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STATE UNIVERSITY OF SANTA CATARINA

ELECTRICAL ENGINEERING DEPARTMENT

BONE FRACTURE DETECTION IN BIOLOGICAL PHANTOMS USING ELECTRICAL BIOIMPEDANCE

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Introduction

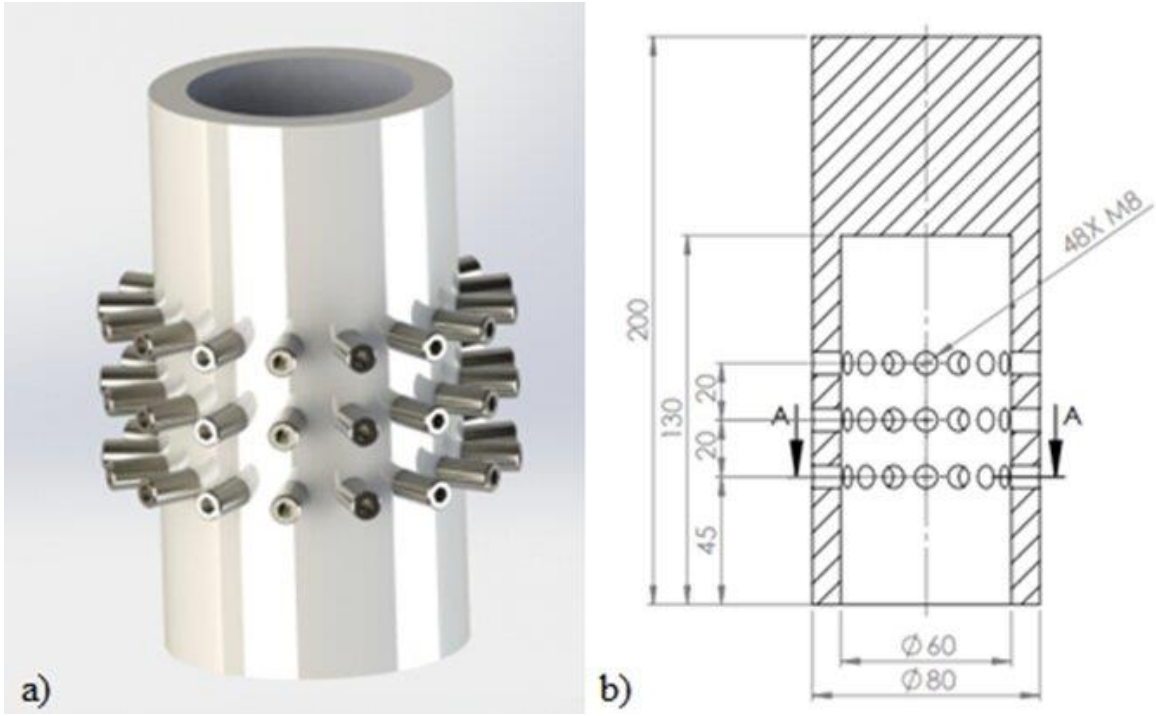
- **Bone health is an important aspect of a good quality of life.**
- **Bone tissue is primarily responsible for supporting the weight of the human body and for controlling locomotion.**
- **Nowadays there are many imaging diagnostic tools and technologies to detect bone fractures, among which X-ray is the mainly used.**
- **Bioimpedance (BIA) is a highly versatile tool, being used in several areas of research.**

Objetive

This article aims at investigating the sensitivity of the detection of healthy and fractured bones using electrical impedance spectroscopy through a 3D biological phantom.

Materials and Methods

Two identical cylindrical containers were manufactured out of nitacetal resin blocks:



Materials and Methods

The phantoms were made using a gelatin mixture.

The mixture comprised 74% distilled water, 0.5% salt, 0.5% agar-agar, and 25% gelatin. For each experiment, a 1,000 g ± 1g mixture was used. In some phantoms, chilled turkey femurs were also used along with the gelatin mixture.

Materials and Methods

Four phantoms were manufactured, consisting of:

1 - only of the gelatin mixture;

2 - the gelatin mixture and an intact turkey femur centered in the container;

3 - the gelatin mixture and a fractured turkey femur centered in the container with the fracture positioned at the level of the third electrode layer; and

4 - the gelatin mixture and a fractured turkey femur centered in the container with the fracture positioned at a level between the second and the third electrode layers.

