AZIENDA OSPEDALIERO - UNIVERSITARIA
Città della Salute e della Scienza di Torino

POLITECNICO DI TORINO

DEPARTMENT OF ONCOLOGY
UNIVERSITY OF TURIN

29 Marzo 2019 - Trieste

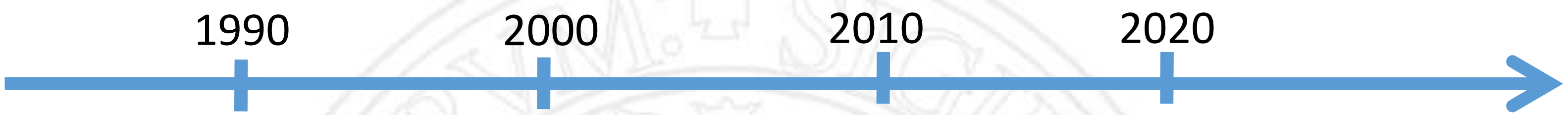
ICTP School of Medical Physics for Radiation Therapy: Dosimetry and Treatment Planning for Basic and Advanced Applications

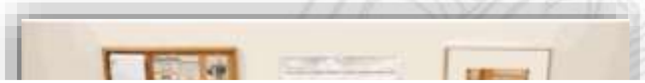
Automatic vs manual planning: validation process among different clinical contests

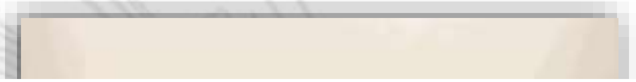
Christian Fiandra

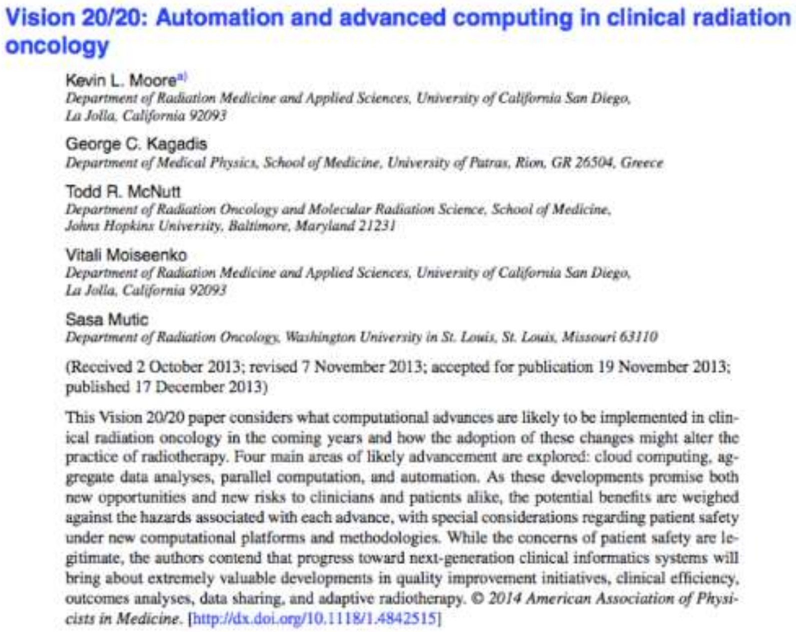
Overview

Radiotherapy Planning









Vision 20/20: Automation and advanced computing in clinical radiation oncology

Kevin L. Moore[a)]
Department of Radiation Medicine and Applied Sciences, University of California San Diego, La Jolla, California 92093

George C. Kagadis
Department of Medical Physics, School of Medicine, University of Patras, Rion, GR 26504, Greece

Todd R. McNutt
Department of Radiation Oncology and Molecular Radiation Science, School of Medicine, Johns Hopkins University, Baltimore, Maryland 21231

Vitali Moiseenko
Department of Radiation Medicine and Applied Sciences, University of California San Diego, La Jolla, California 92093

Sasa Mutic
Department of Radiation Oncology, Washington University in St. Louis, St. Louis, Missouri 63110

(Received 2 October 2013; revised 7 November 2013; accepted for publication 19 November 2013; published 17 December 2013)

This Vision 20/20 paper considers what computational advances are likely to be implemented in clinical radiation oncology in the coming years and how the adoption of these changes might alter the practice of radiotherapy. Four main areas of likely advancement are explored: cloud computing, aggregate data analyses, parallel computation, and automation. As these developments promise both new opportunities and new risks to clinicians and patients alike, the potential benefits are weighed against the hazards associated with each advance, with special considerations regarding patient safety under new computational platforms and methodologies. While the concerns of patient safety are legitimate, the authors contend that progress toward next-generation clinical informatics systems will bring about extremely valuable developments in quality improvement initiatives, clinical efficiency, outcomes analyses, data sharing, and adaptive radiotherapy. © *2014 American Association of Physicists in Medicine.* [http://dx.doi.org/10.1118/1.4842515]

Developments hold promise to improve clinical radiation oncology computing

- Cloud-based service models
  - server-based "virtual machines" that facilitate remote user access and leverage centralized computations while minimizing large data transfers over network
- Parallel computation
  - distributed calculation frameworks for dose calculation and enterprise software systems (HPC, GPU..)
- Aggregate data analyses
  - the synthesis of quantitative information from a multiplicity of measurements
- Automation

Google

artificial intelligence

Tutti | Notizie | Immagini | Video

Circa 631.000.000 risultati (0,42 secondi)

Google

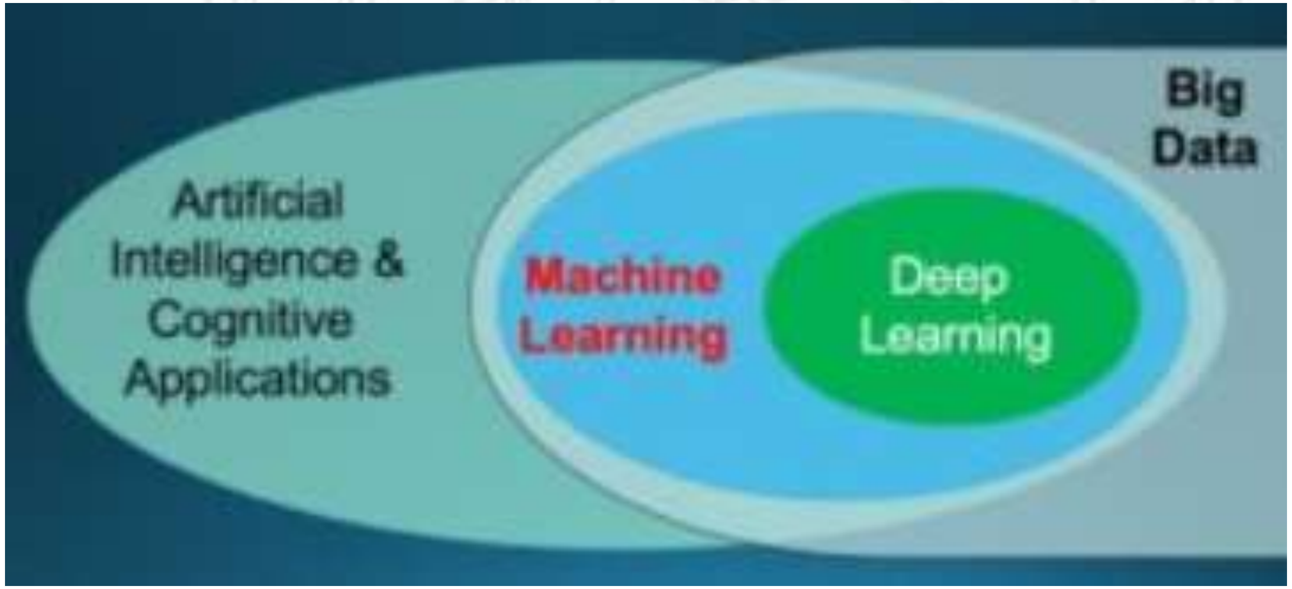
cristiano ronaldo

Tutti | Notizie | Immagini | Video

Circa 218.000.000 risultati (0,52 secondi)


RayStation
MCO
VARIAN
medical systems
RapidPlan
Elekta I-cycle
PHILIPS
Pinnacle
Pinnacle Auto-Planning
Home made

ALGORITMO


Big Data
Artificial Intelligence & Cognitive Applications
Machine Learning
Deep Learning


The Fourth Industrial Revolution
Klaus Schwab
Founder and Executive Chairman, World Economic Forum

Kai-Fu Lee

Scrittore

Nascita: 3 dicembre 1961 (età 57 anni), Nuova Taipei, Taiwan

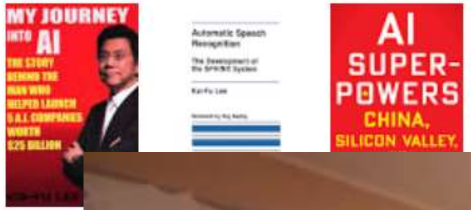
Coniuge: Hsieh Shen Ling (s. 1983)

Istruzione: Università Carnegie Mellon (1988), C (1983), Oak Ridge High School

Figli: Jennifer Lee, Cynthia Lee

Genitori: Li Tien Min, Ya-Ching Wang

Libri



Fear of the toll that AI might take on job security is substantiated. As I point out in my new book, *AI Superpowers: China, Silicon Valley, and the New World Order*, about 50% of our jobs will, in fact, be taken over by AI and automation within the next 15 years. Accountants, factory workers, truckers, paralegals, and radiologists—just to name a few—will be confronted by a disruption akin to that faced by farmers during the industrial revolution. As research suggests, the pace in which AI will replace jobs will only accelerate, impacting the highly trained and poorly educated alike.

