Development of machine-learning-based techniques for illness and injury detection in medical images

uniri-tehnic-18-15, 2018-2021

Introduction

Clinical decision-support systems are often built by manually gathering, formalising and implementing specialist knowledge. Therefore, they are limited by existing human knowledge concerning modelling clinical conditions, diagnosis and therapy, and can be inaccurate because of variations and complexity inherent to medical data. In order to circumvent these limitations, following an obvious growth of publicly available collections of medical-radiology diagnostic images, machine learning has become an irreplaceable tool for solving various problems concerning radiology image analysis.

The goal of this project is to utilise the strength of contemporary findings in the machine-learning and computer-vision field for building quality models for: 1) automating the process for radius bone fracture detection and localisation from arm radiogram, and; 2) automating the process for early diagnosis of arthritis from multimodal (hyperspectral, thermographic, 3D) scans of patient's hand. This will be achieved through understanding the process of clinical interpretation in medical diagnostics, developing matching physical models of mentioned phenomena for feature extraction and generating synthetic data, whilst using large collections of labelled data for learning models for tissue localisation/segmentation and detection/classification of said phenomena.

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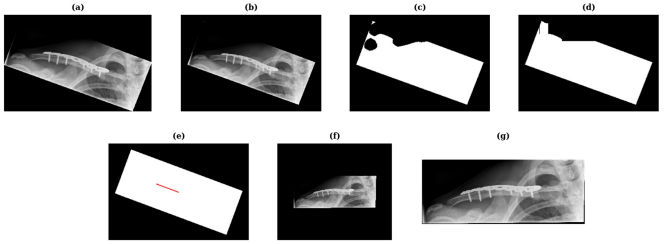
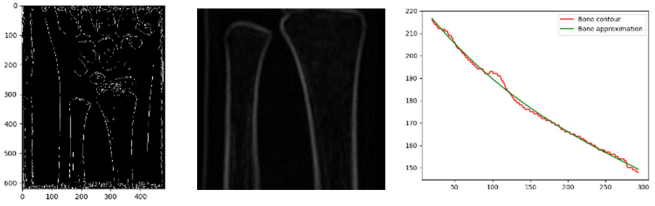
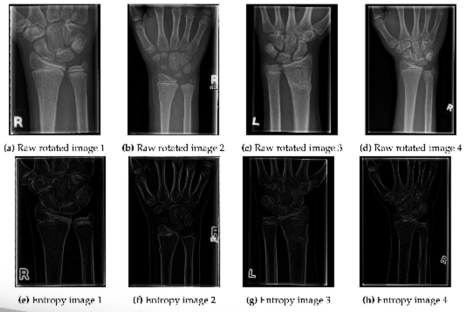
X-ray Fracture Detection and Localisation

Computer-aided diagnostics rely on machine learning algorithms that require filtered and preprocessed data as the input. Aligning the image in the desired direction is an additional manual step in post-processing, commonly overlooked due to workload issues. Therefore, the X-ray images' hanging protocol differs from case to case, which means that images are not always aligned and oriented correctly. As a solution, we propose a two-stage algorithm for X-ray image alignment and orientation.

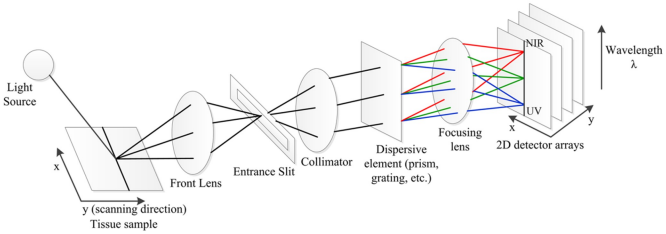


The newly designed method (which is rotation invariant) introduces a concept of local entropy for denoising and tissue removal from analysed X-ray images, followed by an improved procedure for image segmentation. We introduce a classification and localisation procedure for fracture detection by tracking the difference between the extracted contour, and the ideal one, obtained using high-order polynomial interpolation.

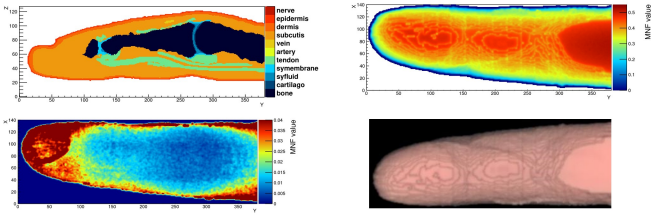




Arthritis classification from HSI data



Arthritis detection from hyperspectral imaging (HSI) scans of finger joints involves performing a non-invasive optical biopsy using the electromagnetic spectrum. This kind of in-vivo diagnosis can be used for assessing patient condition, i.e. predict one of the following: healthy (H), rheumatoid arthritis (RA), psoriatic arthiritis (PA) and osteoarthritis (OA).



A physical model of fingers, handcrafted by medical physicists, is used to generate synthetic data, which is used, along with real-world data gathered through clinical trials, for learning an end-to-end predictive model. This involves developing a pipeline for isolating (segmenting) proximal interphalangeal joints (PIPs) in HSI images, and classifying for PIP condition (H/RA/PA/OA).