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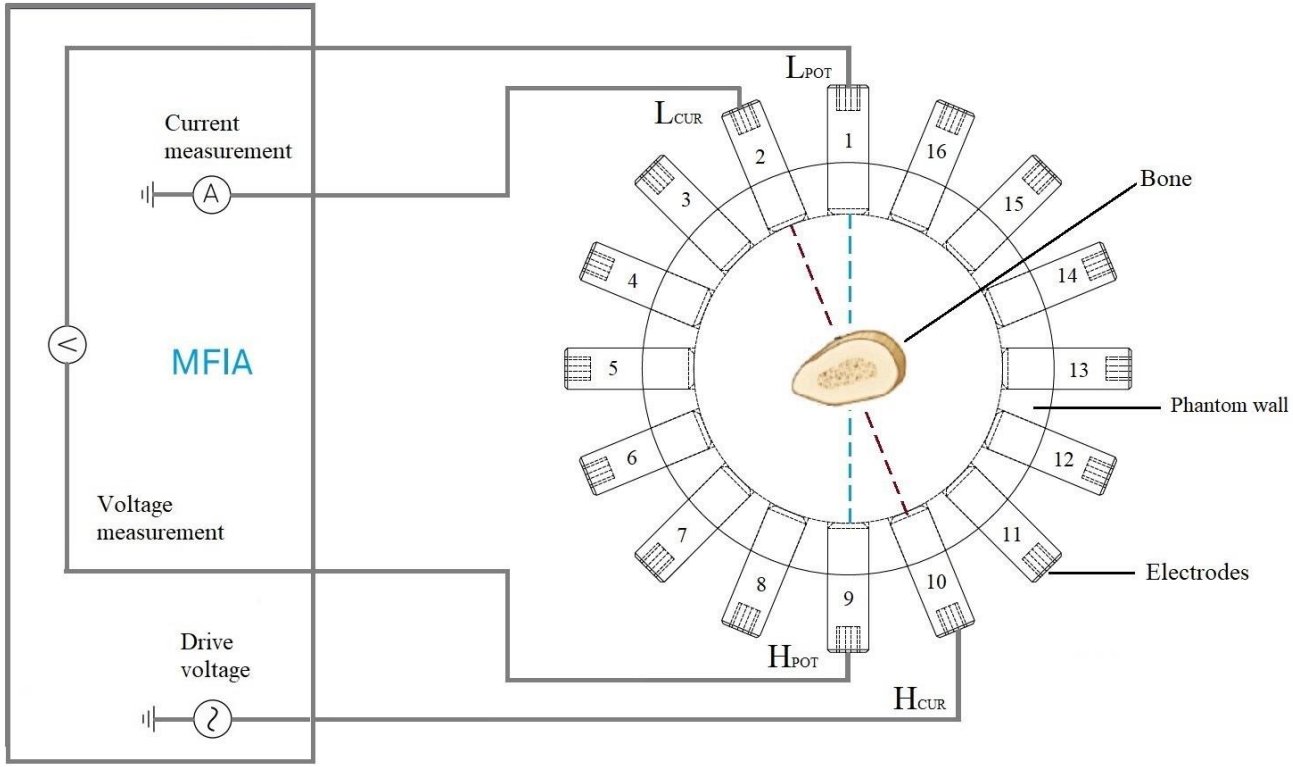
Materials and Methods

Zurich Instruments MFIA Impedance Analyzer was used for signal acquisition. Frequency ranged from 1 kHz to 1 MHz, with a measured current of 10 mA and a drive voltage of 300 mV.

Three hundred data points were collected in each frequency sweep, and five measurements were saved for each configuration of electrode pairs.