Overview

Automation in Radiotherapy Planning

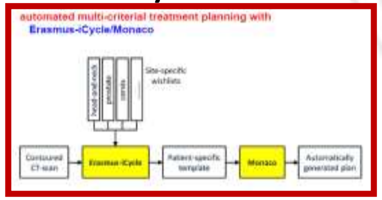
Implementation

RayStation

MCO

VARIAN medical systems

Elekta I-cycle

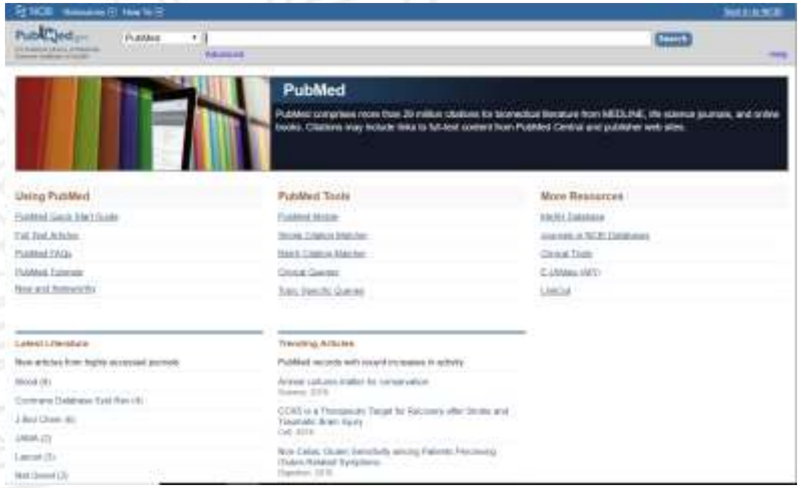


PHILIPS

Pinnacle³

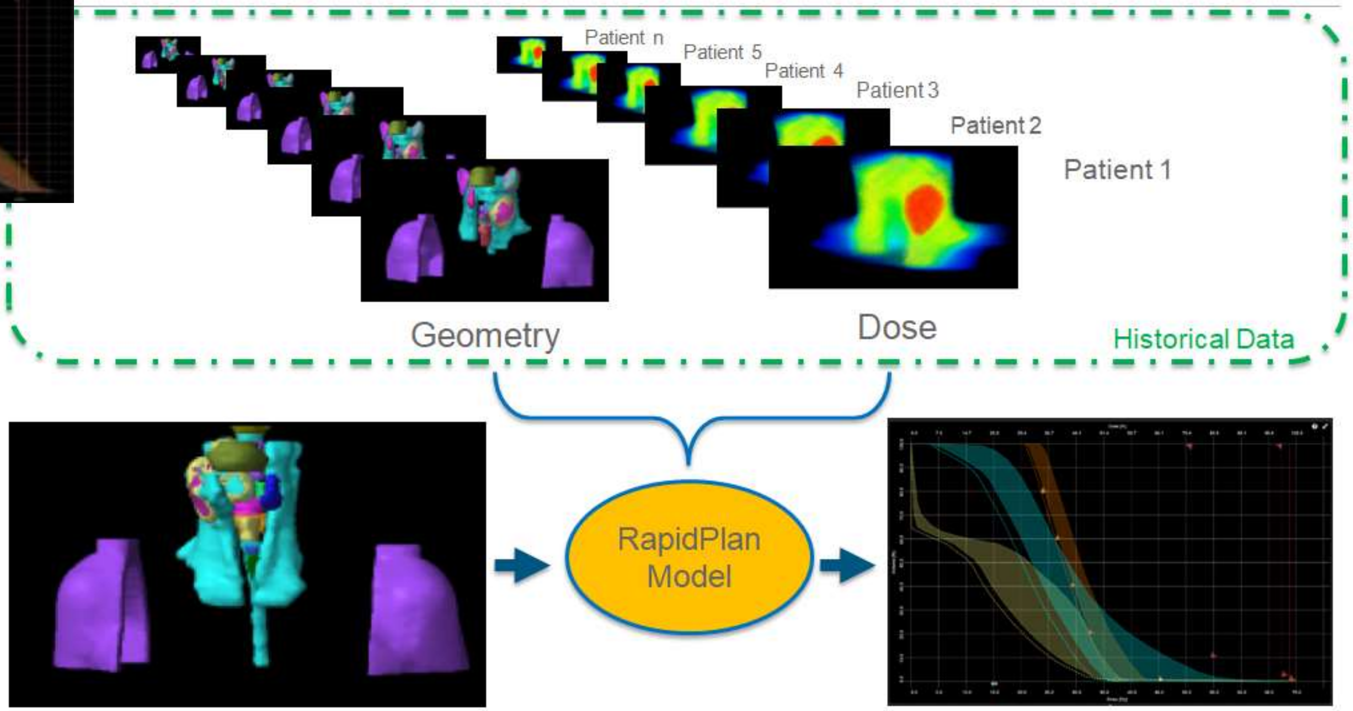
Pinnacle³ Auto-Planning

Validation



Treatment planning automation

<u>A knowledge-based planning (KBP)</u>



Treatment planning automation

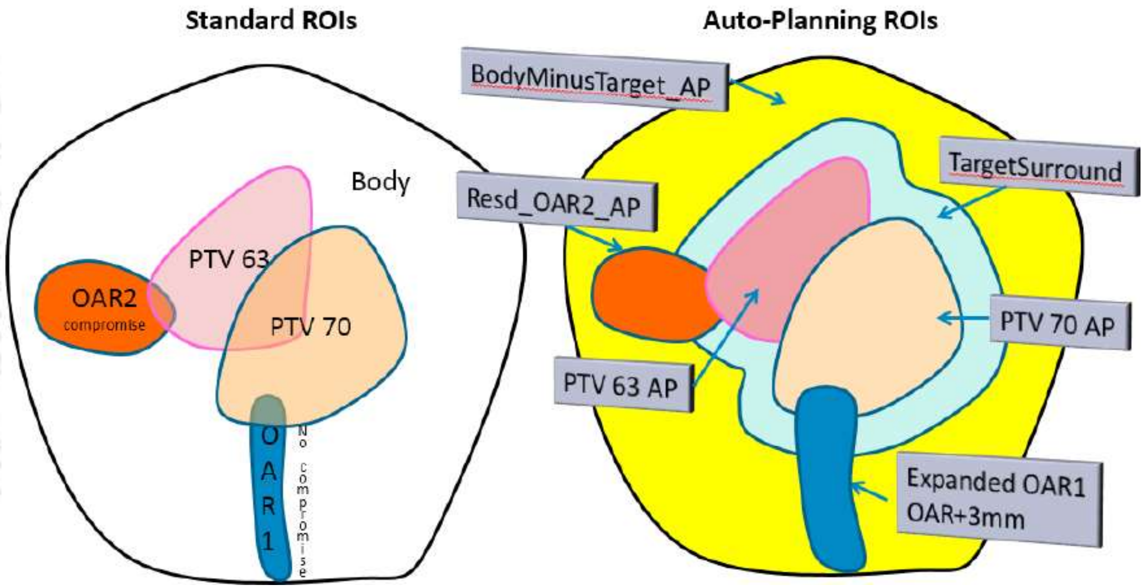
PHILIPS

Pinnacle³

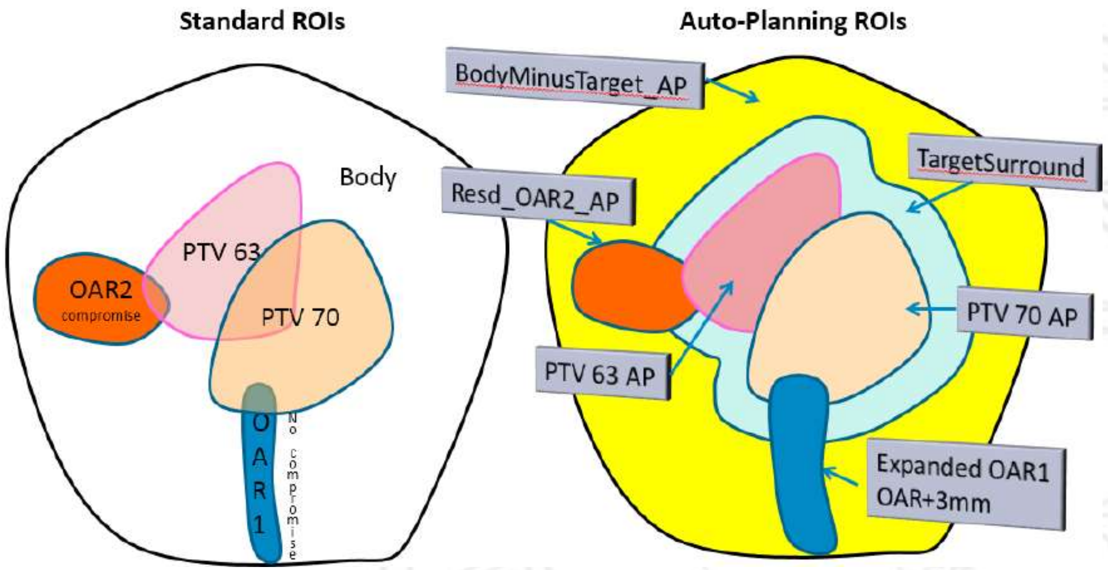
Pinnacle³ Auto-Planning

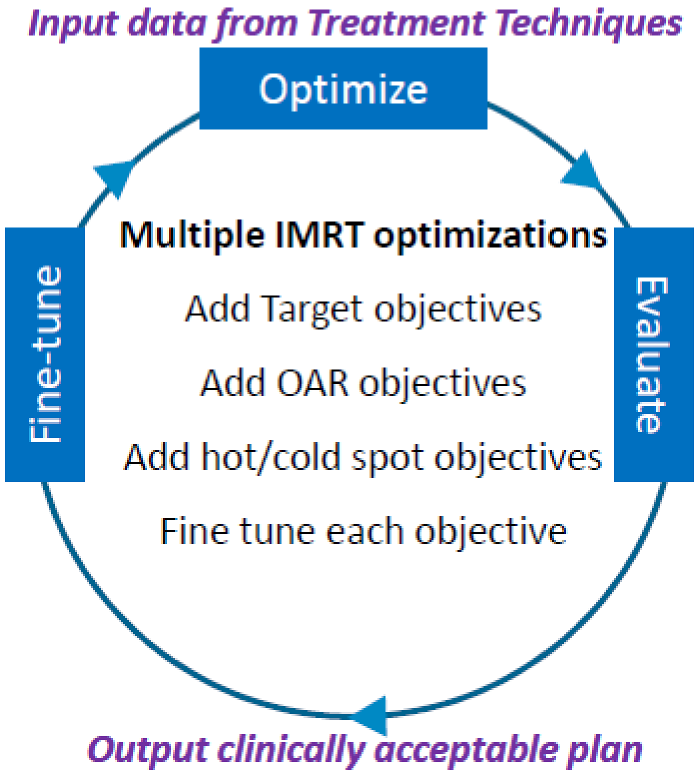
Progressive Optimization Algorithm POA

Auto-Planning ROIs



Auto-Planning ROIs





Loop1: Resets the beams. Add **Target Objectives**. Opti

Loop2: Add **OAR Objectives**. Optimize.

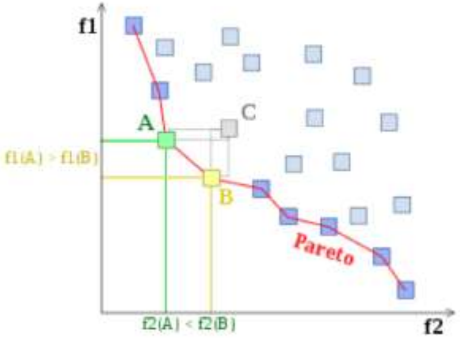
Loop3: **Tune** OAR Objectives. Optimize

Loop4: Reset the Beams. Tune/Add OAR Objectives**. Hot/Cold spot objectives**. Optimize.

