

RAPTOR - LOOP REQUIREMENTS 4th-9th SEPTEMBER 2022



Report of Contributions

Contribution ID: 97

Type: **not specified**

Deep Learning meets Imaging Science: Explainable Hybrid Solvers for Medical Imaging

Monday, September 5, 2022 11:00 AM (1 hour)

Deep neural networks have already been tremendously successful in real-world applications, ranging from science to public life. The area of imaging sciences has been particularly impacted by deep learning-based approaches, which sometimes by far outperform classical approaches for particular problem classes. This talk shall give an introduction into this exciting research field. We will first discuss deep neural networks in general, their set-up as well as their advantages and disadvantages. Then we will focus on the application of deep neural networks to problems in imaging sciences. Due to their success, we will pay particular attention to so-called hybrid methods, namely those which optimally combine traditional model-based methods with deep learning-based approaches to not neglect known and valuable domain knowledge. As a numerical illustrative example, we will discuss the application of limited-angle computed tomography. Finally, we will also touch upon the issue of how to interpret the results of such algorithms, and present a novel, state-of-the-art explainability method based on information theory.

Summary

Primary author: KUTIONIK, Gitta

Presenter: KUTIONIK, Gitta

Contribution ID: 98

Type: **not specified**

AI in Radiotherapy –Machine Learning and Deep Learning for Treatment Planning

Monday, September 5, 2022 12:00 PM (1 hour)

Over the last century radiotherapy has had a remarkable success in cancer treatment. After the early years of trial-and-error, the evidence based use of radiation has established fractionated photon treatments as standard of care for most patients. Decades of research has led to novel machinery and procedures –such as charged particle treatments, image guidance and adaptive treatments –that allow targeting tumors with unprecedented precision today. Computational tools and sophisticated mathematical modelling played an undeniably crucial role in this success, and Artificial Intelligence (AI) methods are increasingly the key drivers behind further improvements, holding the promise for breakthroughs via enabling real-time adaptive and biologically optimized treatments.

In this presentation I will give an overview of the current state-of-the-art in the use of AI methods in various steps of the modern radiotherapy treatment planning workflow. I will explain how Deep Learning (DL) based convolutional and transformer networks can speed up dose calculations, both for photons and for charged particle therapies. I will review AI's role in imaging, segmentation and registration, and we will learn about traditional machine learning (ML) and current DL approaches to plan optimization and quality assurance. I will also describe how AI can help modelling the dynamics between breathing motion and dose delivery, which is crucial for the most advanced particle beam scanning techniques. Last, I will talk about the limitations and outstanding challenges of AI in radiation oncology clinical practice.

Primary author: PERKÓ, Zoltán

Presenter: PERKÓ, Zoltán

Contribution ID: 99

Type: **not specified**

Big data: acquiring and using large (patient) datasets/ Big Data in a Clinical Context

Monday, September 5, 2022 2:30 PM (1 hour)

The rise and widespread adoption of internet technologies in the last twenty years have triggered the generation and storage of massive amounts of data. This abundance has fostered the development of systems able to perform distributed computations on a large scale that later came to be known as “big data technologies”. As often happens in the medical technology field, digital innovations that have matured in other industries eventually make their way into the research and clinical workflow.

This talk will give a brief introduction to the distributed computing core principles, providing a historical perspective on which technologies have developed over time and which are the most commonly used nowadays. It will then focus on how these technologies can be applied to data generated during the radiation therapy treatment course, addressing the unique challenges arising during data extraction, transformation, and analysis. Lastly, it will present how oncology analytics platforms like RayIntelligence have been developed to address the specific needs of radiation therapy data analysis.

Primary author: RUFFA, Giorgio

Presenter: RUFFA, Giorgio

Contribution ID: **100**Type: **not specified**

Biostatistics

Monday, September 5, 2022 3:30 PM (1 hour)

The talk will present the basic concepts of biostatistics and statistical inference in general. We will start with the estimation of the population mean and explain the terms like sampling distribution and the standard error. We will explain why and how the central limit theorem plays a central role in the underlying statistical theory. We shall then turn to hypothesis testing and give an intuitive presentation of its main steps. The example of testing the mean value will be used to present the ideas and to discuss the duality between testing the hypotheses and parameter estimation. The presentation will focus heavily on the ideas as well as the interpretation of the obtained estimates, intervals and the statistical hypothesis results, to give an overall picture of the key ideas of statistical inference. The talk will be wrapped up by a brief discussion on the most frequent methodology used in biostatistics.

