Bone remodelling: A data science approach

Ana Pais

ana.i.pais@gmail.com

–

Supervisor(s): Jorge Belinha[1], Jorge Lino Alves[2,3],

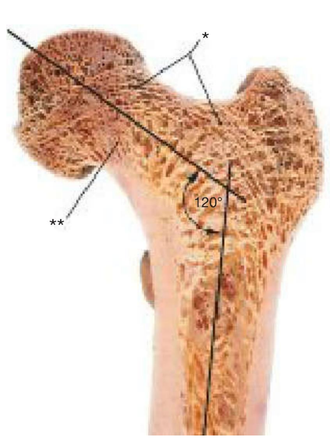
1. ISEP – Instituto Superior de Engenharia do Porto
2. FEUP – Faculdade de Engenharia da Universidade do Porto
3. INEGI – Instituto de Ciência e Inovação em Engenharia Mecânica e Engenharia Industrial

MIT Portugal

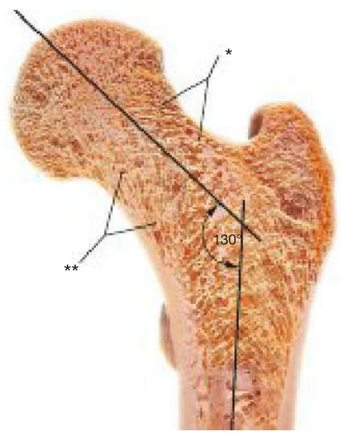
2022 Annual Conference

Motivation

Understanding the key mechanisms in bone remodelling in order to deepen the knowledge for the development of bone tissue scaffold for the repair of large bone defects



Coxa vara

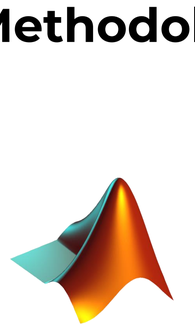


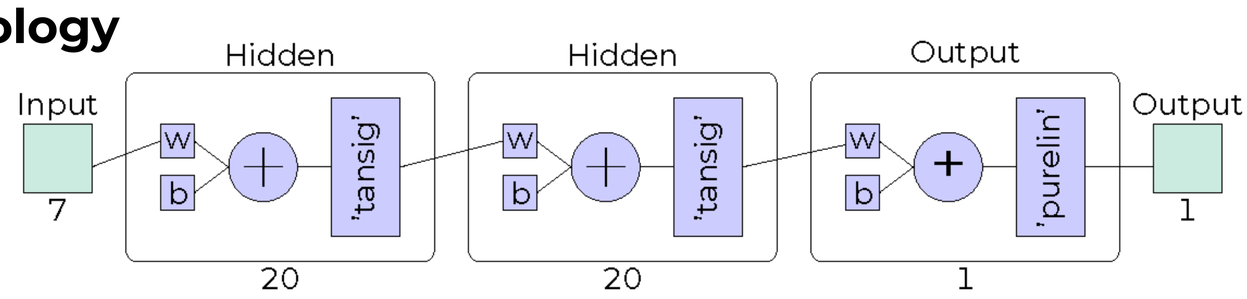
Coxa valga

The finite element method (FEM) is a highly popular discretization numerical technique in computational mechanics. However, nowadays, the numerical applications are becoming increasingly complex. Thus, traditional solving techniques also demand increasingly larger computational capacity and higher computational costs. Machine learning techniques can be combined with the FEM to reduce the computational cost associated with the numerical analysis, being applied as surrogate solvers or as a predictive tool.

Differences in the anatomy of this bone occur naturally in the population and will lead to very different structural responses. Taking for example the angle of inclination the conditions of *coxa vara* and *coxa valga* both alter hip biomechanics. The differences in the load cases ultimately lead to a different trabecular arrangement.

Methodology





Training: Levenberg-Marquadt backpropagation

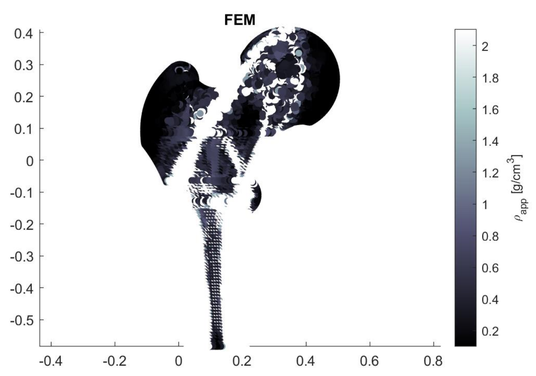
Data set

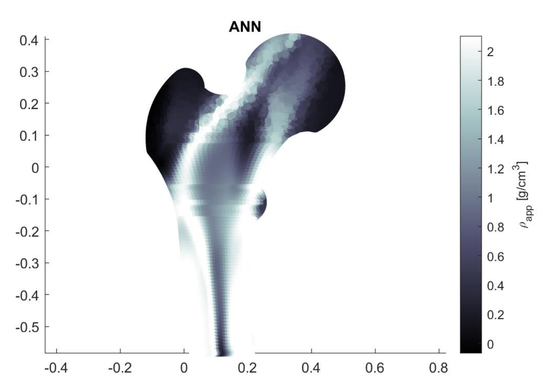
The network was trained with the results from 152 remodelling analyses, using the FEM, which vary in anatomy and load case