Loop5: Tune/Add OAR Objectives, Hot/Cold spot objectives. Optimize.

Treatment planning automation

MultiCriteria Optimization

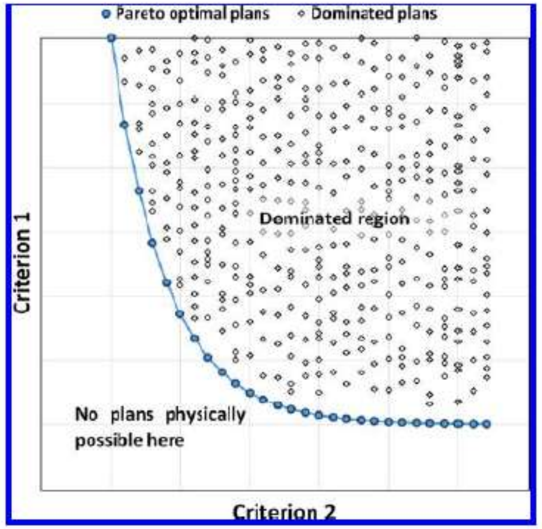


Key concept: PARETO OPTIMAL SOLUTION

A plan that cannot be improved in any of the objectives without degrading at least one of the other objectives

Treatment planning automation

a posteriori MCO approach



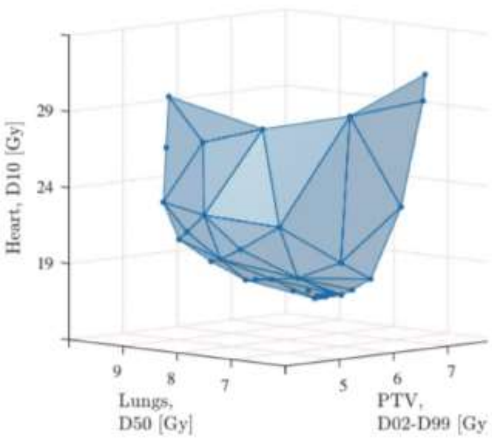
(Hussein, BJR 2018)

- Multiple plans are automatically generated where each criterion is optimised to the extent where it cannot be improved upon without affecting at least one other criterion; each of these plans is a so-called pareto optimal solution
- The graph shows a large number of different feasible planning solutions, representing a variety of different permutations for criterion 1 and 2.
  - The solid line represents the pareto front where improving one criterion inevitably leads to the worsening of the other and vice-versa. Plans that lie on this front are the "pareto optimal solutions" (blue circles o).
  - The plans shown as diamonds ◊ are referred to as "dominated" because there is always a solution on the Pareto front where at least one criterion can be improved.
- Pareto optimality by itself does not imply clinical optimality and Pareto optimal plans can be clinically highly undesirable. On the other hand, the best clinically acceptable plan is Pareto optimal. (..)
- The database of Pareto optimal plans (AUTOMATICALLY GENERATED) is interactively (a posteriori) navigated by the treatment planner to choose a clinically optimal plan: N objectives -> N+1 plans to build Pareto front

Treatment planning automation

a posteriori MCO approach or navigation-based

RayStation



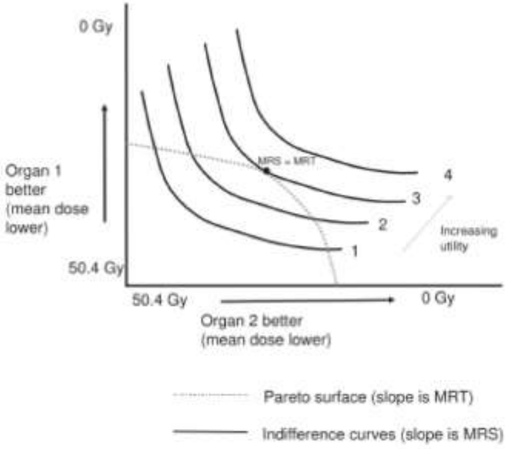
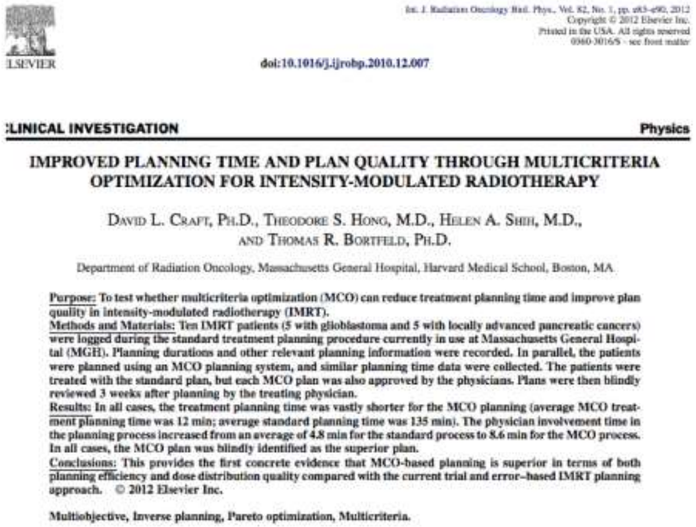


Fig. 5. Curves illustrating the idea from decision theory that the optimal choice in a two-dimensional tradeoff is the point on the Pareto surface that maximizes utility. This is also the point where MRT (marginal rate of transformation, or the slope of the Pareto curve) is equal to MRS (marginal rate of substitution).



LSEVIER

Int. J. Radiation Oncology Biol. Phys., Vol. 82, No. 1, pp. e83–e90, 2012

0360-3016/$ - see front matter

doi:10.1016/j.ijrobp.2010.12.007

:LINICAL INVESTIGATION — Physics

IMPROVED PLANNING TIME AND PLAN QUALITY THROUGH MULTICRITERIA OPTIMIZATION FOR INTENSITY-MODULATED RADIOTHERAPY

David L. Craft, Ph.D., Theodore S. Hong, M.D., Helen A. Shih, M.D., and Thomas R. Bortfeld, Ph.D.

Department of Radiation Oncology, Massachusetts General Hospital, Harvard Medical School, Boston, MA

Purpose: To test whether multicriteria optimization (MCO) can reduce treatment planning time and improve plan quality in intensity-modulated radiotherapy (IMRT).
Methods and Materials: Ten IMRT patients (5 with glioblastoma and 5 with locally advanced pancreatic cancers) were logged during the standard treatment planning procedure currently in use at Massachusetts General Hospital (MGH). Planning durations and other relevant planning information were recorded. In parallel, the patients were planned using an MCO planning system, and similar planning time data were collected. The patients were treated with the standard plan, but each MCO plan was also approved by the physicians. Plans were then blindly reviewed 3 weeks after planning by the treating physician.
Results: In all cases, the treatment planning time was vastly shorter for the MCO planning (average MCO treatment planning time was 12 min; average standard planning time was 135 min). The physician involvement time in the planning process increased from an average of 4.8 min for the standard process to 8.6 min for the MCO process. In all cases, the MCO plan was blindly identified as the superior plan.
Conclusions: This provides the first concrete evidence that MCO-based planning is superior in terms of both planning efficiency and dose distribution quality compared with the current trial and error–based IMRT planning approach. © 2012 Elsevier Inc.

Multiobjective, Inverse planning, Pareto optimization, Multicriteria.

Potential limitation: optimised plans are *near Pareto optimal* in the fluence phase without direct machine-parameter consideration (then converted into deliverable plans by DAO)

Treatment planning automation

a priori MCO approach: a single pareto-optimal plan

- Planner sets up in advance a set of goals, related to clinical prescriptions, that are ordered with respect to importance (whish list).
- Lexicographic Optimization is performed as a *stepwise sequence* of constrained optimizations, starting with the highest prioritized objective function.
- At each iterative step, a new objective function from the list is optimized with the previous goals incorporated as constraints so that the higher prioritized goals are not deteriorated.

- The constraints are non-negotiable and therefore have the highest priority. Additional constraints may be included from the beginning throughout all optimization steps to prevent unacceptable plans.
- The feasible solution space is gradually reduced as the method proceeds with the added constraints.
- Sometimes a preselected "slip factor" allows a small relaxation of the constraints since they may be so strict that there is no room for improvements in lower priority goals (a minor deviation from a uniformity constraint of a PTV may enable significant sparing of an OAR).

Treatment planning automation

a priori MCO approach: The Rotterdam Experience

IOP Publishing — Physics in Medicine and Biology
Phys. Med. Biol. **54** (2009) 7199–7209 doi:10.1088/0031-9155/54/23/011

The equivalence of multi-criteria methods for radiotherapy plan optimization

Sebastiaan Breedveld, Pascal R M Storchi and Ben J M Heijmen

Department of Radiation Oncology, Erasmus MC Rotterdam, Groene Hilledijk 301, 3075 EA Rotterdam, The Netherlands

Integrated multicriterial optimization of beam angles and intensity profiles for coplanar and noncoplanar head and neck IMRT and implications for VMAT

Peter W. J. Voet,[a] Sebastiaan Breedveld, Maarten L. P. Dirkx, Peter C. Levendag, and Ben J. M. Heijmen
Erasmus MC–Daniel den Hoed Cancer Center, Department of Radiation Oncology, Groene Hilledijk 301, 3075EA Rotterdam, The Netherlands

Erasmus MC
Universitair Medisch Centrum Rotterdam

International Journal of Radiation Oncology biology • physics
www.redjournal.org

Physics Contribution

Toward Fully Automated Multicriterial Plan Generation: A Prospective Clinical Study

Peter W.J. Voet, RTT, Maarten L.P. Dirkx, PhD, Sebastiaan Breedveld, MSc, Dennie Fransen, RTT, Peter C. Levendag, MD, PhD, and Ben J.M. Heijmen, PhD

Department of Radiation Oncology, Erasmus Medical Center—Daniel den Hoed Cancer Center, Groene Hilledijk 301, Rotterdam 3075EA, The Netherlands

Received Jan 24, 2012, and in revised form Mar 27, 2012. Accepted for publication Apr 10, 2012

Erasmus MC
Universitair Medisch Centrum Rotterdam

International Journal of Radiation Oncology biology • physics
www.redjournal.org

Physics Contribution

Fully Automated Volumetric Modulated Arc Therapy Plan Generation for Prostate Cancer Patients

Peter W.J. Voet, RTT, Maarten L.P. Dirkx, PhD, Sebastiaan Breedveld, PhD, Abrahim Al-Mamgani, MD, PhD, Luca Incrocci, MD, PhD, and Ben J.M. Heijmen, PhD

Department of Radiation Oncology, Erasmus MC—Daniel den Hoed Cancer Center, Rotterdam, The Netherlands

Received Sep 19, 2013, and in revised form Dec 10, 2013. Accepted for publication Dec 28, 2013.