Materials and Methods

Measurements were conducted using a four-wire configuration:



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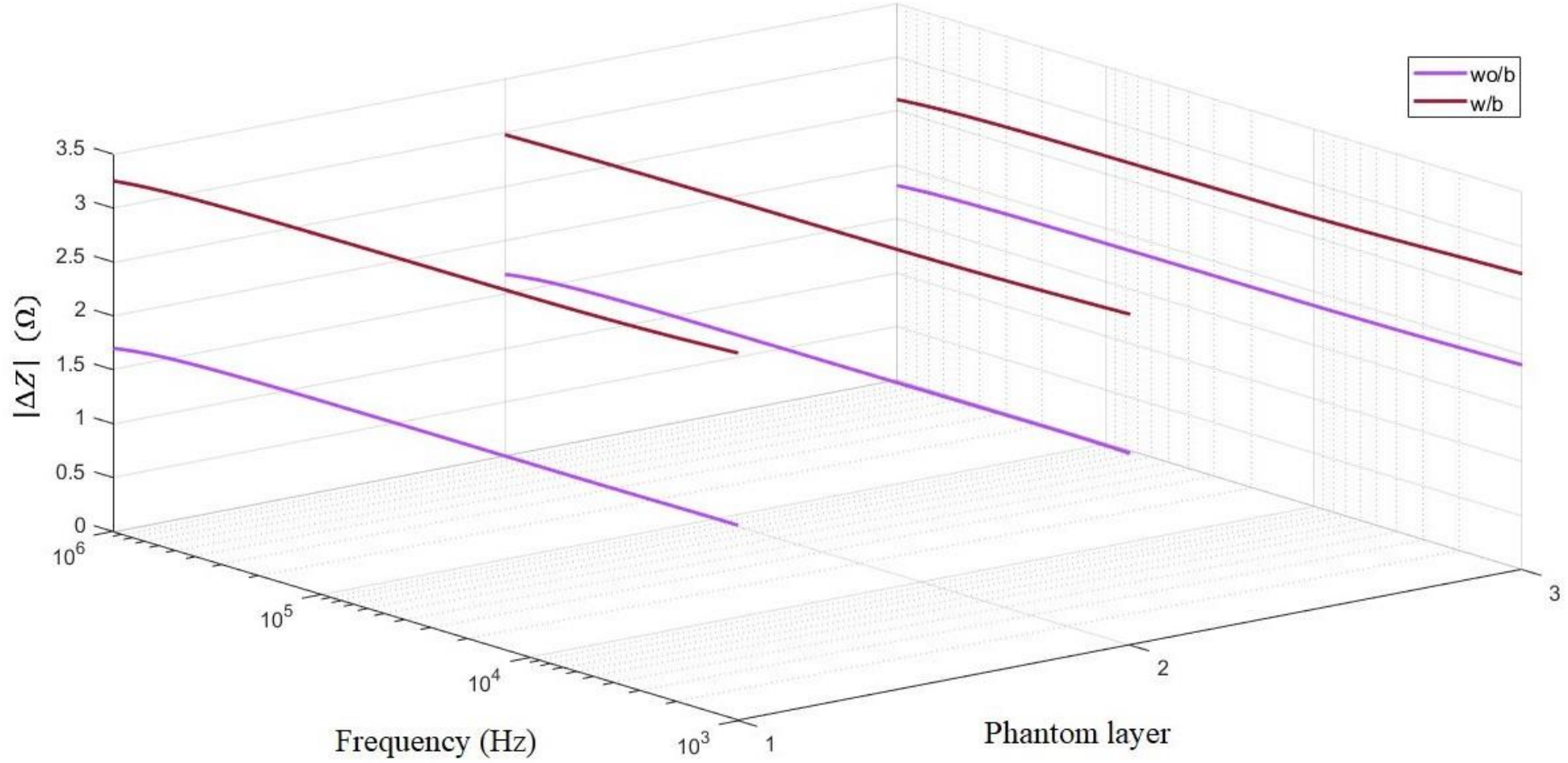
Materials and Methods

Data obtained from the MFIA, including impedance module, phase, real part, and imaginary part, were extracted for all measurements and added to an Excel spreadsheet to aid in data processing. The arithmetic mean of the five measurements for each electrode pair was calculated.

