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Development of an Electroacoustic Device for the Early Diagnosis of Osteoporosis

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Abstract. Osteoporosis is a health condition that weakens bones, making them fragile and more likely to break. An electroacoustic device, "the Bone Radar", developed and built in the Medical Physics laboratory is an alternative in this diagnostic. Measuring cylindrical samples of different length and density were used for the calibration. The prototype improves to establish its validation stage analyzing bone density was performed. The calibration showed a relationship between the parameters of acoustic intensity and density of the samples. This is a first approximation, advancing in the direction of establishing a new technique for early diagnosis of osteoporosis.

Keywords. Osteoporosis, electroacoustic device, bone radar.

1 Introduction

Establishing the appropriate diagnostic test could stop excess of morbidity and mortality [1]. Bone mineral density (BMD) assessment is the gold standard practice in this diagnostic. The most widely used method for measuring bone mass is a dual-energy X-ray absoptiometry (DXA) [2].

Focused ultrasound (US) technique is an alternative tool in the assessment of BMD [3]. Glüer et al. found a relationship between US and DXA of bone densitometry, measured in two women groups [4].

Barkmann et al. studied parameters such as the speed of the acoustic wave and determined that with these parameters it is feasible to analyze bone density in the femur [5].

The benefits of the US as a way to measure osteoporosis include low cost, portability, and no radiation exposure [6]. Broadband ultrasonic attenuation (BUA) and speed of sound (SOS) are two crucial US metrics. Additionally, US provides BMD-independent information about cortical and trabecular microstructures. According to evidence, the peripheral US method can identify individuals who have low bone density at the axial skeleton as determined by DXA [7].

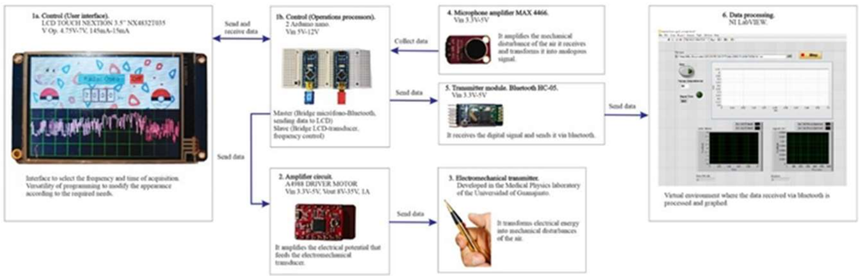

Fig. 1. Diagram with all the stages of the Bone Radar (from left to right): 1) control stage with a NEXTION LCD and two Arduino NANO, 2) power amplifier A4988 DRIVER MOTOR, 3) electromechanical transducer, 4) MAX 4466 microphone and 5) HC-05Bluetooth module.

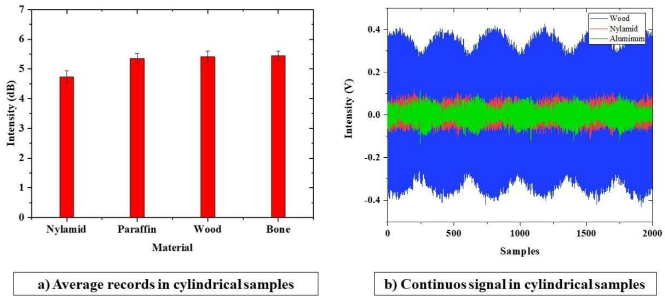

Fig. 2. Device calibration results: in a) the averages of the 10 records made in each of the samples are shown, while in b) the continuous signal of the records saved in a period of 5 seconds is observed.

There was designed and built, in the Medical Physics Laboratory of Science and Engineering Division, a device called "Radar Bone". Padilla et al. used it for diagnose congenital hip dysplasia in newborn babies [8–10]. The main objective of this work is to make improvements to the Bone Radar prototype to establish its validation stage, analyzing bone density in patients with suspected osteoporosis.

2 Methodology

2.1 Bone Radar Structure and Improvements

The components update was according to functionality and ease of configuration, they are listed below, see figure 1.

1 The control stage consists of two parts. The first one works as a control interface containing a NEXTION 3.5" LCD touch screen model NX4832T035. The second part consist of two Arduino NANO modules connected in parallel. One module works as a slave emitting a high and low digital signal according to the frequency selected by the user (100 Hz-2 kHz). The second module works as a master and connects between the data detected by the sound receiver module, the control interface and the data transmission module.

2 An A4988 DRIVER MOTOR power amplifier circuit which receives the analog signal from the slave module and amplifies the power of the signal to be sent to the transducer.
3 An electromechanical transducer. The component has a metallic pointer through which the sound is focused, it has a switch-type button adapted as a short current in order to allow the user to have better control of the acquisition time.
4 An audio sensor, MAX 4466 amplifier microphone through which the acoustic signal is acquired. The module sends the analog signal equivalent to the received sound to the master processor to be sent to the data transfer module as a digital signal.
5 Finally, the data transmission is done via Bluetooth through an Arduino HC-05 module to a computer where the signal acquired is processed in the NI Labview Sotfware.

3 Conclusions

During the Bone Radar calibration measurements, it was possible to identify a relationship between the acoustic parameter of sound intensity and the density of each of the measured samples. It can be corroborated this behavior in each of the construction stages of the device, obtaining discrete values and later continuous signals. Later on, this relationship will help to detect porosity in a bone due to osteoporosis, as has been verified in the literature with other acoustic parameters such as wave speed. Work was done to make improvements to the device, giving importance to features such as size, shape and operation of the prototype. With this stage, the electroacoustic device has been enhanced and with its previous characterization it is possible to start working on the validation stage to establish it as an additional diagnostic technique in patients with osteoporosis.

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