Elekta I-cycle

Prostate wishlist

Constraints

Volume	Type	Limit
PTV	max	104% of prescribed dose
PTV shell 50 mm	max	60% of prescribed dose
Unspecified tissue	max	104% of prescribed dose
Right + Left hip	max	40 Gy

Objectives

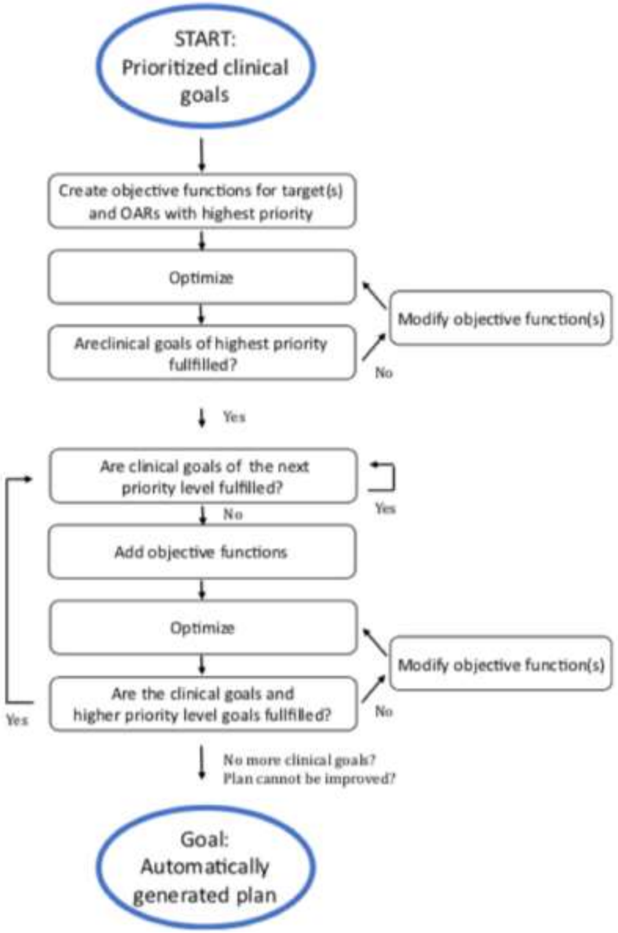
Priority	Volume	Type	Goal
1	PTV	↓LTCP	0.5
2	Rectum	↓gEUD (parameter 12)	40% of prescribed dose
3	Rectum	↓gEUD (parameter 8)	25% of prescribed dose
4	Rectum	↓mean	33% of prescribed dose
5	External ring	↓max	40% of prescribed dose
6	PTV shell 5 mm	↓max	93% of prescribed dose
7	Anus	↓mean	10% of prescribed dose
8	PTV shell 15 mm	↓max	70% of prescribed dose
9	PTV shell 25 mm	↓max	50% of prescribed dose
10	Bladder	↓mean	60% of prescribed dose
11	Right + Left Hip	↓mean	25% of prescribed dose
12	Unspecified tissue	↓mean	10 Gy

Treatment planning automation

Lexicographic optimization

RayStation Plan Explorer

A set of clinical goals are listed and ordered in terms of importance, where several goals can have the same priority level.
Objective functions that correspond to the clinical goals for the ROIs considered at the current priority level are automatically created by the algorithm, and their priority weights and dose levels are modified iteratively until the optimized plan fulfils the clinical goals stated for them. For each group of goals, objective functions are automatically added and modified with the aim of fulfilling the clinical goals without violating the levels achieved for the previous (higher prioritized) goals. *This automatic process can be performed for different beam configurations, other treatment machines, treatment techniques and modalities*



Treatment planning automation

Heuristic Optimization

IOP PUBLISHING PHYSICS IN MEDICINE AND BIOLOGY
Phys. Med. Biol. 56 (2011) 3873–3893 doi:10.1088/0031-9155/56/13/009

A methodology for automatic intensity-modulated radiation treatment planning for lung canc[illegible]

Xiaodong Zhang[1], Xiaoqiang Li, [illegible] and Yupeng Li

Department of Radi[illegible] [illegible]versity of Texas, 1515 [illegible]

In this paper, we describe a [illegible] planning process. The system base[illegible] [illegible] system, and the IMRT plan des[illegible] [illegible]accAutoPlan system's purpose is [illegible] [illegible]ive/cost function parameters auto[illegible] [illegible] tumor coverage and normal tissue [illegible] [illegible]ded to be better than, or at least equivalent [illegible] [illegible]ough trial-and-error. It is also our goal that the [illegible] [illegible]ly enough to be used in routine clinical practice. We have [illegible] [illegible]utoPlan system as a plug-in to the Pinnacle[3] treatment planning [illegible] [illegible]ips Nuclear Medicine, Inc., Fitchburg, WI). Once the contours are ready [illegible] patient, the autoplans can be generated by one button click in the TPS. The [illegible]accAutoPlan system was already adopted in a clinical trial that randomized proton and photon treatments for patients with stage III non-small-cell lung cancer so that the clinical value of passive-scattering proton therapy (PSPT) could be compared with that of IMRT. Initially for that trial, all photon IMRT plans were designed by the *mdaccAutoPlan* system and by experienced medical dosimetrists. Plans designed by the *mdaccAutoPlan* system and by the medical dosimetrists were simultaneously evaluated by experienced radiation oncologists, and the plans designed by the *mdaccAutoPlan* system were consistently judged to be better or no worse than the plans designed by medical dosimetrists. The trial was modified so that all photon clinical plans would be designed by the *mdaccAutoPlan* system. The system is now being used at The University of Texas, MD Anderson Cancer Center, for lung cancer cases. The same approach could be easily applied to other cancer types, although the details may differ. To our knowledge, the *mdaccAutoPlan* system is the first that can design IMRT plans using one button click and the first to be adopted into clinical

Heuristic is an approach for finding a solution to the problem not assuring to be optimal or perfect, but sufficiently good.

Treatment planning automation

Automation Plan Generation
Templates, protocols, and scripting

- For a specific indication there may be standard ways in a clinic to set up the plan for most of these patients
  - For example, the clinic may have a standard number of beams with certain beam orientations, a set of structures and ROIs with consistent names that are defined and contoured, some optimization functions that usually give a good starting point, and clinical goals to which the plan is evaluated against. These types of repetitive and recurrent steps in the planning process can be automated with **TEMPLATES**.
  - In a next step, templates and some actions can be grouped together to standardize the planning. In addition to templates running consecutively in a predefined schedule, certain settings such as grid resolution, the number of fractions, and the number of optimization iterations may be set to run automatically as well as certain actions such as optimization and dose computation
- Another approach is to record mouse clicks and keystrokes and then play the recorded program on other cases. **SCRIPTING** is an even more flexible tool. Besides automation of treatment planning, *it can be used to extract data, extend and further develop functionality, communicate with other programs, etc., which can be useful for specific needs for a clinic or in research projects*

Advanced Scripting

Heuristic Optimization - Genetic Algorithm

Scientific Research Publishing

International Journal of Medical Physics, Clinical Engineering and Radiation Oncology, 2018, 7, 414-425
http://www.scirp.org/journal/ijmpcero
ISSN Online: 2168-5444
ISSN Print: 2168-5436

Automated Heuristic Optimization of Prostate VMAT Treatment Planning

Christian Fiandra[1], Alessandro Alparone[2], Elena Gallio[3], Claudio Vecchi[2], Gabriella Balestra[4], Sara Bartoncini[5], Samanta Rosati[4], Riccardo Ragona[1], Umberto Ricardi[1]

[1]Department of Oncology, Radiation Oncology, University of Turin, Turin, Italy
[2]Tecnologie Avanzate T.A. Srl, Turin, Italy
[3]Medical Physics Unit, A.O.U. Città della Salute e della Scienza, Turin, Italy
[4]Department of Electronics and Telecommunication, Politecnico di Torino, Turin, Italy
[5]Radiation Oncology Unit, A.O.U. Città della Salute e della Scienza, Turin, Italy
Email: christian.fiandra@unito.it

GAs are a particular class of evolutionary algorithms that use techniques inspired by evolutionary biology such as inheritance, mutation, selection, and crossover (also called recombination)

Abstract

Purpose: To investigate a genetic algorithm approach to automatic treatment planning. **Methods:** A Python script based on genetic algorithm (GA) was implemented for VMAT treatment planning of prostate tumor. The script was implemented in RayStation treatment planning system using Python code. Two different clinical prescriptions were considered: 78 Gy prescribed to planning target volume in 39 fractions (GROUP 1) and simultaneous integrated boost (70.2 Gy to prostate bed and 61.1 Gy to seminal vesicles) in 26 fractions (GROUP 2). The script automatically optimizes doses to PTV and OARs according to GA. A comparison with corresponding plans created with Monaco TPS (M) and Auto-Planning module of Pinnacle[3] (AP) was carried out. The plans were evaluated with a total score (TS) of PlanIQ software in terms of target coverage and sparing of OARs as well as clinical score (CS) performed by a Radiation Oncologist. **Results:** In GROUP 1, mean value of TS were 150.6 ± 30.7, 146.3 ± 36.1 and 137.4 ± 35.7 for AP, GA and M respectively. For GROUP 2, mean value for TS were 163.5 ± 16.8, 163.4 ± 24.7 and 162.9 ± 16.6 for AP, GA and M respectively with no significance differences. In terms of CS, the highest value has been attributed to GA in four patients out of five for both GROUP 1 and 2. **Conclusions:** Genetic approach is practicable for prostate VMAT plan generation and studies are underway in other anatomical sites such as Head and Neck and Rectum.

