D Y PATIL
RAMRAO ADIK INSTITUTE OF TECHNOLOGY
NAVI MUMBAI

DEPARTMENT OF COMPUTER ENGINEERING

Ultrasound Bone Densitometer

Abstract

Osteoporosis means "porous bone." If a healthy bone is looked under a microscope, it will look like a honeycomb. In case of osteoporosis, the holes and spaces in the honey comb are much larger . This means bone has lost is density. As bones become less dense they tend to break easily, the bones of the spine are at great risk. The objectives of this project is to develop an ultrasound device to estimate bone mineral density (BMD). The device is entirely self-contained, portable, and handheld, and permits real-time evaluation of the BMD by computing a parameter known as net time delay (NTD). The NTD is defined as the difference between the transit time through the heel of an ultrasound signal and the transit time through a hypothetical object of equal thickness (to the heel) but containing soft tissue only. This parameter is sensitive primarily to the total amount (i.e., the average total thickness) of bone contained in the propagation path, and thus is equivalent to the bone mineral content estimated by dual-energy x-ray absorptiometry (DXA) scanners, and to the (areal) BMD when normalized by transducer area. Computer simulations of ultrasound propagation were used to study the relationship between NTD and BMD. The NTD and BMD were found to be very highly correlated (r = 0.99), demonstrating the high sensitivity of NTD to bone mass. The research described here, in conjunction with the fact that the devices are designed to be manufactured at very low cost, should enable the significant expansion of diagnosis and monitoring of osteoporosis.

Introduction

Bone density, or bone mineral density (BMD), is the amount of bone mineral in bone tissue. The concept is of mass of mineral per volume of bone (relating to density in the physics sense), although clinically it is measured by proxy according to optical density per square centimetre of bone surface upon imaging. Improper BMD can cause Osteoporosis i.e. "porous bone." If a healthy bone is looked under a microscope, it will look like a honeycomb. In case of osteoporosis, the holes and spaces in the honey comb are much larger . This means bone has lost is density. As bones become less dense they tend to break easily, the bones of the spine are at great risk

Machine Learning refers to the ‘learning’ of machinery. ML has been on the Radar of technology leaders for decades and these autonomous machines can help us making decisions or carry out complex tasks.
Advantages of ML:
Machines can do complex and stressful work
Faster than Human
Multiple task at a time.
So in order to get appropriate data and accurate result, we decided to use ML in our project.

Current existing system for bone densitometer scanning uses X-rays, hence is costly. Also, the size and weight of such a system is massive. Using X-rays might have some side effects on a person’s body. So, to avoid all these problems a new idea of using Ultrasonic sound for measuring the bone density is used. Bone density can be easily calculated using the difference between sound intensity at two different points. This system can be made handy, as size of the equipment needed isn’t large. Also, it’s setup is easy as compared to X-ray based system. So, in order to provide neat and elegant solution, we decided to use Ultrasonic sound based scanning system.

Requirements

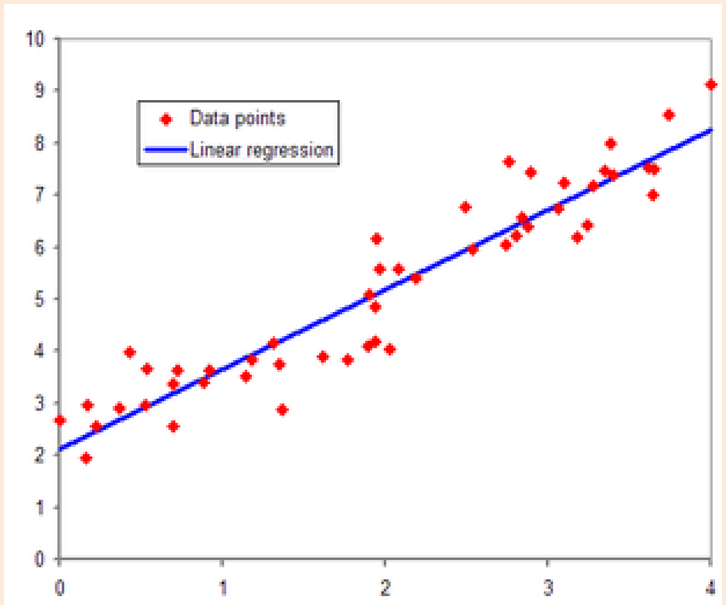
Software Requirements :
Operating System : Any OS with Python support
Platform : Python 3.5 or above pre-installed with data analysis modules
Python libraries used: numpy, scipy, matplotlib
We will collect the data via a digitizer using PyUsb, do the computing on the NTD and calculate the bone density to get the T-Score.

