Deconvolution of ionization chamber-measured small field profiles using a neural network

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INTRODUCTION

Ionization chambers are frequently used for profile measurements due to their desired low energy dependence. However, the large size of the chamber's sensitive volume leads to the volume-averaging effect, and the low-density air cavity causes further perturbation to secondary electron fluence. These combined effects, named as the volume effect, lead to the broadening of the penumbra regions and, at small fields, also cause underestimation of the measured output [1,2]. Therefore, the volume effect associated with ionization chamber-measured dose profiles needs to be corrected.

METHODS

The neural network (NN) method introduced by Liu et al. [3] uses a feedforward three-layer neural network (see fig. 1) to deconvolve ionization chamber- measured dose profiles. A sliding window (L_{sw}) extracts input data of the measured profiles for the NN. The size of the hidden layer depends on the number of hidden nodes (N_{hn}). To determine the optimal combination of the NN parameters the measurement data is divided into training, validation, and test data sets.

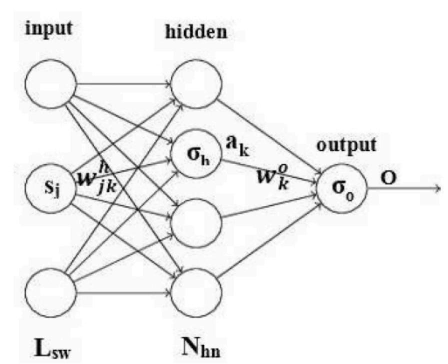

Fig. 1: Structure of a three-layer neural network consisting of an input layer, a hidden layer, and an output layer. [3]

The NN method was applied to deconvolve beam profiles of small fields between 0.3 x 0.3 cm² and 2 x 2 cm². Three ionization chambers with different sensitive volumes (PTW 31021, PTW 31022, SNC 125c; see tab. 1) were used to collect three sets of beam profiles. Another set of beam profiles was collected with a microDiamond detector and used to train separate NNs for each ionization chamber. To test the NNs, a different set of profiles was measured and used as input to the NN. The deconvolved results were compared with the microDiamond measurements.

Table 1: Geometrical properties of detectors used for measurements.

	Diameter of sens. volume	Depth of sens. volume	Sensitive volume
PTW 60019	2.2 mm	2.0 µm	0.008 mm³
SNC 125c	4.75 mm	7.05 mm	0.108 cm³
PTW 31021	4.8 mm	4.8 mm	0.07 cm³
PTW 31022	2.9 mm	2.9 mm	0.016 cm³

RESULTS

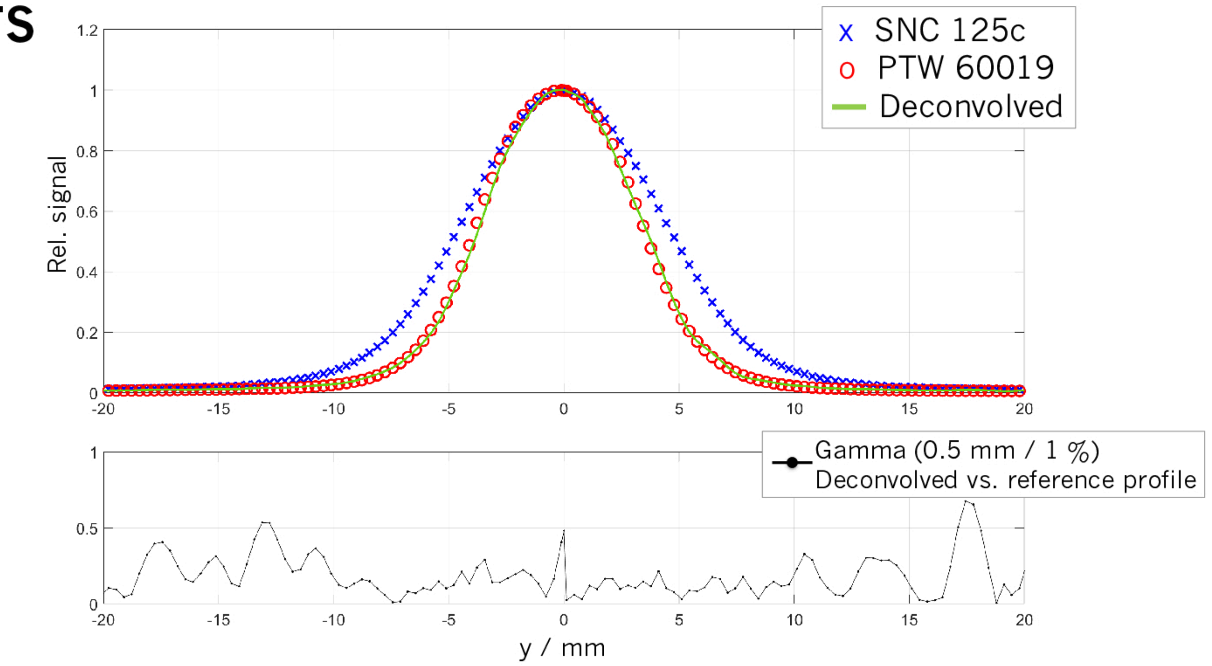

Fig. 2: Lateral dose profile of a 0.6 x 0.6 cm² field measured with SNC 125c ionization chamber (x) and PTW microDiamond (o). The deconvolved profile (—) is compared with the microDiamond-measured reference profile by applying a gamma analysis (0.5 mm / 1 %) with a 3 % threshold.

The comparison between the deconvolved profiles and the microdiamond-measured reference profiles was performed using gamma analysis (0.5 mm / 1 %) for all data points above 3 % of the dose maximum. The passing rates are above 80 % for all field sizes and ionization chambers. For fields up to 0.8 x 0.8 cm², they are even above 99 % for all three chambers.
Fig. 2 shows the profile of a 0.6 x 0.6 cm² field in 10 cm depth measured with the SNC 125c ionization chamber (x) and the PTW 60019 microDiamond (o) as reference. The deconvolved profile (—) is determined by the NN trained with the SNC 125c data and resembles the reference profile of the diamond detector. The comparison of the deconvolved and the reference profile is shown in the gamma plot below, which shows that all data points pass the gamma analysis of 0.5 mm / 1 %.

CONCLUSIONS

The separately trained NNs successfully correct the volume effect of all ionization chamber-measured dose profiles of very small field sizes down to 0.3 x 0.3 cm². The deconvolved profiles were compared with microDiamond-measured profiles. The applied gamma analysis (0.5 mm / 1 %) confirms the good agreement of deconvolved and reference profile throughout all field sizes.

REFERENCES

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