Volume

UNIVERSITÀ DEGLI STUDI DI TORINO

Dottorato interateneo in **bioingegneria e scienze medico chirurgiche**

2017 - 2020

TECNOLOGIE AVANZATE → Autoplanning su RayStation

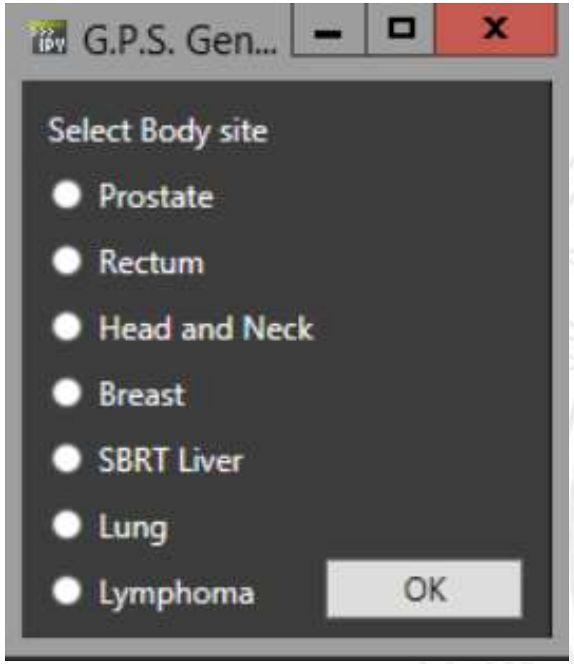
Phyton + algoritmi ottimizzazione

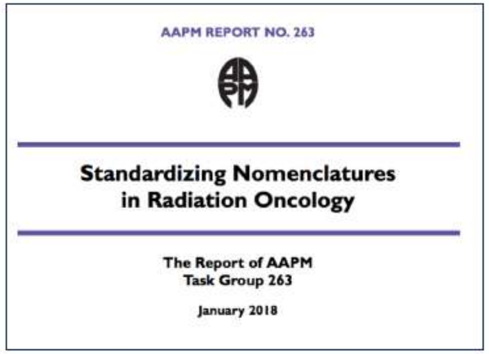
- Dr. C. Vecchi (Fisico)
- Ing. A. Alparone, Ing. S. Zara
- Prof.ssa G. Balestra, Ing. C. Castagneri, Ing. S. Rosati

UNIVERSITÀ DEGLI STUDI DI TORINO → Esperienza di pianificazione in rt

- Dr C. Fiandra
- AZIENDA OSPEDALIERO - UNIVERSITARIA Città della Salute e della Scienza di Torino — Prof. U. Ricardi

Genetic Planning Solution 2.0

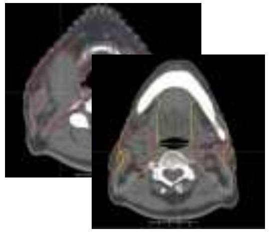




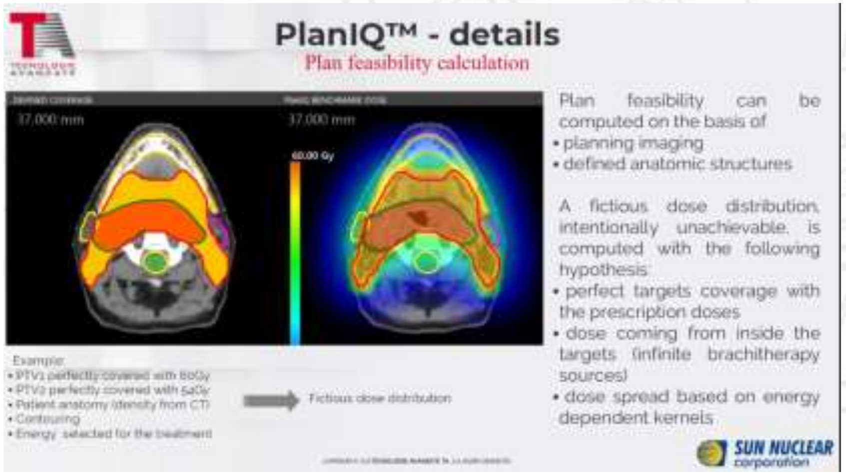
Physical Composite Objective				
Min DVH	Plan	PTV1.1	Min DVH 7000 cGy to 95% volume	100.00
Max DVH	Plan	PTV1.1	Max DVH 7490 cGy to 2% volume	100.00
Max Dose	Plan	PTV1.1	Max Dose 7490 cGy	100.00
Max Dose	Plan	ring1.1	Max Dose 6650 cGy	50.00
Min DVH	Plan	PTV1.2	Min DVH 6300 cGy to 95% volume	100.00
Max DVH	Plan	RealPTV1.2	Max DVH 6741 cGy to 2% volume	100.00
Max Dose	Plan	newringbis1.2	Max Dose 5985 cGy	50.00
Min DVH	Plan	PTV1.3	Min DVH 5400 cGy to 95% volume	100.00
Max DVH	Plan	RealPTV1.3	Max DVH 5778 cGy to 2% volume	100.00
Max Dose	Plan	newringbis1.3	Max Dose 5130 cGy	50.00
Uniform Dose	Plan	PTV1.1	Uniform Dose 7000 cGy	150.00
Uniform Dose	Plan	RealPTV1.2	Uniform Dose 6300 cGy	150.00
Uniform Dose	Plan	RealPTV1.3	Uniform Dose 5400 cGy	150.00
Dose Fall-Off	Plan	Ext1	Dose Fall-Off [H]7000 cGy [L]1400 cGy, Low dose distance 4.00 cm	80.00

Genetic Planning Solution 2.0

Background knowledge

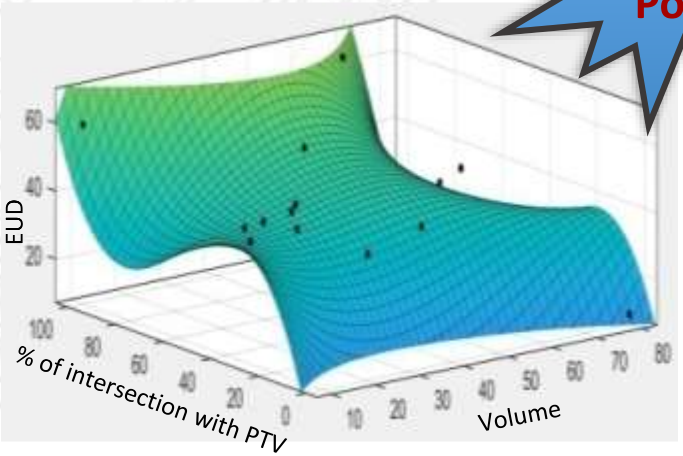


n>20



For each “genetic” OAR

Starting Point



Genetic optimization

Genetic algorithms are commonly used to generate high-quality solutions to optimization and search problems by relying on bio-inspired operators such as mutation, crossover and selection

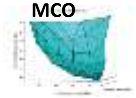
Overview

Automation in Radiotherapy Planning

Implementation

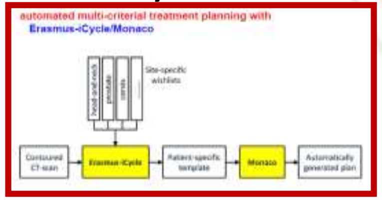
RayStation

MCO



VARIAN medical systems

Elekta I-cycle



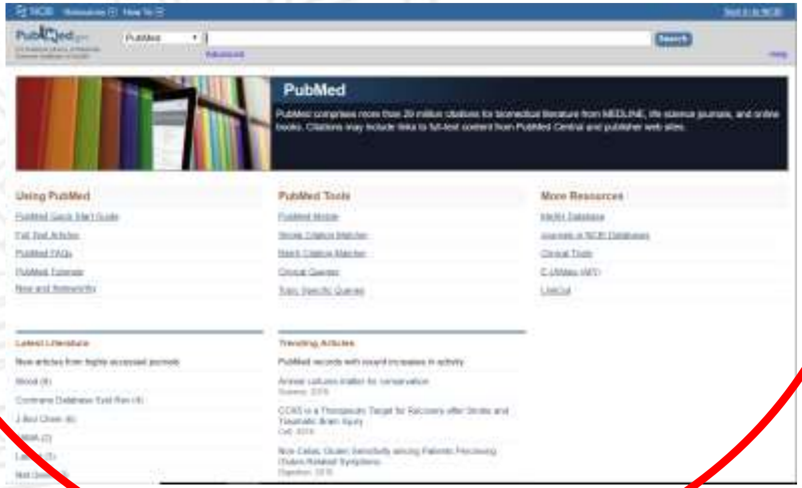
PHILIPS

Pinnacle³

Pinnacle³ Auto-Planning

Home made

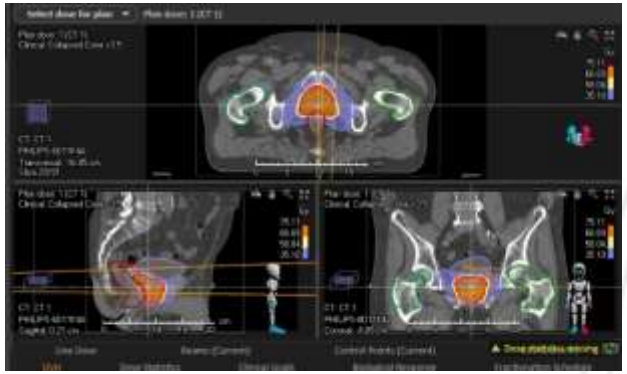
Validation



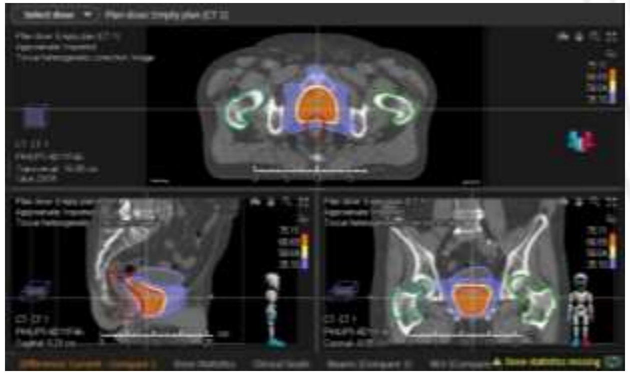
Validation

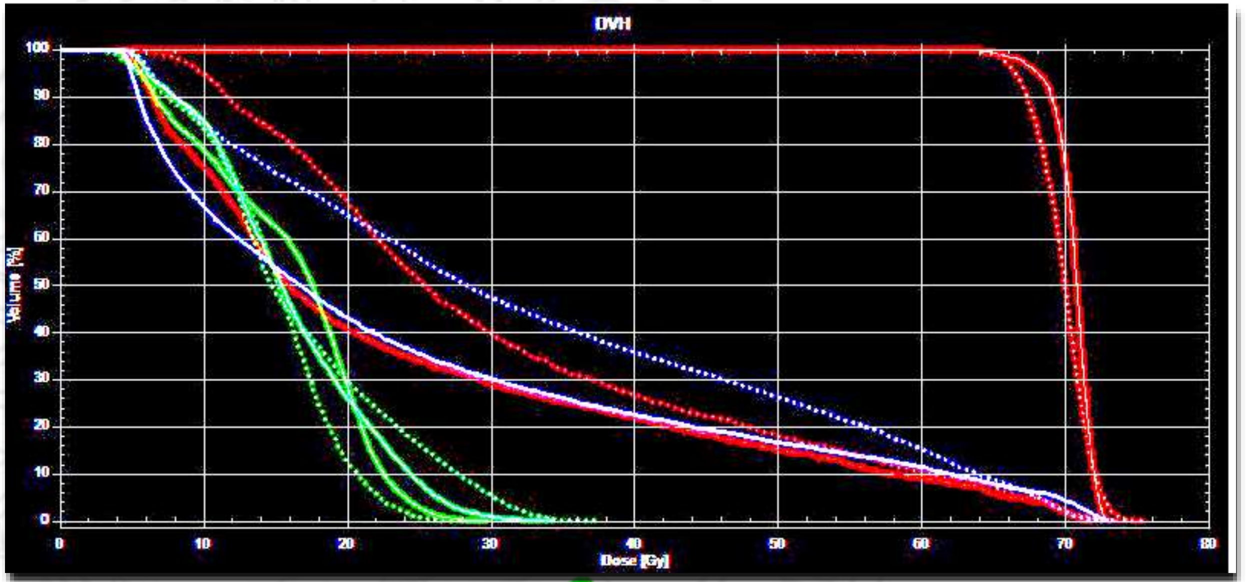
Which is the better plan?

