Artificial intelligence-based solution for bioluminescence tomography reconstruction for glioblastoma multiforme

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A Reflection on Scientific and Social Impacts

Bioluminescence Imaging (BLI) is a technique that's often used in research to examine tumors in small animals. However, the extent of BLI application is limited to tumor growth monitoring, which is an important aspect but does not fully employ the potential of the imaging technology. During the course of this thesis, various advanced computer science methods, known as Artificial Intelligence (AI) models, are developed to enhance the accuracy of the 3D Bioluminescence Tomography (BLT) reconstructed from a set of 2D BLI images. The conducted research in this thesis paves the way for more advanced BLI-based tumor targeting in small animal irradiation platforms, which in turn reduces the ionizing radiation burden on the animals. Therefore, the developed methods within this thesis can be directly employed in the commercially available small animal irradiators, such as the SMART+ (Precision X-ray Inc., Madison, CT, USA) and the SARRP (Xstrahl Life Sciences, Suwanee, GA, USA), to improve the quality of otherwise limited BLI-based tumor targeting with the X-ray radiation beam. Furthermore, the standalone Bioluminescence imaging systems, such as IVIS (PerkinElmer, Shelton, CT, USA) and MILabs' stand-alone optical imaging (MILabs, Houten, Netherlands), can also adapt the developed AI-based methods to enhance the provided BLI-based volumetric tumor monitoring. In addition, the reduced imaging X-ray radiation dose on the animals provided by BLT allows for more imaging checkpoints during a longitudinal study, which is otherwise impossible due to the excessive accumulated X-ray imaging dose. Therefore, the overall quality of the conducted research will increase due to better overall monitoring. Furthermore, the BLI also enables monitoring of substructures within the tumor, such as the hypoxic region, which is deprived of oxygen and directly linked to the poor prognosis.

The findings of this thesis help biologists to employ the full potential of the BLI in their research, especially in order to improve the treatment quality for glioblastoma patients. The developed algorithms in this thesis also allow for more accurate tumor volume monitoring during the course of the treatment in small animals and, therefore, help biologists validate their hypothesis and identify a more efficient treatment option for glioblastoma. Therefore, the outcome of this thesis indirectly contributes to a better treatment option for glioblastoma patients, with currently poor average survival time of only 12 months after the initial diagnosis. However, since the BLI is a dedicated imaging technology for small animal preclinical cancer research and is not applicable for imaging a human subject, the developed methods cannot directly be translated to clinical trials. Nevertheless, the shared fundamentals between BLI and various other types of optical imaging, such as fluorescence imaging, optical coherence tomography, and Cerenkov imaging, allow for fast adaptation of the proposed algorithms in other domains. In more

detail, other researchers can build upon the outcome of this thesis, communicated through scientific journals and conferences, to solve similar 3D reconstruction problems in other optical imaging modalities, some of which with clinical applications.
Even though this thesis focuses on glioblastoma, the developed methods in this thesis can easily be adapted for many other tumor types. In other words, the observation-based AI methods developed in this thesis can be re-trained using a new set of observations for totally different tumor types, such as lung cancer. Therefore, the presented AI-based reconstruction algorithms developed in this thesis can be employed in a variety of different pre-clinical cancer research in order to improve the quality of the conducted pre-clinical investigations, which consequently can play a small role in enhancing the treatment outcome for human patients.