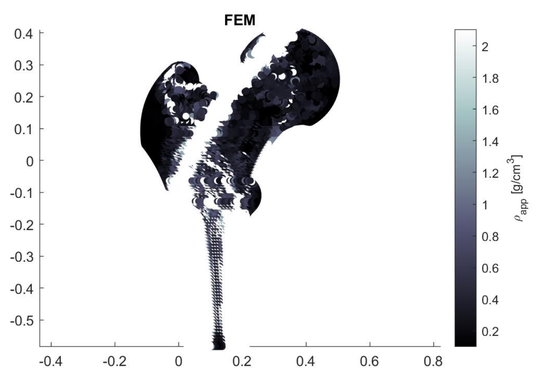
Inputs: point coordinates, model dimensions, and distortion, load angle

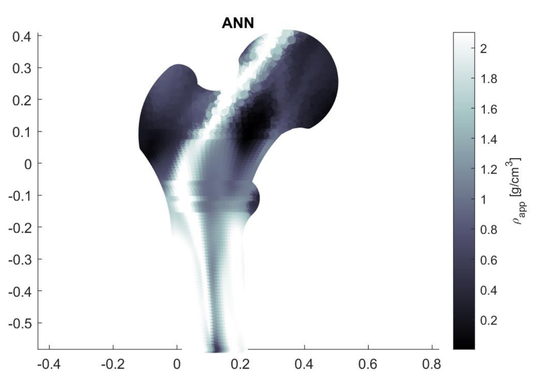
Outputs: apparent density at the point

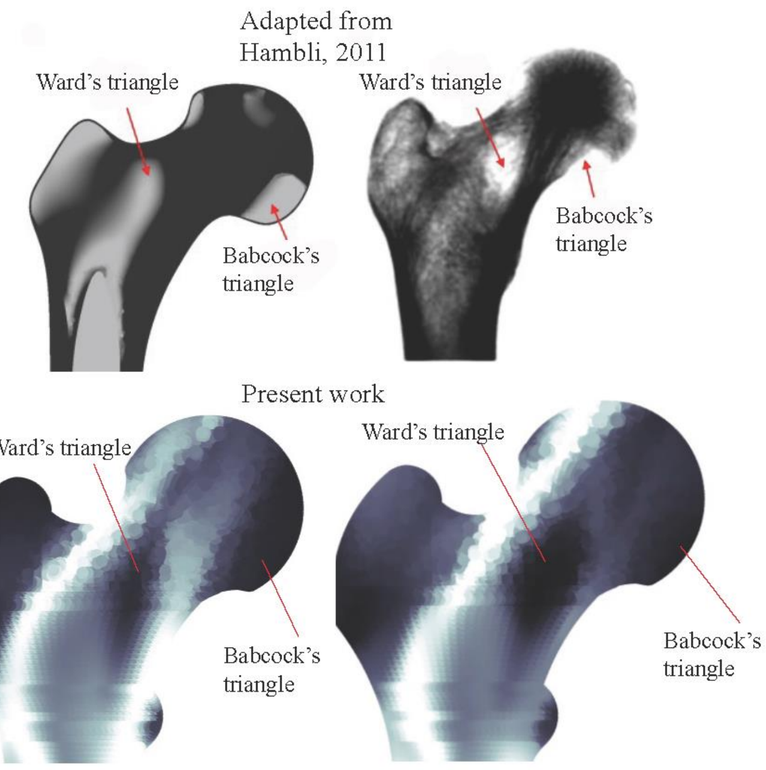
Results and discussion





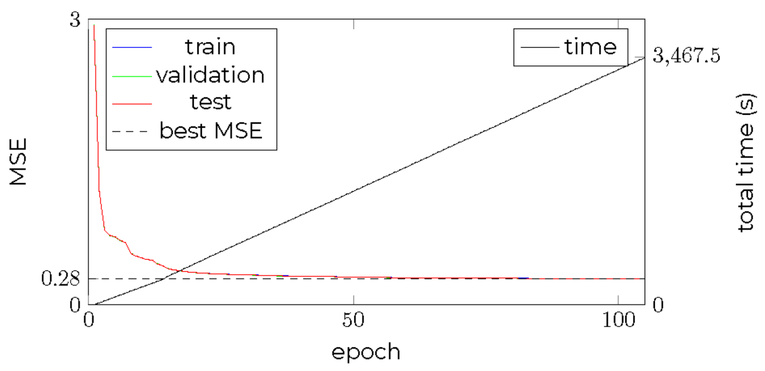






Reference: Hambli, R. (2011). Numerical procedure for multiscale bone adaptation prediction based on neural networks and finite element simulation. *Finite elements in analysis and design*, *47*(7), 835-842.

Neural network performance



Comparison to the FEM

	time (s)
Remodelling analysis using the FEM	1020
ANN training	3467.5
Prediction using ANN	0.064

Conclusion

The ANN was capable of delivering good predictions on a fraction of the time necessary to run FEM analysis

Further steps may include the addition of time information as for now the network was only trained with the final configuration

Funded by:

FCT Fundação para a Ciência e a Tecnologia

MIT Portugal

under the Doctoral Grant SFRH/BD/151362/2021 | MIT Portugal Program research areas Digital Transformation in Manufacturing and Data Science