1



2





1 —

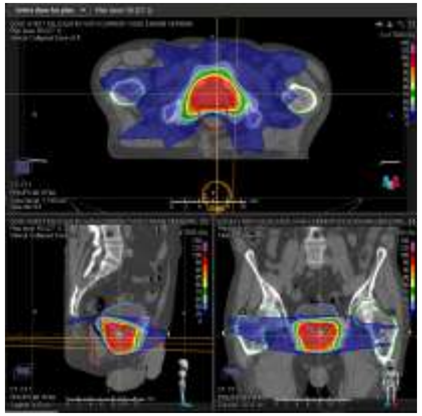
2 .....

1 or 2

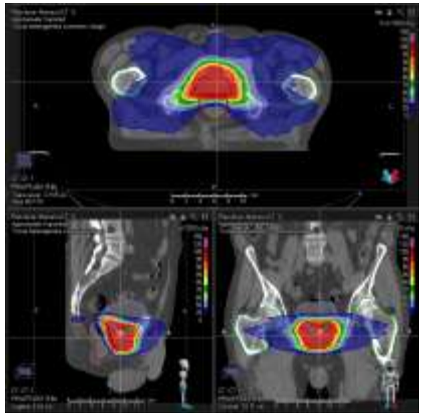
Validation

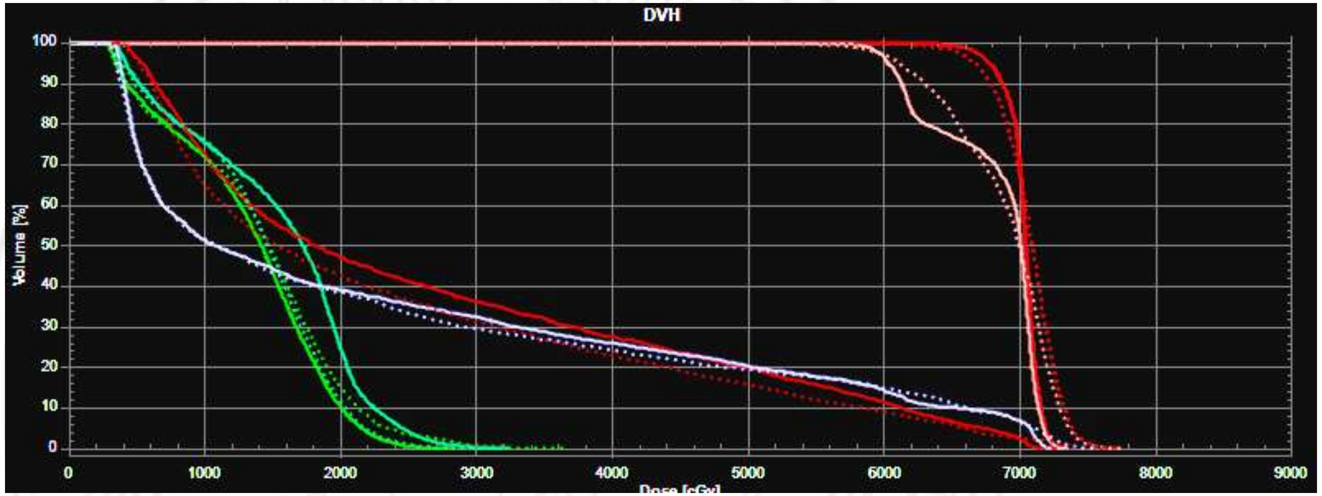
Which is the better plan?

1



2



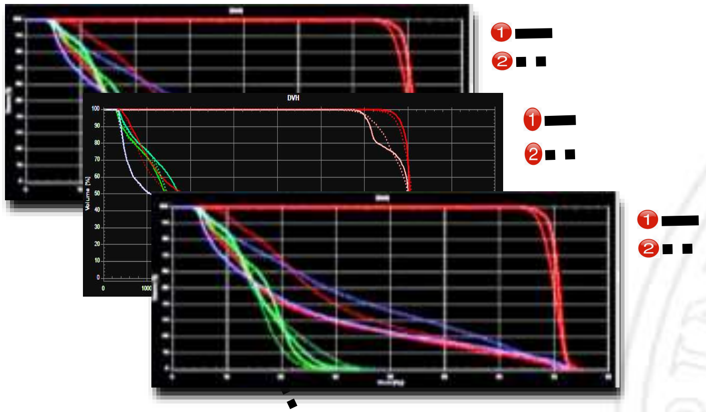


1 —

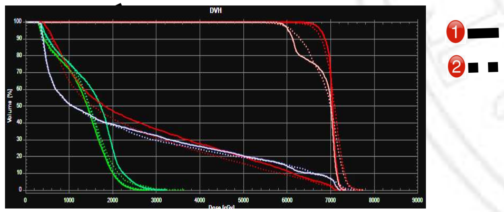
2 ·····

1 *or* **2**

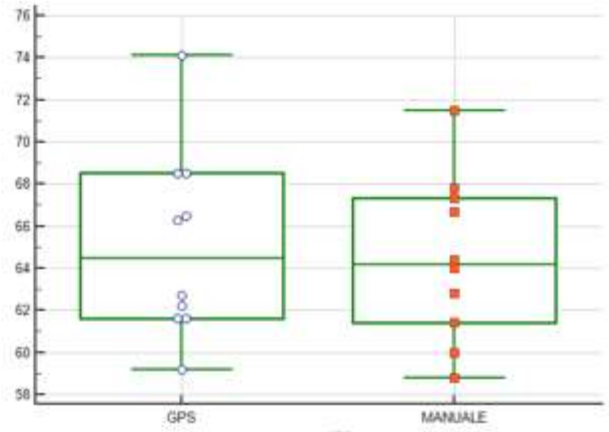
Validation

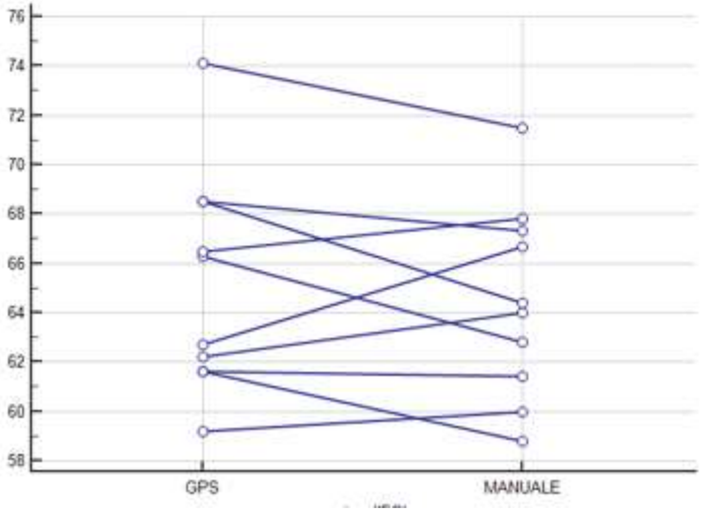


many patients…..



PQM (%)





RP - Validation

Radiotherapy and Oncology 120 (2016) 473–479

Contents lists available at ScienceDirect

Radiotherapy and Oncology

journal homepage: www.thegreenjournal.com

Knowledge-based treatment planning

Clinical validation and benchmarking of knowledge-based IMRT and VMAT treatment planning in pelvic anatomy

Mohammad Hussein [a,*], Christopher P. South [a], Miriam A. Barry [a], Elizabeth J. Adams [a], Tom J. Jordan [a], Alexandra J. Stewart [c], Andrew Nisbet [a,b]

[a] Department of Medical Physics, Royal Surrey County Hospital NHS Foundation Trust; [b] Centre for Nuclear and Radiation Physics, University of Surrey; and [c] Department of Oncology, Royal Surrey County Hospital NHS Foundation Trust, Guildford, UK

Therefore the key questions addressed in this study were:

1. How does plan quality depend on the statistical robustness of the DVH-prediction model and the methods used to convert predicted DVHs into plan optimisation objectives?
2. How does RapidPlan perform when multiple dose levels are prescribed?
3. How does RapidPlan perform when there are significant geometric variations in target volumes?

Model of 40 prostate IMRT applied to 37 cervical cancer

Conclusions: The Varian RapidPlan™ system was able to produce IMRT & VMAT treatment plans in the pelvis, in a single optimisation, that had comparable sparing and comparable or better conformity than the original clinically acceptable plans. The system allows for better consistency and efficiency in the treatment planning process and has therefore been adopted clinically within our institute with over 100 patients treated.

Ueda et al. Radiation Oncology (2018) 13:46
https://doi.org/10.1186/s13014-018-0994-1

Radiation Oncology

RESEARCH Open Access

Evaluation of multiple institutions' models for knowledge-based planning of volumetric modulated arc therapy (VMAT) for prostate cancer

Yoshihiro Ueda[1], Jun-ichi Fukunaga[2], Tatsuya Kamima[3], Yumiko Adachi[4], Kiyoshi Nakamatsu[5] and Hajime Monzen[6*]

Conclusions

It has been suggested that KBP performs correctly regardless of institutional plan design. KBP was able to reproduce dose distributions based on the experience of institutions. There was very wide variation in the organ dose calculated with KBP among sites. To share models for KBP, it will be necessary to determine whether the registered DVH curves in the models match the plan design. The models for the KBP were characterized with the ratio of OAR's volume overlapping with the PTV to the whole organ volume.