Primary author: PERME, Maja Pohar**Presenter:** PERME, Maja Pohar

Contribution ID: **101**Type: **not specified**

Inventions, patents and crime –What a researcher needs to know about IP

Monday, September 5, 2022 5:00 PM (1 hour)

Intellectual property (IP) helps to protect creations of the mind that include technological inventions, designs, images, symbols, slogans etc. If you create a product, publish a book, or find something new in your research, intellectual property rights ensure that you benefit from your work. These rights protect your creation or work from unfair use by others and can be a catalyst to attract cooperation partners. In this talk, we will discuss different types of intellectual property rights (patents, trademarks, designs) and learn how they can help researchers, developers and entrepreneurs.

Primary authors: NEETZ, Manuel; SCHINDLER, Matthias

Presenter: SCHINDLER, Matthias

Contribution ID: **102**Type: **not specified**

Gender, Inclusion and Gendered Innovation I

Monday, September 5, 2022 6:00 PM (1 hour)

Aim: to create awareness about gender issues and to stimulate practices for a good behavior.

Main Topics: (After a short presentation about myself and my involvement in science and in EPWS)

(I) State of the art of the participation of women in research with particular focus on Europe.

(II) overview about the most crucial gender issues:

- the stereotypes and the unconscious bias;
- the stereotypes in science and specifically about gender;
- who are the women scientists? (role models and mentoring);
- stereotypes and scientific communication;

(III) the European policies of ERA (European Research Area) to overcome the gender gap in science (evolution from 1999 to 2022):

- the projects for supporting the presence of girls in science;
- the Gender Equality Plans (GEP);
- the gendered innovation;
- the inclusive language.

Suggested texts:

(i) Schiebinger, L., Klinge, I., Sánchez de Madariaga, I., Paik, H. Y., Schraudner, M., and Stefanick, M. (Eds.) (2011-2021). *Gendered Innovations in Science, Health & Medicine, Engineering and Environment*. URL: <https://genderedinnovations.stanford.edu/>

(ii) Toward an inclusive communication: example in the English language. "Toolkit on gender-sensitive communication" by EIGE, 3/3/22.

URL: <https://eige.europa.eu/print/publications/toolkit-gender-sensitive-communication>

Primary author: MARTINELLI, Lucia

Presenter: MARTINELLI, Lucia

Contribution ID: **103**Type: **not specified**

Control systems for ART

Tuesday, September 6, 2022 8:30 AM (1 hour)

I will introduce our product TreatmentOne. which was developed with the future in mind, specially to support the evolution towards adaptive methodologies. It is in fact a three-in-one solution: A Record and Verify (R&V), a treatment session manager, and a treatment control system that synchronizes the operation of all devices and subsystems and enables users to perform clinical and QA workflows. It was designed and developed according to strict medical standards and the latest best practices for usability. It provides streamlined workflows and the features needed to address the challenges of operating and integrating modern radiotherapy devices. TreatmentOne is modular and configurable, making integration easy and a perfect fit for customer-specific radiation therapy devices.

I will walk you through a treatment workflow and explain the features and configurations.

Primary author: HENGOVIC, Jasna

Presenter: HENGOVIC, Jasna

Contribution ID: 104

Type: **not specified**

Clinical QA procedures/ Clinical QA procedures and their applicability in ART

Tuesday, September 6, 2022 9:30 AM (1 hour)

Clinical QA procedures and their applicability in APT / OAPT

Quality assurance (QA) procedures in radiotherapy are necessary to ensure an accurate and safe dose delivery to the patient. Improvement and assurance of radiotherapy safety relies on two major pillars. Incident reporting and incident learning are most meaningful for improving existing processes while prospective risk assessment, e.g. carried out by failure mode effect analyses, is recommended when modifying or implementing new processes like online-adaptive radiotherapy.

Besides the theoretical background, we will review complementary approaches for patient-specific PBS plan quality control. A combination of phantom-based measurement, independent dose calculation and log-file analysis are under consideration to efficiently make use of resources in the clinic. This ensemble complemented with automated checks of the replanning input data, plan integrity checks, in-vivo dose monitoring, online imaging and a well-interacting team are considered as key components for overcoming the major QA challenges in an online adaptive radiotherapy QA workflow: (1) it is impossible to perform pre-treatment QA measurements with the patient on the table, (2) there is very limited time for excessive plan evaluation and physics checks, and (3) adaptation-based errors might be missed with the current tools.

The aim of the presentation is to provide awareness for required changes in QA procedures when realizing online adaptive RT.