Hardware Requirements:
The hardware required for data collection is out of the scope of the project:
Computational hardware required:
Minimum 4 GB RAM on system
Processor with high clock rate
USB input peripheral should be available

Proposed System

As Net Time Delay(NTD) of ultrasound and the Bone Density(BD) are correlated, a Linear Regression Model can be used for predicting BD according to NTD.

Linear Regression is a statistical method to regress the data with dependent variable having continuous values whereas independent variables can have either continuous or categorical values. In other words Linear Regression is a method to predict dependent variable (Y) based on values of independent variables (X). It can be used for the cases where we want to predict some continuous quantity.



Here the X axis is called independent axis, which will be plotted with NTD data. Y axis or dependent axis will be plotted with BD data. Regression line (as shown in blue) will be plotted optimally for all points. As it is assumed that the two variables are linearly related. Hence, we try to find a linear function that predicts the response value(y) as accurately as possible as a function of the feature or independent variable(x).
The equation of regression line is represented as:

$$y = b0 + b1 * x$$

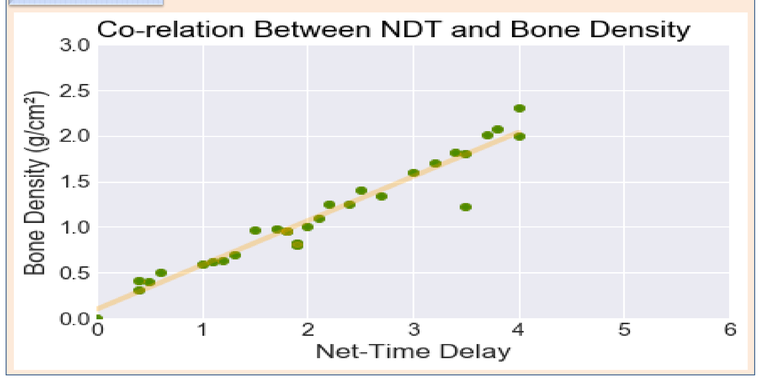
Presented By

1) Mayur Kurup 2) Dhanesh Katre 3) Swapnil More
Mentor:- Dr. Bharti Joshi

Analysis

For value 0.04 as test value, we get
The estimated value of b0 = -0.004395604395604602
The estimated value of b1 = 0.5355311355311357
The estimated value of Predicted Bone Density = 0.017025641025640827
We’ve got the prediction about bone density for given NTD. We will use this BD to obtain the statistical T - score for given density. A T-score shows how much your bone density is higher or lower than the bone density of a healthy 30-year old adult. A healthcare provider looks at the lowest T-score to diagnosis osteoporosis.
According to the World Health Organization (WHO):
A T-score of -1.0 or above is normal bone density. Examples are 0.9, 0 and -0.9.
A T-score between -1.0 and -2.5 means you have low bone density or osteopenia. Examples are T-scores of -1.1, -1.6 and -2.4.
A T-score of -2.5 or below is a diagnosis of osteoporosis. Examples are T-scores of -2.6, -3.3 and -3.9.
The lower a person’s T-score, the lower the bone density. Based on T - score, we can predict the category of bone density found for given bone sample, hence can predict chance of Osteoporosis.
> t_score = (BD - popu_mean)/(std_dev/math.sqrt(sample_size-1))
Where BD is predicted value of NTD and popu_mean is the mean of population or dataset taken for analysis.
t_score = -3.851155020921751
> Your t-score is below -2.5, you have Osteoporosis

Results



Conclusions

The aim of the proposed system has been achieved. A well trained system can now predict Osteoporosis accurately in low cost operations. The ease of calculation is possible due to Linear Regression algorithm used for prediction. Trained well enough for accurate dataset, it provides neat and accurate basis for calculation of BMD value. Apriori detection of Osteoporosis can now be done easily to improvise doctor’s diagnostics.

References

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1763043/pdf/v087p00341.pdf