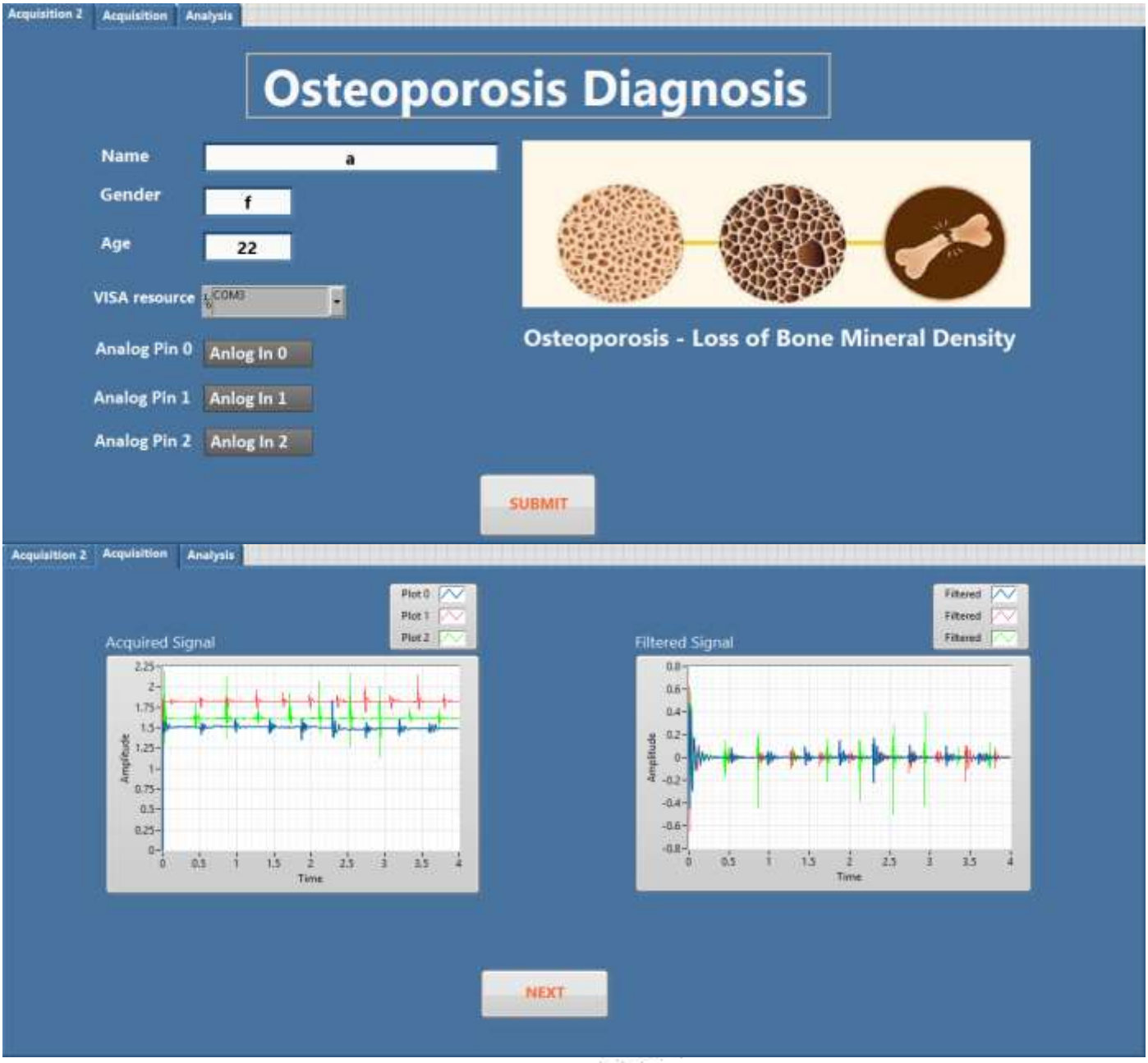
The natural frequency of the vibration was significantly decreased in osteoporosis subjects which in turn indicate the loss in mechanical strength of the bone and bone mineral density.

