Engineering and Physical Sciences Research Council Doctoral Landscape Award

PROJECT TITLE: Development of a Deep-Learning Model for Osteoporosis Risk Prediction From Wrist Radiographs

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Project details: Osteoporosis is a progressive skeletal disorder characterised by low bone mineral density (BMD) and microarchitectural deterioration, leading to increased risk of fragility fractures. Globally, over 200 million people are affected, with fractures representing a major cause of healthcare burden. Early identification of individuals at high risk is critical to enabling preventative interventions before debilitating fractures occur. Current diagnostic tools, such as dual-energy X-ray absorptiometry (DXA), provide measures of BMD but lack sensitivity to microarchitectural deterioration in bone. DXA also requires an additional referral, whereas opportunistic softwares applied to existing imaging can potentially reduce burden and cost to patients and healthcare services.

This project proposes the development of a deep-learning framework that integrates multimodal data from DXA, wrist radiographs and peripheral quantitative computed tomography (pQCT) scans to evaluate osteoporosis risk and thereby predict low-impact fractures from a single modality using wrist radiographs. DXA provides objective measures of wrist BMD. Wrist radiographs, a widely accessible and low-cost imaging modality, provides two-dimensional information suitable for radiographic texture analysis. pQCT, in contrast, offers higher resolution, three-dimensional insights into bone geometry, volumetric BMD, and microstructural properties. By integrating these complementary data sources, the project aims to generate a predictive model that surpasses the limitations of DXA and contributes toward a more comprehensive opportunistic assessment of bone fragility, capturing BMD and structural integrity, when applied to wrist radiographs. Previous work by the research team, in collaboration with our industry partner Ibex Innovations Ltd, has demonstrated the reliability of radiographic image analysis for estimating BMD from wrist radiographs. This has now been regulatory approved and is in clinical use. However, current outputs provide limited insight into trabecular architecture and cortical thickness, both crucial determinants of fracture resistance. pQCT scans address this gap by quantifying volumetric BMD and capturing bone structural properties at the distal radius. Combining radiographic texture features with pQCT-derived parameters through deep-learning methods has the potential to enhance early osteoporosis detection, reduce false negatives, and improve stratification of patients according to fracture risk.

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Project Objectives

1. Prospective data acquisition of relevant clinical history, DXA scans, wrist radiographs and pQCT scans from a representative cohort of 100 over-50s participants, ensuring ethical approval and appropriate curation of diagnostic labels.
2. To develop a deep-learning framework for automatic feature extraction from DXA, wrist radiographs and pQCT scans, focusing on bone texture, geometry, and microstructural integrity.
3. A convolutional neural network (CNN) architecture, supplemented by transformer-based modules, will be developed to capture DXA measures, local radiographic texture patterns, and global bone structural features. Radiograph-derived features will be fused with volumetric and architectural metrics from pQCT scans, forming a multimodal deep-learning pipeline.
4. To evaluate the predictive power of combined DXA, wrist radiograph and pQCT datasets for estimating osteoporosis risk and low-impact fracture probability of the model developed in (3), applying the developed model to a blinded test subset of participants with imaging and clinical history data.
5. Model will be further validated by comparing outcomes with finite element analysis to evaluate bone mechanical performance and susceptibility to fracture.

Project specific entry requirements: Previous experience in imaging data analysis

Potential PhD programme of study: PhD in Medical Imaging

Department: Health and Care Professions; Engineering

Location: South Cloisters; St Luke's campus

Please direct project specific enquiries to: Dr Robert Meertens (Associate Professor (Medical Imaging) R.M.Meertens@exeter.ac.uk

Please ensure you read the entry requirements for the potential programme you are applying for.

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