The Detection of Implanted Radioactive Seeds on Ultrasound Images Using Convolution Neural Networks

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Abstract : A common modality for the treatment of early stage prostate cancer is the implantation of radioactive seeds directly into the prostate. The radioactive seeds are positioned inside the prostate to achieve optimal radiation dose coverage to the prostate. These radioactive seeds are positioned inside the prostate using Transrectal ultrasound imaging. Once all of the planned seeds have been implanted, two dimensional transaxial transrectal ultrasound images separated by 2 mm are obtained through out the prostate, beginning at the base of the prostate up to and including the apex. A common deep neural network, called DetectNet was trained to automatically determine the position of the implanted radioactive seeds within the prostate under ultrasound imaging. The results of the training using 950 training ultrasound images and 90 validation ultrasound images. The commonly used metrics for successful training were used to evaluate the efficacy and accuracy of the trained deep neural network and resulted in an loss_bbox (train) = 0.00, loss_coverage (train) = 1.89e-8, loss_bbox (validation) = 11.84, loss coverage (validation) = 9.70, mAP (validation) = 66.87%, precision (validation) = 81.07%, and a recall (validation) = 82.29%, where train and validation refers to the training image set and validation refers to the validation training set. On the hardware platform used, the training expended 12.8 seconds per epoch. The network was trained for over 10,000 epochs. In addition, the seed locations as determined by the Deep Neural Network were compared to the seed locations as determined by a commercial software based on a one to three months after implant CT. The Deep Learning approach was within \strikeout off\uline off\uwave off2.29\uline default\uwave default mm of the seed locations determined by the commercial software. The Deep Learning approach to the determination of radioactive seed locations is robust, accurate, and fast and well within spatial agreement with the gold standard of CT determined seed coordinates.

Keywords : prostate, deep neural network, seed implant, ultrasound

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