Results and Discussion



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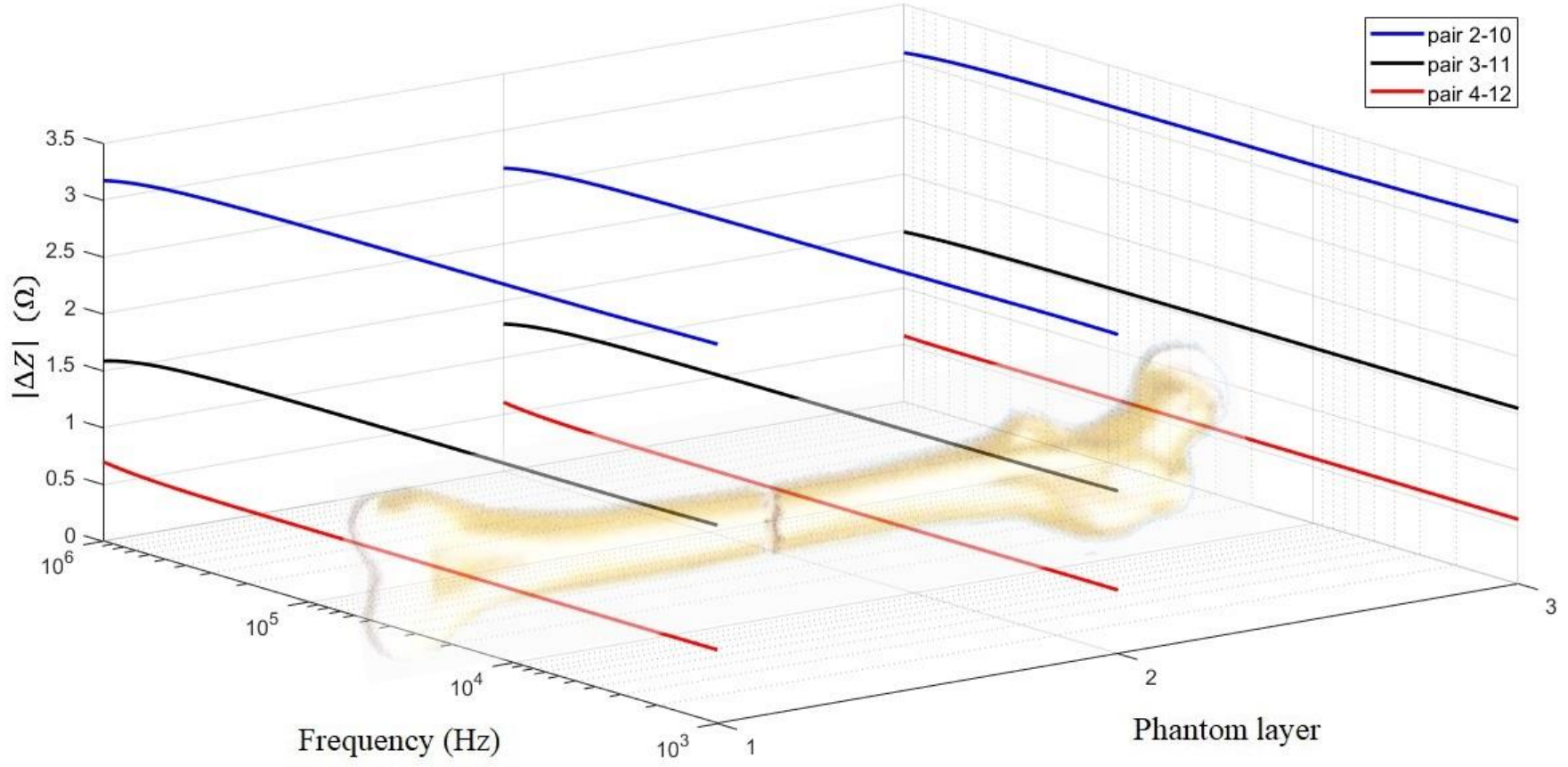
Results and Discussion

Another important point to note is that the calibration vector used in the system has an average impedance value of 16 Ω, so the observed variation in layer 1 was approximately 10% of the baseline value.

