**Implications of AI in cancer diagnosis, treatment and outcome prediction**

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The term artificial intelligence (AI) stands for an ensemble of technologies that enable a machine algorithm to perform tasks that are deemed characteristic of human intelligence. Typical examples are perception, comprehension, acquiring knowledge, making decisions, and acting. AI encompasses other typical terms used in the field such as statistical learning, machine learning (including deep learning), computer vision, expert systems, natural language processing, and robotics. Over the past 10 years, the field of deep learning has allowed us to leverage big data and past experience to enable prediction, detection, classification, semantic transcription, image processing and workflow optimization. Deep learning comprises the use of neural networks with more than a few (i.e., 3) layers.

AI is entering the field of cancer care through clinical tools based on AI methodologies that may facilitate different tasks performed by clinicians. There are several characteristics that are critical for an “AI-based clinical tool” and should be verifiable by the professionals responsible for clinical implementation (i.e., in cancer medicine often the medical physicist). Those are (1) generalizability, i.e., a model that is trained in one centre should work in other centres – there may be a commissioning process involved and extra training. The model should be (2) unbiased with respect to accounting for confounding factors or dataset imbalances. The model should be (3) interpretable - the output of the model should be consistent with state-of-the-art medical knowledge. It should be (4) robust, safe and effective.

Technologies currently used in the field of cancer therapy, such as imaging and radiotherapy (RT) are rapidly embracing AI methods. In the field of image processing [1], this is playing out in patient-specific image reconstruction of many known imaging modalities (CT, MRI, PET/CT, etc), in synthetic image generation between MR and CT [2] as well as facilitation of intra- and inter-modality image registration and fusion. Image dose prediction on CT in radiation therapy treatment planning, or dose prediction in nuclear medicine procedures, mammography, tomosynthesis and fluoroscopy benefits from AI. In the field of computer-assisted diagnosis (CAD) and detection of pathologies, AI algorithms have already shown great promise in screening programs for mammography and lung cancer as well as tumor detection and segmentation in breast, lung and liver CT [3]. Delineation and segmentation for disease localisation in screening applications, and for volume definition in radiation therapy treatment planning is another field that is benefiting greatly from AI. In radiation therapy, dose distribution prediction is an important step in knowledge-based planning which benefits from AI methods. This allows for the automatic generation of beam placement and subsequent optimization [4]. Treatment plan quality assurance using AI-predicted secondary dose calculation algorithms will help in result-prediction for RT quality assurance. Modern adaptive RT technologies require fast image analysis, online delineation and fast dose prediction from patient images affected by intra-fraction motion and inter-fraction anatomical changes (e.g., head and neck RT). Automation of these various steps in the adaptive RT workflow will become possible using AI algorithms. Finally, AI algorithms will be helpful in the mining of the large datasets as part of machine and equipment quality assurance and this has applications in all areas associated with cancer diagnosis and treatment.

The implementation of AI-based clinical tools puts training requirements on the clinical professionals in cancer medicine, i.e., the physicians, medical physicists, radiation technologists, nurses and administrators. It should be emphasized that, since the AI is a clinical tool, responsibility for its implementation and commissioning should not lie within the area of information technology (IT) departments but in the domain of the clinical-professional, quantitative physical scientist in the hospital environment, i.e., the medical physicist. Roles and responsibilities for the medical physicist therefore include (1) technical aspects of procurement, (2) supervision of installation, operation, and maintenance safe, effective, efficient and ethical unbiased use; (3) education (resident, students) and training of other health care professionals (e.g., physicians, IT, radiation technologists, vendors, AI developers) and (4) research and development. To prepare medical physicists for this expanded role, they should know the principles and processes of AI-based tools rather than approaching them as “black-boxes”. Curricula of medical physicists must contain academic course work on advanced statistical learning and continuing education modules on this subject must be developed and made available.

The holy grail of cancer medicine is optimization of patient outcomes following a treatment intervention that has been decided upon based on all patient-personalized data and domain knowledge available. The hospital, or more broadly, the health care system is a massive machine collecting such data ultimately aimed at helping clinicians and patients to plan and follow the most appropriate intervention. Despite widespread adoption of electronic health records (EHRs), most hospitals are not ready to implement data science approaches in the clinical pipelines. There is therefore need for a continuously learning infrastructure through which multi-modal health data are systematically organized and data quality is assessed with the goal of applying AI for individual prognosis and treatment planning. One such approach is MedOmics [5-6], where real-world data and clinical encounters can be captured in an integrated ‘data story’ to enable continuous learning and hypothesis generation in oncology. It is expected that, over a considerable period [7], health care institutions and governments will gradually work towards the implementation of such systems following ethically sound and patient health information-protective guiding principles.

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