Short Biography

Kristin Stützer is the operational leader of the High Precision Proton Therapy group at OncoRay – National Center for Radiation Research in Oncology, Dresden, Germany. Together with other researcher at OncoRay, the clinical team and renowned industry partners it is her long-term vision to realize an online adaptive proton therapy in a fully automated, decision supported feedback loop of imaging, adaptation, delivery and prompt gamma imaging-based treatment verification.

After graduating with honors in physics from the TU Dresden, she started her research in the field of particle therapy during her PhD studies including several experiment campaigns at the GSI Helmholtzzentrum in Darmstadt, Germany. Her doctoral thesis on in-beam PET dose monitoring for intrafractionally moving targets was awarded the Behnken-Berger Prize of the German Society for Medical Physics in 2014. During her PostDoc period at OncoRay and the University of Pennsylvania she worked on robust and adaptive proton treatment planning, the optimization of proton therapy for moving targets, strongly supported the clinical commissioning of the University Proton Therapy Dresden and gained administrative and organizational experience as research assistant at the HZDR Institute of Radiooncology.

In addition to her professional work, she acts as an honorary national referee in the German figure skating union and has been running her own small business called family since 2017.

Summary

Primary author: STUTZER, Kristin

Presenter: STUTZER, Kristin

Contribution ID: 105

Type: **not specified**

Prompt gamma particle imaging

Wednesday, September 7, 2022 4:30 PM (1 hour)

The lecture will give an overview of the utilization of prompt-gamma (PG) radiation, emitted from the patient's body during fractionated particle therapy treatment, for range and treatment verification. After the nuclear physics basics of the emission of prompt gamma rays have been refreshed, the three fundamental approaches for PG-based particle range determination will be discussed, which use either spatial, temporal or spectroscopic information of PG - namely prompt gamma imaging (PGI), prompt gamma timing (PGT) and prompt gamma spectroscopy (PGS), respectively. Special emphasis will be on the interpretation of the complex PG data for the distinction of clinically relevant from irrelevant treatment deviations, necessary for the clinical application of PG for treatment intervention in an online-adaptive PT realization. Results from the evaluation of clinically acquired PGI data will be presented.

Primary author: RICHTER, Christian

Presenter: RICHTER, Christian

Contribution ID: 106

Type: **not specified**

Logfile-based (4D) dose reconstruction

Wednesday, September 7, 2022 8:30 AM (1 hour)

The interplay of motion with a highly dynamic dose delivery process like Pencil Beam Scanned (PBS) proton beam is inherently complex. Although by using four-dimensional (4D) dose calculation, the foreseen 4D dose distributions can be estimated prospectively, their accuracy to which extent can be predicted a priori is questionable, due to the large number of variables involved. Therefore, reconstructing 4D dose retrospectively instead, based on the machine logfiles, allows for the re-assessment of the applied plan quality after patient treatment. However, besides considering the logged info on the actual beam delivery (e.g. spot positions, fluences, and time stamp), it is also important to incorporate the actual patient motions, ideally during delivery of the day. The conventional approach to reconstruct 4D dose relies on a single pre-treatment 4DCT, which subjects to the uncertainty of motion variabilities in frequency and amplitude both intra- and inter-fractionally. By phase-binning the delivered pencil beams according to the timings contained in the machine log-files, it only partially accounts for these variabilities during delivery. In order to achieve a more accurate 4D dose distribution towards reality, the motion model driven approach is beneficial, which can provide more realistic 4D patient representation for dose reconstruction by the predicting the time-resolved 3DCT images from the real-time measured respiratory surrogate during the dose delivery.

Primary author: ZHANG, Ye**Presenter:** ZHANG, Ye

Contribution ID: **107**Type: **not specified**

Industrialization

Tuesday, September 6, 2022 11:00 AM (1 hour)

Placing on the market a Medical Device is subject to regulation in most of jurisdictions to ensure safety for patients and health care personnel. A new medical device needs to undergo a conformity assessment before being placed on the market and is subject to surveillance during its lifetime to ensure its safety and correct performance. According to the potential risks posed by the medical device, the conformity assessment follows different routes and can involve or not external accredited organisms. Additionally, the manufacturer is responsible to maintain the safety and performance of the medical device for its whole lifetime once it is placed on the market. This talk focus on the medical device regulations of the United States and Europe by going through the steps for placing and maintaining a medical device on the market and clarifying the role and responsibilities of the different stakeholders.

