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Méthodes pour l'automatisation de la dosimetrie pour les traitements radiothérapiques.

Methods for automatization of the dosimetry for radiotherapy treatments.

Thèse de doctorat de l'université Paris-Saclay

Spécialité de doctorat: ...
École doctorale n° 573 Interfaces : matériaux, systèmes, usages, ED INTERFACE
Graduate School: Sciences de l'Ingénierie et des Systèmes, SIS

Thèse préparée dans les unités de recherche **Radiothérapie** (Institut Régionale du Cancer de Montpellier), **Advanced Research** (TheraPanacea), et **MICS, Mathématiques et Informatique pour la Complexité et les Systèmes** (Université Paris-Saclay, CentraleSupélec) , sous la direction de **Nikos Paragios**, Professeur, et la co-direction de **Paul-Henry Cournède**, Professeur

Thèse soutenue à Paris-Saclay, le JJ mois AAAA, par

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Composition du jury

Membres du jury avec voix délibérative

Prénom NOM Titre, Affiliation	Président ou Présidente
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THESE DE DOCTORAT

NNT : 2020UPASA001

université PARIS-SACLAY | ÉCOLE DOCTORALE Interfaces: matériaux, systèmes, usages

Titre: Méthodes pour l'automatisation de la dosimetrie pour les traitements radiothérapiques.

Mots clés: Mathématiques, Intelligence Artificielle, Radiothérapie

Résumé: Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

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Title: Methods for automatization of the dosimetry for radiotherapy treatments.

Keywords: Mathematics, Artificial Intelligence, Radiotherapy

Abstract: Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

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Acknowledgments

A PhD is more than just hard work; it thrives on mentorship, collaboration, and unwavering support. [...]

List of Contributions

- Teaching: *Consistency and Reproducibility of Grades in Higher Education: A Case Study in Deep Learning replace icon*

- ArXiV: Radiotherapy Dosimetry: A Review on Open-Source Optimizer
- ESTRO: A Novel Framework for Multi-Objective Optimization and Robust Plan Selection Using Graph Theory
- SFPM: Dose Volume Histograms Guided Deep Dose Predictions
- AIME: Radiotherapy Dose Optimization via Clinical Knowledge Based Reinforcement Learning (full paper coming soon)
- ASTRO: Clinically Dependent Fully Automatic Treatment Planning System
- SFRO: Attention Mechanism on Dose-Volume Histograms for Deep Dose Predictions

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Radiotherapy

Abstract

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1.1 Medical context

1.1.1 10 cancer markers

- cell proliferation
- reprogram cellular metabolism
- stop cell growth arrest
- evade apoptosis
- escape immune system
- ability to undergo a sufficient number of successive cell cycles of growth and division to generate macroscopic tumors
- create new blog vessels to get nutriments
- allow cell escape and metastasis formation
- change cellular response phenotypic via plasticity
- senescence

1.1.2 4 cancer conditions

- mutation
- epigenetic reprogramming
- inflammatory context
- disruption of microbiota

1.1.3 phases of cancer

initiation

promotion

tumorigenesis + neoangiogenesis

evolution (local, regional, metastasis)

1.1.4 cancer classification:

tumor, node, mestastasis

stages classification:

1. stage 0 which corresponds to a so-called in situ tumor
2. stage 1 which corresponds to a single, small tumor
3. stage 2 which corresponds to a larger local volume
4. stage 3 which corresponds to invasion of the lymph nodes or surrounding tissues
5. stage 4 which corresponds to a wider extension in the body in the form of metastases

1.1.5 treatment types

surgery

RT

chemotherapy

combination

1.2 Patient Path

1.2.1 Detection / diagnostic

1.2.2 RT Prescription

1.2.3 CT scan

1.2.4 Contouring

1.2.5 Treatment Planning

1.2.6 Irradiation Sessions

1.2.7 Follow-up

1.3 Machines

1.3.1 Molds / 3D-RT

1.3.2 MLC-LINAC

1.3.3 Tomotherapy

1.3.4 CyberKnife

1.3.5 Brachytherapy

1.4 Irradiations techniques

1.4.1 IMRT

Step and Shoot

Sliding Window

1.4.2 VMAT

1.5 Treatment Planning Systems

1.5.1 Manufacturer

Eclipse (Varian)

ONE | Planning (Elekta)

Precision (Accuray)

1.5.2 Non-manufacturer

RayStation (RaySearch)

matRad (German Cancer Research Center - DKFZ)

AutoPlan (TheraPanacea - coming soon)

1.6 Dosimetry steps

Challenges

1.6.1 BOO

1.6.2 FMO

1.6.3 LF

1.7 Simulation

Introduction

Abstract

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2.1 Context

Cancer; RT; optim to be done

2.2 Problematic

Manual optim is time consuming; need to automate

2.3 State of the Art

2.4 Unsolved problems

2.5 Contribution

Dosimetry Optimization

Abstract

3.1 Optim engine: classic and dose mimicking

3.2 relation between optim doses (distance and network)

3.3 ESTRO (novel approach with graph theory)

Automation: Classical Approach

Abstract

4.1 RL + classic optim algo (AIME / ASTRO)

Automation: Deep Dose

Abstract

5.1 DVH guided deep dose + dose mimicking algo (SFPM / SFRO)

Conclusion

Perspectives