Results and Discussion



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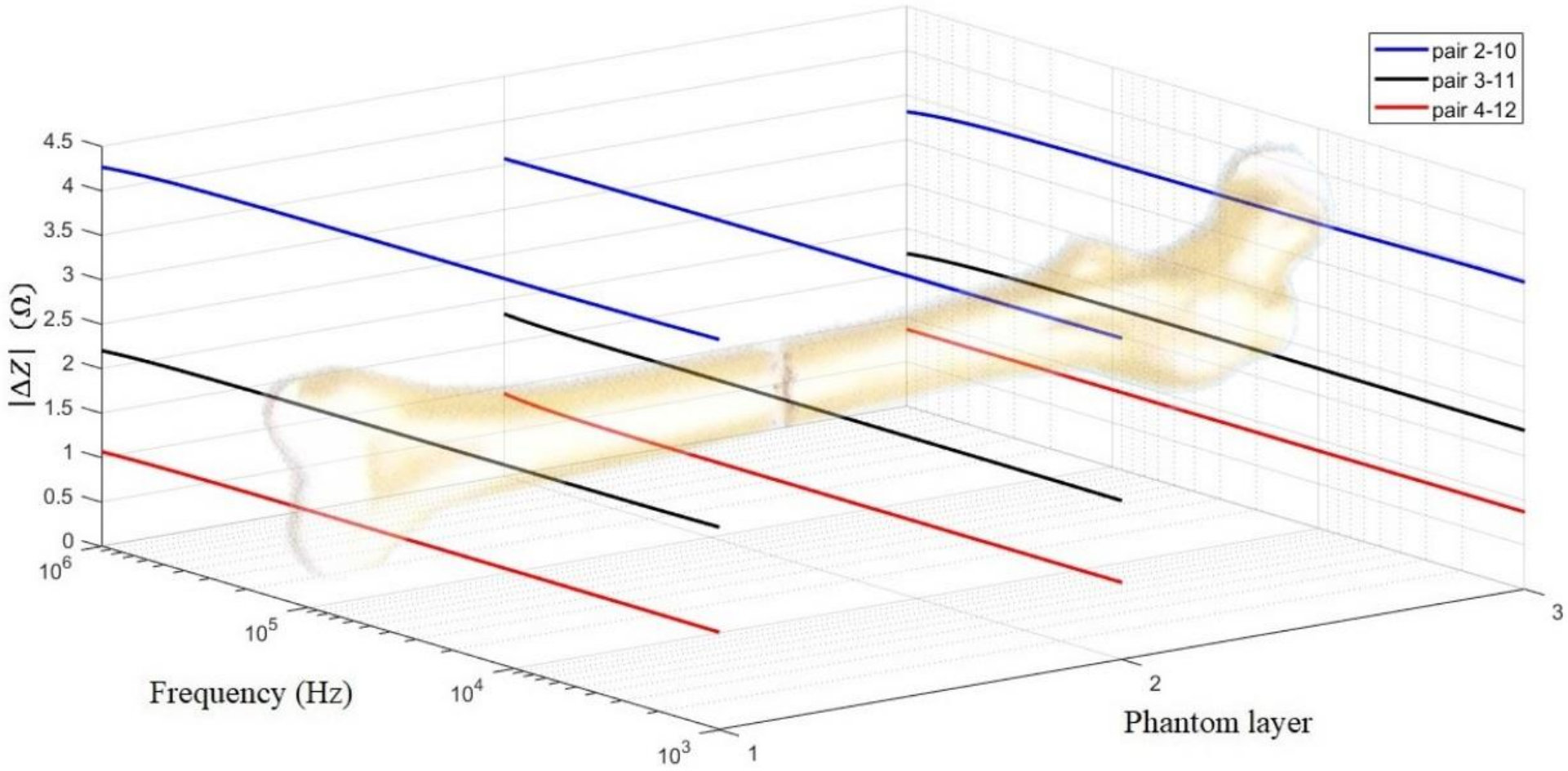
Results and Discussion



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Conclusion

Impedance values obtained with and without the bone in the phantom showed a variation of 10% from the baseline value (measured impedance of the NaCl solution), with a maximum observed error of 2%. The system proved to be sensitive to detecting fractures, as it exhibited changes in impedance values between layers close to and far from the fracture. Considering that the maximum dispersion of the measurements is in the range of tenths of milliamperes, the variation in measurements near and far from the fracture demonstrates a considerable difference compared to the average deviation present in the collected data.

Acknowledgements

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