Primary author: BRUSASCO, Caterina

Presenter: BRUSASCO, Caterina

Contribution ID: **108**Type: **not specified**

Big data: fast access, transfer, storage

Tuesday, September 6, 2022 12:00 PM (1 hour)

Data acquisition in high energy physics is a challenging task in terms of reliability and scalability. We present a framework for transferring raw acquisition data to the large-scale distributed file system Lustre and additionally archive the data in an archiving system in near real-time. The framework employs multiple queue data-structures and exploits producer-consumer paradigm to leverage reliable and scalable asynchronous data transfer. Latest 2022 beam time of the HADES experiment underpins the effectiveness of the framework.

Primary author: STIBOR, Thomas

Presenter: STIBOR, Thomas

Contribution ID: **109**Type: **not specified**

Deformable image registration

Thursday, September 8, 2022 11:00 AM (1 hour)

Over the last few decades, deformable image registration (DIR) has gained popularity in image-guided adaptive radiotherapy for a number of applications, such as contour propagation, dose warping, and accumulation. The variety of proposed DIR algorithms is vast, ranging from well-known image-based iterative optimization processes to novel machine learning solutions.

However, proper validation of the available DIR algorithms from both a geometrical and dosimetric standpoint is mandatory to properly adopt this methodology into the clinical practice. This is even more evident in case of particle therapy where steep dose-gradients are present and where DIR inaccuracies need to be properly assessed.

In this talk, basic concepts of image registration will be presented along with different algorithms available in the literature. A specific focus will be also put on DIR validation to provide robust, reliable and accurate patient-specific strategies for DIR application in adaptive particle therapy.

Primary author: PAGANELLI, Chiara

Presenter: PAGANELLI, Chiara

Contribution ID: **110**

Type: **not specified**

(Automated) contouring in the context of ART

Thursday, September 8, 2022 12:00 PM (1 hour)

Primary author: SONKE, Jakob

Presenter: SONKE, Jakob

Contribution ID: 112

Type: **not specified**

Challenges of operating a PT facility

Wednesday, September 7, 2022 10:30 AM (1 hour)

Primary author: KIRKBY, Karen

Presenter: KIRKBY, Karen

Contribution ID: 113

Type: **not specified**

Certification standards: Health, Safety, Environmental

Wednesday, September 7, 2022 2:30 PM (1 hour)

Primary author: KRALJ KUNČIČ, Marjetka

Presenter: KRALJ KUNČIČ, Marjetka

Contribution ID: 114

Type: **not specified**

Data Constructs and Computations in Adaptive Radiotherapy

Wednesday, September 7, 2022 3:30 PM (1 hour)

Radiotherapy workflow assumed a linear sequence from intake to last treatment. Tasks were decoupled, without feedback and data was sparse. Adaptive radiotherapy (ART) presents data increase with feedback anywhere. Changes need to be processed within this changing context. Complexity management requires the use of up-to-date computing concepts.

We define two levels. The first concerns task automation given patient and objectives context. We ensure sequencing within context and return results to update the context. The second concerns task computations with changed inputs. Computational graphs model these and ensure minimal re-computations. DICOM Second generation real-world model and IHE-RO are specifications for our model.

The workflow collects data generated in task execution into a DICOM 2G RT Course instance which models the patient state. An interpreter uses the RT Course and objectives to produce new tasks. Tasks are posted on the network and accepted by compatible task providers. The task produces data, returned and added to the RT Course. DICOM models the correct interment of results in the RT Course and ensures data traceability. ART requires automation of, typically repetitive, tasks executions. This requires traceability of the computation chain and processed data. We use computational graphs to record these details. The graphs allow for sparse, optimal, re-computations given antecedent property changes.

We deployed a workflow environment and a task automation model consistent with ART requirements. Requirements include data immutability, traceability to antecedents and of computations. The environment uses a service-oriented architecture that allows for extensibility and complexity by decomposition into “small” tasks.

Primary author: KOOY, Hanne

Presenter: KOOY, Hanne

Contribution ID: 116

Type: **not specified**

Clinical Monte Carlo for particles

Thursday, September 8, 2022 8:30 AM (1 hour)

Monte Carlo is the golden standard for computing dose in radiotherapy, but has traditionally been burdened with long computation times compared to analytical dose algorithms. Due to its superior accuracy in complicated geometries, and the possibility to score additional components in addition to dose (e.g. LET), Monte Carlo can be a very useful tool for the optimization and final dose computation of treatment plans, given that it can be fast enough.