ADXL 335 is a 3-axis accelerometer with signal conditioned voltage outputs. The sensor captures acceleration with a full-scale range of ±3g. It can be used in tilt-sensing applications, as well as dynamic acceleration resulting from shock or vibrations. ADXL 335 captures the vibrations which were generated due to the impact of surgical hammer in X, Y and Z axes. Arduino Board is used for interfacing between Sensor and LabVIEW

LabVIEW offers a graphical programming approach that helps you visualize every aspect of your application, including hardware configuration, measurement data, and debugging. The acquired signals were then analyzed in LabVIEW which is an application software. Considering the advantage of graphical user interfacing, LabVIEW was chosen as the simulation tool. The acquired signal was conditioned using a high pass filter and then were converted to a frequency response using Fast Fourier Transform and the natural frequency was estimated.

IV RESULT

For normal person natural frequency of bone is above 100Hz, osteopenia patient has between 75 to 100Hz frequency and osteoporotic patient have below 75Hz frequency. Depending on the natural frequency of bone patient will be classified as normal, osteopenia or osteoporosis.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Osteoporosis - Loss of Bone Mineral Density
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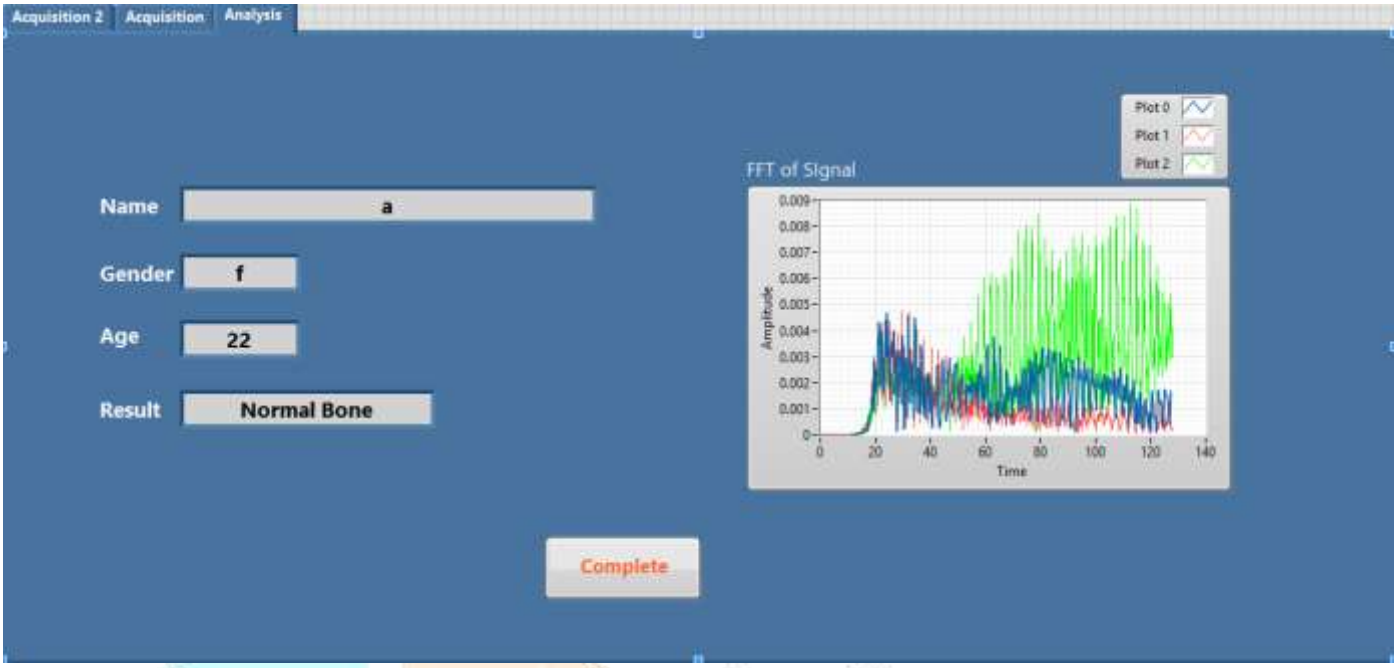

V CONCLUSION

The conventional technique used for detection of osteoporosis is very expensive & it also used radiation which is harmful to patient. The proposed system is an inexpensive technique to diagnose osteoporosis as compared to conventional technique. Use of automatic hammer instead of manual hammer impact gives a better result. This proposed system is portable and easy to use in a clinical application.

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