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Deep learning-based dosimetry in medical x-ray imaging

In medical x-ray imaging procedures, it is essential to achieve an acceptable image quality at a minimal dose. The measured application-specific dose quantities (ASD) are dose area product (DAP) in general radiography, fluoroscopy and cone beam computed tomography (CBCT) and dose length product (DLP) in conventional CT. These quantities are conceptionally different and cannot easily be converted into each other.

ASD values are the basis for quality assurance and diagnostic reference levels. However, they are not equivalent to patient dose. Patient dose is usually given in terms of organ or effective dose, which are useful quantities for the determination of potential radiation detriments. Conversion factors are needed to obtain patient dose from measured ASD values. They are usually calculated with Monte Carlo methods for reference x-ray devices and a set of mathematical reference patients. Therefore, they are neither machine nor patient specific and introduce large uncertainties.

An increasing number of imaging tasks can be performed with different x-ray imaging modalities, like CT and C-arm CBCT. The comparison of the radiation risk can often only be achieved using patient dose, as the ASD of different modalities are generally not comparable. Direct methods to determine the individual patient dose are therefore highly desirable. Recently, procedures have been developed which allow quick and precise patient and x-ray machine specific dose estimates in conventional CT [1-4]. These are based on deep learning tools which use the CT image of the individual patient to estimate organ doses by simulation of the machine specific CT scan. Comparable tools are not yet available for other x-ray imaging modalities although there is an increasing demand.

The aim of the project is to develop and provide procedures for the quick determination of patient dose for medical x-ray imaging procedures. Quick means that the individualized patient dose in terms of organ and/or effective dose is indicated at the display monitor of the medical x-ray device immediately after the imaging process without causing serious delays in the clinical workflow.

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References

[1] Z. Peng *et al.*, A method of rapid quantification of patient-specific organ doses for CT using deep-learning-based multi-organ segmentation and GPU-accelerated Monte Carlo dose computing. *Medical Physics*. **47**, 2526–2536 (2020).

[2] S. Sharma *et al.*, A real-time Monte Carlo tool for individualized dose estimations in clinical CT. *Physics in Medicine and Biology*. **64** (2019), doi:10.1088/1361-6560/ab467f.

[3] S. Chen *et al.*, Automatic multi-organ segmentation in dual-energy CT (DECT) with dedicated 3D fully convolutional DECT networks. *Medical Physics*. **47**, 552–562 (2020).

[4] J. Maier, E. Eulig, S. Dorn, S. Sawall, M. Kachelrieß, in *2018 IEEE Nuclear Science Symposium and Medical Imaging Conference, NSS/MIC 2018 - Proceedings* (Institute of Electrical and Electronics Engineers Inc., 2018)