The RayStation TPS (RaySearch Laboratories) has had a clinical Monte Carlo dose computation for proton PBS since 2016. In 2020, it was reimplemented on GPU, bringing major improvements to the computation speed. I will present the general algorithms for a clinical Monte Carlo, and the special considerations necessary to make it fast without compromising on the accuracy for clinical radiotherapy purposes.

Development of the Monte Carlo dose computation for carbon and helium ions is ongoing. Many features, e.g. transport mechanics, are the same, but there are multiple challenges specific to heavier ions. Primary ions will fragment into multiple lighter particles, and heavier target recoils will also have an impact. This requires a large set of cross sections for all interactions having a significant contribution to the dose. Furthermore, clinical practice requires that RBE-weighted dose is computed, typically using the Local Effect Model (LEM) or the Mikrodosimetric Kinetic Model (MKM). In order to do this, it is necessary to score additional quantities like the dose-averaged alpha and beta, putting additional challenges to performance and memory consumption. Because of the beamline contribution to the fragmentation of the initial beam, this will also have to be taken into account.

Primary author: GLIMELIUS, Lars

Presenter: GLIMELIUS, Lars

Contribution ID: 117

Type: **not specified**

Projection Methods, Superiorization and Applications

Thursday, September 8, 2022 9:30 AM (1 hour)

Projection methods are iterative algorithms that use projections onto sets while relying on the general principle that when a family of sets is present, then projections onto the given individual sets are easier to perform than projections onto other sets that are derived from the given individual sets.

Their robustness, low computational effort and their ability to handle huge-size problems make them very useful for many convex and non-convex real-world problems such as Intensity-Modulated Radiation Therapy (IMRT) Treatment Planning as well as Sudoku and 8 Queens Puzzle.

The Superiorization Methodology is a heuristic tool and its goal is to find certain good, or superior, solutions to feasibility and optimization problems. In many scenarios, solving the full problem can be rather demanding from the computational point of view, but solving part of it, say the feasibility part is, often, less demanding.

It has been developed and applied successfully to feasibility, single and multi-objective optimization.

In this talk I will provide an overview on the above concepts, present several theoretical and practical results and also potential direction for future research.

Primary author: GIBALI, Aviv

Presenter: GIBALI, Aviv

Contribution ID: **121**

Type: **not specified**

Hackathon challenge

Friday, September 9, 2022 8:30 AM (3h 55m)

Coding workshop to control a Proton therapy device.

Contribution ID: 122

Type: **not specified**

Entrepreneurship

Sunday, September 4, 2022 5:30 PM (1 hour)

A famous physics professor once said »if you want to make money, don't go through physics. Go the direct way, study economics«. This may have been true in his time, but it certainly isn't now. I will demonstrate with myself as example, how a "simple" physicist and a couple of physics students, like "you and me", started on an entrepreneurial journey 20 years ago and are now running the world's leading company in their field. By honestly explaining what we had (actually, it would be more correct to use the expression "didn't have") to become successful, I will try to generalize and give some common sense useful advice in case you want to start your own company. An important point will be the comparison of the academic and business cultures –where are the differences and what are the similarities.

Primary author: PLESKO, Mark**Presenter:** PLESKO, Mark

Contribution ID: 123

Type: **not specified**

Public Talk: INNOVATION IN MEDICAL PHYSICS

Primary author: MACKIE, Rock

Presenter: MACKIE, Rock

Contribution ID: 124

Type: **not specified**

New Product Development: Systems engineering approach for Regulatory compliance

Wednesday, September 7, 2022 9:30 AM (1 hour)

ProtonVDA was funded by the USA National Cancer Institute to develop a clinically realistic proton radiography and tomography prototype system. This funding also requires a commercialization plan, including for regulatory certification. Our research team includes several medical physicists and radiation oncologists to help ensure the clinical applicability. This talk will provide an overview of our system, and how we designed it to efficiently integrate with treatment rooms and clinical workflows using pencil beam scanning.

Primary author: DE JONGH, Fritz

Presenter: DE JONGH, Fritz

Contribution ID: 127

Type: **not specified**

Health Economics

Tuesday, September 6, 2022 2:00 PM (1 hour)

Presenter: Prof. LIEVENS, YOLANDE

Contribution ID: 128

Type: **not specified**

Clinical needs for adaptive proton therapy

Thursday, September 8, 2022 3:30 PM (1 hour)

Presenter: Prof. TROOST, Esther

Contribution ID: **129**

Type: **not specified**

Concluding remarks

Thursday, September 8, 2022 4:30 PM (30 minutes)