Knowledge-based automated planning for oropharyngeal cancer

Aaron Babier[a)] and Justin J. Boutilier
Department of Mechanical and Industrial Engineering, University of Toronto, 5 King's College Road, Toronto M5S 3G8, ON, Canada

Andrea L. McNiven
Radiation Medicine Program, UHN Princess Margaret Cancer Centre, 610 University of Avenue, Toronto M5T 2M9, ON, Canada
Department of Radiation Oncology, University of Toronto, 148 - 150 College Street, Toronto M5S 3S2, ON, Canada

Timothy C.Y. Chan
Department of Mechanical and Industrial Engineering, University of Toronto, 5 King's College Road, Toronto M5S 3G8, ON, Canada
Techna Institute for the Advancement of Technology for Health, 124 - 100 College Street, Toronto M5G 1L5, ON, Canada

(Received 21 November 2017; revised 12 March 2018; accepted for publication 5 April 2018; published 9 May 2018)

217 patients

5. CONCLUSION

In this paper, we developed a framework that unites knowledge-based planning with inverse optimization to create a knowledge-based automated treatment planning pipeline. The approach was tested on a large dataset of 217 oropharyngeal patients. Our pipeline is flexible enough to accommodate different KBP methods. We developed two new KBP methods, the BQ and gPCA methods, and found that in general the gPCA method for prediction resulted in treatment plans that more closely matched clinical plans, without requiring extra plan complexity. Overall, because our framework not only predicts DVHs but also optimization model parameters, we can provide a high-quality, personalized "warm-start" to the inverse planning process that can also be adjusted easily, if necessary, in subsequent replanning iterations.

Contents lists available at ScienceDirect

Radiotherapy and Oncology

journal homepage: www.thegreenjournal.com

ELSEVIER

Knowledge-based planning

Cross-institutional knowledge-based planning (KBP) implementation and its performance comparison to Auto-Planning Engine (APE)

Binbin Wu[a,*], Martijn Kusters[b], Martina Kunze-busch[b], Tim Dijkema[b], Todd McNutt[c], Giuseppe Sanguineti[d], Karl Bzdusek[e], Anatoly Dritschilo[a], Dalong Pang[a]

[a] Department of Radiation Medicine, MedStar Georgetown University Hospital, Washington, USA; [b] Radboud University Medical Center, Nijmegen, The Netherlands; [c] Department of Radiation Oncology and Molecular Radiation Sciences, The Johns Hopkins University, Baltimore, USA; [d] Department of Radiotherapy, Istituto Nazionale Tumori Regina Elena, Roma, Italy; and [e] Philips Radiation Oncology Systems, Madison, USA

This study focuses on SIB-IMRT for oropharyngeal cancer, and is a joint effort of three academic institutions: MedStar Georgetown University Hospital (MGUH, Washington, D.C.), Radboud University Medical Center (RUMC, Nijmegen, The Netherlands) and the Johns Hopkins Universit
RUMC provided a patier
patients, including clinica
ative APE plans. (2) JHU
179 clinically-delivered
(3) MGUH provided a K
histogram (OVH-KBP), wi
RUMC patient's KBP plar
KBP plans were compare
In accordance with HIPA
Accountability Act of 199
lowing appropriate gover

Conclusions

The comparable results obtained with OVH-KBP and APE suggest that either method may be used to generate plans for treatment planning, as supported by publications demonstrating the quality comparability between OVH-KBP (or APE) and clinically-delivered plans [2,17,18]. However, the "automation" as implied in the auto-planning process should not be taken literally, as both approaches still require certain skilled manual inputs to achieve acceptable results, e.g., the planning parameters determined in training cycles. In addition, this study was focused on oropharynx cancer only and whether the results will hold for other disease sites needs further investigation. Nevertheless, the auto-planning applications discussed here and by other authors offer useful avenues to shorten treatment planning time and reduce plan quality variation, as evidenced in the commercial application of RapidPlan in Eclipse TPS and APE in Pinnacle TPS.

AP - Validation

Clinical sites:
- prostate
- brain
- head and neck
- breast
- SBRT liver and lung
- lymphoma

Original Article

Technology in Cancer Research & Treatment
Volume 17: 1-7

DOI: 10.1177/1533033818780064
journals.sagepub.com/home/tct
SAGE

Dosimetric Evaluation of Pinnacle's Automated Treatment Planning Software to Manually Planned Treatments

Kristen A. McConnell, PhD[1], Tyler Marston, BSc[1],
Brianna Elizabeth Zehren, MS[1], Aziz Lirani, BSc[1],
Dennis N. Stanley, PhD[1], Aaron Bishop, BS[1],
Richard Crownover, MD,
Ying Li, MD, PhD[1], Diana
Karl Rasmussen, PhD[1], N
Alonso N. Gutierrez, PhD

Conclusion

Comparison of AP to manually planned treatment plans for early and advanced stage prostate cancer as well as brain cancer demonstrated significant changes in OAR doses while offering minimal changes in PTV dosimetric indices. Specifically, AP was shown to be able to produce plans that delivered similar high dose conformity, PTV homogeneity, and dose falloff to the target, however offered significant reductions in median dose to OARs independent of treatment site. The results of this study reinforce results of similar AP studies that suggest that AP may be a valuable clinical tool to standardize plan quality and improve clinic efficiency using high-quality templates coupled with the AP engine.

AP - Validation

Breast

Radiotherapy and Oncology 132 (2019) 85–92

Contents lists available at ScienceDirect

Radiotherapy and Oncology

journal homepage: www.thegreenjournal.com

Original Article

Auto-planning for VMAT accelerated partial breast irradiation

Livia Marrazzo [a,*], Icro Meattini [b,c], Chiara Arilli [a], Silvia Calusi [c], Marta Casati [a], Cinzia Talamonti [a,c], Lorenzo Livi [b,c], Stefania Pallotta [a,c]

[a] Medical Physic Unit; [b] Radiation Oncology Unit, Azienda Ospedaliero – Universitaria Careggi, Florence, Italy; and [c] Department of Experimental and Clinical Biomedical Sciences "Mario Serio", University of Florence, Florence, Italy

A B S T R A C T

Purpose: To evaluate the quality of accelerated partial breast irradiation (APBI) plans generated by the Auto-Planning module of a commercial treatment planning system (TPS).

Material and methods: Twenty patients, previously planned and treated with manual planning in a TPS (manM), were re-planned using manual (manP) and automatic (AP) module of a different TPS. Plans were compared in terms of dosimetric parameters, degree of modulation, monitor units and treatment time, and by blind qualitative scoring by a physician. Dosimetric verification was evaluated in terms of γ passing rate and point dose measurements. Statistical differences were evaluated using paired two sided Wilcoxon's signed-rank test.

Results: A statistically significant improvement in PTV coverage was observed for AP plans compared to clinical plans, while no differences in organs at risk doses were observed. When compared to manP plans, a statistically significant improvement was observed for PTV coverage and homogeneity and for the ipsilateral breast and lung dosimetric parameters. The modulation degree was reduced with AP compared to manM treatment plans, while it was increased compared to manP treatment plans. No differences were observed in γ passing rate. Planning time was reduced from (54.5 ± 8.0) min for manM planning and (62.8 ± 15.0) min for manP planning to (9.8 ± 1.1) min for AP. In the qualitative scoring, AP plans were considered superior both to manM (10/20 cases) and manP plans (12/20 cases) with high clinical relevance.

Conclusion: Automatic planning for VMAT APBI was always at least equivalent and overall superior to manual planning.

Head and Neck

Clinical and Translational Radiation Oncology 1 (2016) 2–8

Contents lists available at ScienceDirect

Clinical and Translational Radiation Oncology

journal homepage: www.elsevier.com/locate/ctro

Original Research Article

Automatic treatment planning improves the clinical quality of head and neck cancer treatment plans

Christian Rønn Hansen [a,*], Anders Bertelsen [a], Irene Hazell [a], Ruta Zukauskaite [b,c], Niels Gyldenkerne [c], Jørgen Johansen [b,c], Jesper G. Eriksen [b,c], Carsten Brink [a,b]

[a] Laboratory of Radiation Physics, Odense University Hospital, Odense, Denmark
[b] Institute of Clinical Research, University of Southern Denmark, Odense, Denmark
[c] Department of Oncology, Odense University Hospital, Odense, Denmark

A B S T R A C T

Background: Treatment plans for head and neck (H&N) cancer are highly complex due to multiple dose prescription levels and numerous organs at risk (OARs) close to the target. The plan quality is inter-planner dependent since it is dependent on the skills and experience of the dosimetrist. This study presents a blinded prospective clinical comparison of automatic (AU) and manually (MA) generated H&N VMAT plans made for clinical use.

Methods: MA and AU plans were generated for 30 consecutive patients in Pinnacle[3] using the IMRT optimisation module and the new Autoplan module, respectively. The plan quality was blindedly compared by three senior oncologists and the best plan was selected for treatment of the patient. Planning time was measured as the active operator time used. The plan quality was analysed with DVH metrics and the dose delivery accuracy validated on the ArcCheck phantom.

Results: For twenty-nine out of the thirty patients the AU plan was chosen for treatment. Target doses were more homogenous with the AU plans and the OAR doses were significantly reduced, between 0.5 and 6.5 Gy. The average operator time spent on creating a manual plan was 64 min which was halved by Autoplan. The AU plans were more modulated as illustrated by an increase in MUs, which might cause the slightly lower pass rate of 97.7% in the ArcCheck measurements.

Conclusions: Target doses were similar between MA and AU plan, while AU plans spared all OAR considerably better than the MA plans.

AP - Validation

SBRT Liver

Physica Medica 46 (2018) 153–159

Contents lists available at ScienceDirect

Physica Medica

journal homepage: www.elsevier.com/locate/ejmp

ELSEVIER

Original paper

Evaluation of a commercial automatic treatment planning system for liver stereotactic body radiation therapy treatments

Elena Gallio[a,*], Francesca Romana Giglioli[a], Andrea Girardi[b], Alessia Guarneri[c], Umberto Ricardi[d], Roberto Ropolo[a], Riccardo Ragona[d], Christian Fiandra[d]

[a] Medical Physics Unit, A.O.U. Città della Salute e della Scienza, corso Bramante 88/90, 10126 Turin, Italy
[b] Radiation Oncology Department, University Hospital Brussels, Laarbeeklaan 101, 1090 Brussels, Belgium
[c] Oncology Department, Radiotherapy Unit, A.O.U. Città della Salute e della Scienza, corso Bramante 88/90, 10126 Turin, Italy
[d] Oncology Department, Radiotherapy Unit, University of Study of Turin, via Genova 3, 10126 Turin, Italy

A B S T R A C T

Purpose: Automated treatment planning is a new frontier in radiotherapy. The Auto-Planning module of the Pinnacle[3] treatment planning system (TPS) was evaluated for liver stereotactic body radiation therapy treatments.
Methods: Ten cases were included in the study. Six plans were generated for each case by four medical physics experts. The first two planned with Pinnacle TPS, both with manual module (MP) and Auto-Planning one (AP). The other two physicists generated two plans with Monaco TPS (VM). Treatment plan comparisons were then carried on the various dosimetric parameters of target and organs at risk, monitor units, number of segments, plan complexity metrics and human resource planning time. The user dependency of Auto-Planning was also tested and the plans were evaluated by a trained physician.
Results: Statistically significant differences (Anova test) were observed for spinal cord doses, plan average beam irregularity, number of segments, monitor units and human planning time. The Fisher-Hayter test applied to these parameters showed significant statistical differences between AP e MP for spinal cord doses and human planning time; between MP and VM for monitor units, number of segments and plan irregularity; for all those between AP and VM. The two plans created by different planners with AP were similar to each other.
Conclusions: The plans created with Auto-Planning were comparable to the manually generated plans. The time saved in planning enables the planner to commit more resources to more complex cases. The independence of the planner enables to standardize plan quality.

