AI assisted early bowel cancer detection using a self-propelled capsule robot

Kenneth Omokhagbo Afebu*, Jiyuan Tian*, Evangelos Papatheou*, Yang Liu* and Shyam Prasad**
*College of Engineering, Mathematics and Physical Sciences, University of Exeter, UK
**Endoscopy Department, Royal Devon University Healthcare NHS Foundation Trust, UK

Abstract. In attempt to improve bowel cancer treatment efficiency and patient survival via early detection, the present study proposes a less invasive soft tissue biomechanical characterisation. The method uses dynamic signals from a self-propelled robotic capsule and machine learning techniques to develop AI models capable of biomechanical characterisation. Supervised classification models were developed from selected combinations of extracted features using Multi-layer Perceptron (MLP) and Stacked Ensemble network (SE-Net). Unsupervised classification into benign and malignant lesions was also attempted using k-means clustering. The MLP models showed better performances with average accuracies of 96.4% and 96.5% on simulation and experimental data, respectively. SE-Net was better using raw and unprocessed signal data. K-means clustering achieved accuracies as high as 95.8% and 100% on simulation and experiment data respectively. The results indicate the efficacy of the proposed method to detect hard-to-visualise early bowel cancers.

Introduction

Bowel cancer are lesions in the bowel that have mutated over time to become malignant and it ranks second in the global cancer mortality rating with about 1 million deaths per year [1]. Existing diagnosing methods rely on visual observation of BC post-development features such as numbers, sizes and shapes thus making early detection very difficult. With the onset of BC being characterised with changes in the biomechanical properties of affected tissues [2], the current study investigates a non-conventional and less invasive biomechanical tissue characterisation for early BC detection. The method utilises machine learning and measurable dynamics of a self-propelled robotic capsule travelling in the bowel (See Fig. 1) and encountering lesions of different biomechanical properties to develop AI models capable of biomechanical categorisation. The capsule is propelled by the vibration of an internal magnetic mass under the influence of external magnetic excitation [3]. The proposed approach is based on the fact that resulting capsule dynamics will tend to vary with changes in the biomechanical properties of encountered lesions. Resulting signals were processed to extract features that may be indicative of biomechanical changes. Supervised classification into five classes using MLP and SE-Net, and unsupervised classification into two-classes using k-means clustering was carried out. SE-Net base learners include Support Vector Machine, Decision Tree, Naïve Baye and Randomp Forest.

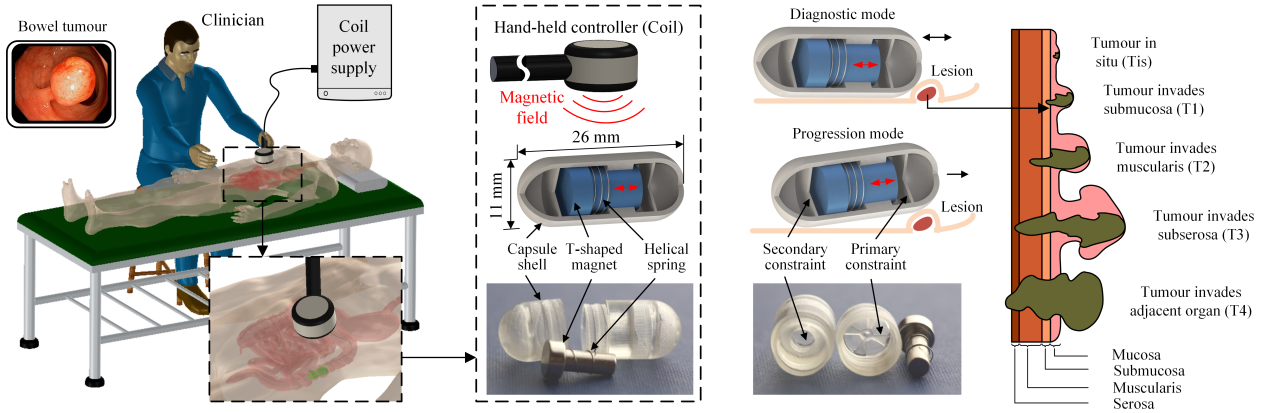

Figure 1: Principle of the proposed early bowel cancer detection and the robotic capsule prototype

Results and discussion

The MLP models showed better performances with average accuracies of 96.4% and 96.5% on simulation and experimental data, respectively. SE-Net, however, had better performance using minimally processed raw signal data. Five class clustering was not possible, however, two class clustering achieved accuracies as high as 95.8% and 100% on simulation and experiment data, respectively. The results indicate that the proposed method has great chances of detecting early stage BC to improve their treatment and survival rate.

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References

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