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PRESENTATION TITLE

Detection and characterisation of prostate cancer from multiparametric MRI using machine learning techniques for bio-focused radiotherapy

AUTHOR(S)

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ABSTRACT

Purpose:

Traditional radiotherapy approaches for prostate cancer (PCa) apply a uniform high radiation dose to the entire prostate. Focal therapy provides a solution to reduce treatment-related side effects by selectively treating tumour sub-volumes with high doses. Our group has proposed a specific form of focal therapy, termed "bio-focused radiotherapy" (BiRT) [1], where the radiation dose delivered to the tumour volume depends on the biological characteristics of the tumour (cell density, tumour aggressiveness and the presence of hypoxia). To implement BiRT, reliable estimation of tumour location and characteristics is required. This study aimed to develop predictive models for tumour location and characteristics from multiparametric MRI (mpMRI) for the implementation of BiRT.

Materials & Methods:

In vivo mpMRI scans were acquired from 30 patients prior to radical prostatectomy. Histology obtained after surgery was used to retrieve the "ground truth" information of tumour location and characteristics for predictive model development. To enable voxel-wise analysis, *in vivo* mpMRI data was co-registered with *ex vivo* histology using a 3D deformable registration framework. This provided the necessary materials for predictive model development, using mpMRI data as features and ground truth from histology as labels. To facilitate the investigation of each specific model, a multi-purposed scalable machine learning workflow (SMLW) was first developed. Preliminary investigations were performed to examine the usefulness of the SMLW in predicting tumour location at a voxel level. After validation of the methodology, following investigations focused on the prediction of prostate cell density and tumour aggressiveness. To address the challenges associated with traditional approaches for measuring hypoxia, a radiogenomics approach was applied to enable integrative analysis of the mpMRI data and corresponding genomic profiles assessed using next generation sequencing.

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Results:

Investigation into predicting tumour location using the SMLW achieved a model with an area under the receiver operating characteristics curve (AUC of ROC) ranging from 0.81 to 0.94 [2] (**Figure 1**). A predictive model for cell density was also developed and gave a root mean square error of 1.06×10^3 cells / mm^2 , equivalent to a relative error of 13.25%. Results for predicting tumour aggressiveness achieved an AUC of 0.91, and two high-performance run length and size zone texture features were identified as promising biomarkers. Radiogenomics analysis of prostate hypoxia revealed a selection of 16 texture features which showed weak but significant correlations with hypoxia-related gene expression levels.

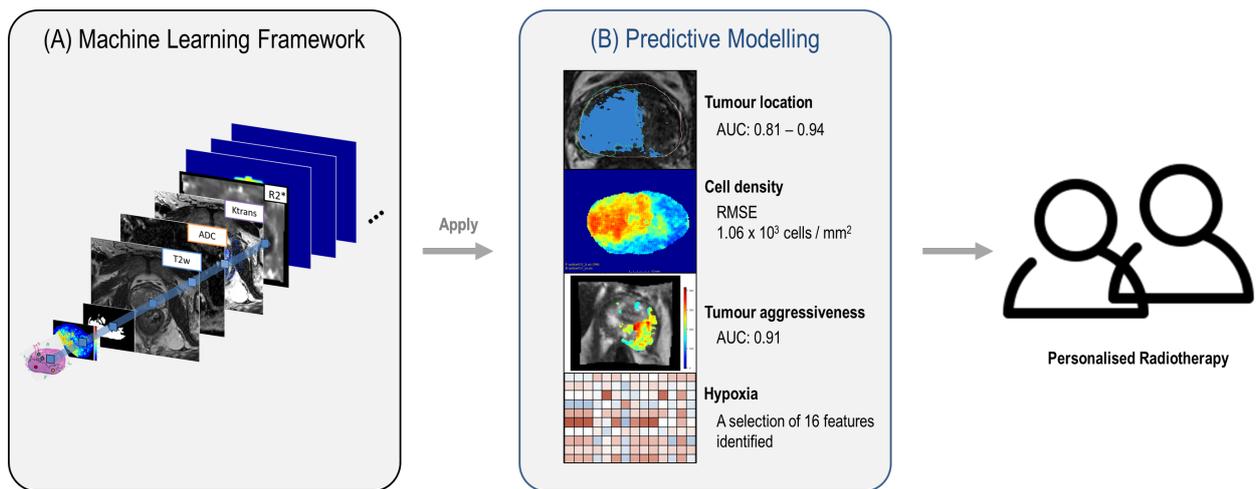


Figure 1. (A) The development of the machine learning framework at voxel level and (B) predictive model development on tumour location and tumour characteristics. Results from the predictive models are used to personalised radiotherapy treatments. (AUC: area under the curve; RT: radiotherapy)

Conclusions:

We have presented a machine learning approach to detect and biologically characterise prostate cancer from mpMRI data with promising results. This resulted in the first model for prostate cell density, a systematic comparison of texture features for predicting tumour aggressiveness and the first study on prostate hypoxia using radiogenomics approaches. This approach can be potentially applied to other cancer types to facilitate radiomics and radiogenomics studies.

References

- [1] A. Haworth, S. Williams, H. Reynolds, D. Waterhouse, G. M. Duchesne, J. Bucci, D. Joseph, S. Bydder, and M. Ebert, "Validation of a radiobiological model for low-dose-rate prostate boost focal therapy treatment planning," *Brachytherapy*, vol. 12, no. 6, pp. 628–636, 2013.
- [2] Y. Sun, H. Reynolds, D. Wraith, S. Williams, M. E. Finnegan, C. Mitchell, D. Murphy, M. A. Ebert, and A. Haworth, "Predicting prostate tumour location from multiparametric MRI using Gaussian kernel support vector machines: a preliminary study," *Australas. Phys. & Eng. Sci. Med.*, pp. 39–49, 2017.