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Review of the dissertation manuscript

Méthodes pour l'automatisation de la dosimetrie en radiothérapie

of Mr **Paul Raymond François DUBOIS.**

This dissertation manuscript was submitted by Mr Paul DUBOIS, supervised by Prof Nikos Paragios and was carried out in the Cancer Hospital in Montpellier together with the Advanced Research Department of the Company Therapanacea as well as the Institute of Biomathematics, Mathematics and Informatics of Complex Systems of the University of Paris-Saclay.

The topic of this PhD thesis is in the field of cancer treatment with radiotherapy. More specifically, the overall aim of Mr Dubois thesis is to automatize the labour intensive and at the same time very complex process of radiotherapy treatment planning. The work focusses on leveraging new approaches from artificial intelligence and machine learning to provide healthcare professionals in radiotherapy with robust and fast solutions for automatic generation and optimization of individual radiotherapy plans. In clinical practice the optimization of such treatment plans is very complex as those are multi-variable problems aiming at providing maximum radiation dose to the cancer while sparing as much as possible healthy surrounding tissue.

The dissertation manuscript of Mr Dubois is written in Englsih language, is 108 pages long and consists of seven chapters.
In a first chapter, he summarizes the underlying medical physics basics, starting from cancer as second cause of death in the western world, describing interaction processes of radiation with matter, radiation effects on tissue and the patient path in radiotherapy, followed by radiotherapy treatment techniques and equipment as well as treatment planning approaches including commercial and non-commercial treatment planning systems.
The second chapter of this thesis consists of brief introduction into the research question along with the outline of this dissertation.

Chapter three focusses on different techniques for fluence optimization. To determine the most suitable strategy for fluence optimization, different classical open source optimizers were compared when solving a simple fluence optimization task. The results suggested that the Newton optimizer was best suited for radiotherapy fluence optimization.
In chapter four, dose relationships or factor best suited for classifying the difference between radiotherapy dose plans were investigated. To do so, Mr Dubois proposed to use distance metrics as a basis for dose volume histogram clustering. Consequently, he proposed to use graph theory approaches for multi-objective optimization in radiotherapy planning for the selection of most optimal and also robust plans. The method was applied to a small public data set, showing that the idea can be realized. Overall, the study failed to proof that this method is superior to classical multi-criterial optimization techniques.
Chapter five then leverages reinforcement learning techniques for automatic radiotherapy planning tasks. To do so, a series of virtual phantoms was used to simulate patient cases and train a reinforcement learning model. Furthermore, a fully automatic treatment planning approach respecting institutional practices was proposed and tried in a small data set.
The last topical chapter then presents a study on dose mimicking, where clinical radiotherapy plans with two different prescriptions were used as a training data set to train different models for dose map prediction.
In chapter seven, results and limitations of the presented works were discussed in the context of the published literature.

Overall, the dissertation manuscript of Paul Dubois is proposing an interesting field of research. After summarizing many existing techniques and classical approaches which were developed and clinically used in the last two decades, he proposed and investigated some new ideas which might be used in the future to automatize radiotherapy treatment planning. The use of reinforcement learning and also the graph theoretical approach to cluster radiotherapy plans can be considered novel ideas in this field. Nevertheless, the dissertation lacks rigorous testing of the proposed ideas in clinical meaningful situations.

The results of this work were published in one conference paper (AIMS 2024), two conference presentations (SFPM 2024 Dijon, AIMS 2024 Salt Lake City) and three posters (SFPM 2024 Dijon, ASTRO 2024 Dijon(?) and SFRO 2024 Paris). No peer-reviewed publication in a medical physics journal was achieved, which makes it difficult to judge the contribution to the field of medical physics/ radiotherapy.

Overall, the dissertation manuscript fulfils the requirements for a PhD thesis and is authorized to be defended.

Prof. Dr. Daniela Thorwarth
Tübingen, December 5th, 2024