Prostate

Radiotherapy and Oncology xxx (xxxx) xxx

Contents lists available at ScienceDirect

Radiotherapy and Oncology

journal homepage: www.thegreenjournal.com

ELSEVIER

Original article

Independent knowledge-based treatment planning QA to audit Pinnacle autoplanning

Tomas M. Janssen *, Martijn Kusters, Yibing Wang, Geert Wortel, Rene Monshouwer, Eugène Damen, Steven F. Petit

Department of Radiation Oncology, The Netherlands Cancer Institute, Amsterdam; Department of Radiation Oncology, Radboud University, Nijmegen; and Department of Radiation Oncology, Erasmus MC Cancer Institute, Rotterdam, The Netherlands

A R T I C L E I N F O

Article history:
Received 4 May 2018
Received in revised form 26 October 2018
Accepted 28 October 2018
Available online xxxx

Keywords:
Knowledge based planning
Autoplanning

A B S T R A C T

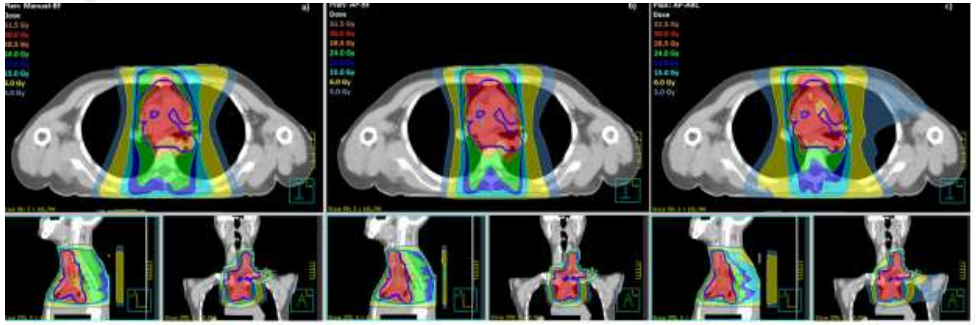
Background and purpose: With the advent of automatic treatment planning options like Pinnacle's Autoplanning (PAP), the challenge arises how to assess the quality of a plan that no dosimetrist did work on. The aim of this study was to assess plan quality consistency of PAP prostate cancer patients in clinical practice.
Materials and methods: 100 prostate cancer patients were included from NKI and 129 from RadboudUMC (RUMC). Per institute a previously developed [1] treatment planning QA model, based on overlap volume histograms, was trained on PAP plans to predict achievable dose metrics which were then compared to the clinical PAP plans. A threshold of 3 Gy (DVH dose parameters)/3% (DVH volume parameters) was used to detect outliers. For the outlier plans, the PAP technique was adjusted with the aim of meeting the threshold.
Results: The average difference between the prediction and the clinically achieved value was <0.5 Gy (mean dose parameters) and <1.2% (volume parameters), with standard deviation of 1.9 Gy/1.5% respectively. We found 8% (NKI)/25% (RUMC) of patients to exceed the 3 Gy/3% threshold, with deviations up to 6.7 Gy (mean dose rectum) and 6% (rectal wall V64Gy). In all cases the plans could be improved to fall within the thresholds, without compromising the other dose metrics.
Conclusion: Independent treatment planning QA was used successfully to assess the quality of clinical PAP in a multi-institutional setting. Respectively 8% and 25% suboptimal clinical PAP plans were detected that all could be improved with replanning. Therefore we recommend the use of independent treatment plan QA in combination with PAP for prostate cancer patients.

AP - Validation

RESEARCH Open Access

Auto- versus human-driven plan in mediastinal Hodgkin lymphoma radiation treatment

Stefania Clemente[1†], Caterina Oliviero[1†], Giuseppe Palma[2], Vittoria D'Avino[2], Raffaele Liuzzi[2], Manuel Conson[3], Roberto Pacelli[3] and Laura Cella[2*]



Methods: CT-scans of 10 female patients with SHL were considered. A "butterfly" (BF) volumetric modulated arc therapy was optimized using SmartArc module integrated in Pinnacle[3] v. 9.10 using Collapsed Cone Convolution Superposition algorithm (30 Gy in 20 fractions). Human-driven (Manual-BF) and AP-BF optimization plans were generated. For AP, an optimization objective list of Planning Target Volume (PTV)/OAR clinical goals was first

Conclusions: Despite the high interpatient PTV (size and position) variability, it was possible to set a standard SHL AP optimization list with a high level of generalizability. Using the implemented list, the AP module was able to limit OAR doses, producing clinically acceptable plans with stable quality without additional user input. Overall, the AP engine associated to the arc technique represents the best option for SHL.

A priori MCO - Validation

CLINICAL INVESTIGATION — Physics

IMPROVED PLANNING TIME AND PLAN QUALITY THROUGH MULTICRITERIA OPTIMIZATION FOR INTENSITY-MODULATED RADIOTHERAPY

David L. Craft, Ph.D., Theodore S. Hong, M.D., Helen A. Shih, M.D., and Thomas R. Bortfeld, Ph.D.

Department of Radiation Oncology, Massachusetts General Hospital, Harvard Medical School, Boston, MA

Purpose: To test whether multicriteria optimization (MCO) can reduce treatment planning time and improve plan quality in intensity-modulated radiotherapy (IMRT).
Methods and Materials: Ten IMRT patients (5 with glioblastoma and 5 with locally advanced pancreatic cancers) were logged during the standard treatment planning procedure currently in use at Massachusetts General Hospital (MGH). Planning durations and other relevant planning information were recorded. In parallel, the patients were planned using an MCO planning system, and similar planning time data were collected. The patients were treated with the standard plan, but each MCO plan was also approved by the physicians. Plans were then blindly reviewed 3 weeks after planning by the treating physician.
Results: In all cases, the treatment planning time was vastly shorter for the MCO planning (average MCO treatment planning time was 12 min; average standard planning time was 135 min). The physician involvement time in the planning process increased from an average of 4.8 min for the standard process to 8.6 min for the MCO process. In all cases, the MCO plan was blindly identified as the superior plan.
Conclusions: This provides the first concrete evidence that MCO-based planning is superior in terms of both planning efficiency and dose distribution quality compared with the current trial and error–based IMRT planning approach. © 2012 Elsevier Inc.

Multiobjective, Inverse planning, Pareto optimization, Multicriteria.

Krayenbuehl et al. Radiation Oncology (2018) 13:170
https://doi.org/10.1186/s13014-018-1113-z

Radiation Oncology

RESEARCH — Open Access

Planning comparison of five automated treatment planning solutions for locally advanced head and neck cancer

J. Krayenbuehl[1*], M. Zamburlini[1], S. Ghandour[2], M. Pachoud[2], S. Lang-Tanadini[1], J. Tol[3], M. Guckenberger[1] and W. F. A. R. Verbakel[3]

1) Automatic Interactive Optimizer (AIO) (in-house developed) in combination with RapidArc version 13.7 from Eclipse (Varian Medical Systems, Palo Alto, USA) from hospital B [4, 12];
2) Auto-Planning version 14.0 (AP) from Pinnacle (Philips Radiation Oncology Systems) from hospital A [6];
3) RapidPlan version 13.6 (RP1) from Eclipse (Varian Medical Systems, Palo Alto, USA) using HNC model from hospital A;
4) RapidPlan version 13.7 (RP2) combined with scripting for automated setup of fields with HNC model from hospital B [13];
5) Raystation multicriteria optimization algorithm version 5 (RS) (RaySearch Laboratories AB, Stockholm, Sweden), from hospital C.

Conclusion

The results obtained for the five ATPS evaluated on two different set of HNC patients show that all ATPS were able to fulfill the hard constraints. For the parallel organs, AP achieved the best results followed by RS, AIO, RP2 and RP1. Nevertheless, the differences were small. The effective working time was reduced to less than 20′ for each ATPS, except RS, and could be reduced to less than 2′ when using scripting, which was the case for AIO and RP2.

A posteriori MCO - Validation

Radiat Oncol. 2018 Apr 23;13(1):74. doi: 10.1186/s13014-018-1032-z.

Automated VMAT planning for postoperative adjuvant treatment of advanced gastric cancer.

Sharfo AWM[1], Stieler F[2], Kupfer O[2], Heijmen BJM[3], Dirkx MLP[3], Breedveld S[3], Wenz F[2], Lohr F[4], Boda-Heggemann J[2], Buergy D[2].

⊕ Author information

Strahlenther Onkol. 2018 Apr;194(4):333-342. doi: 10.1007/s00066-017-1246-2. Epub 2017 Dec 21.

Automated volumetric modulated arc therapy planning for whole pelvic prostate radiotherapy.

Buschmann M[1,2], Sharfo AWM[3], Penninkhof J[3], Seppenwoolde Y[4,5], Goldner G[4], Georg D[4,5], Breedveld S[3], Heijmen BJM[3].

⊕ Author information

Phys Med Biol. 2017 Jun 7;62(11):4318-4332. doi: 10.1088/1361-6560/62/11/4318. Epub 2017 May 5.

Fast and fuzzy multi-objective radiotherapy treatment plan generation for head and neck cancer patients with the lexicographic reference point method (LRPM).

van Haveren R[1], Ogryczak W, Verduijn GM, Keijzer M, Heijmen BJM, Breedveld S.

⊕ Author information

Strahlenther Onkol. 2017 May;193(5):402-409. doi: 10.1007/s00066-017-1121-1. Epub 2017 Mar 17.

Fully automated VMAT treatment planning for advanced-stage NSCLC patients.

Della Gala G[1,2], Dirkx MLP[3], Hoekstra N[1], Fransen D[1], Lanconelli N[2], van de Pol M[1], Heijmen BJM[1], Petit SF[1,4].

⊕ Author information

A posteriori MCO - Validation

Radiat Oncol. 2017 Jan 31;12(1):33. doi: 10.1186/s13014-017-0767-2.

Fully automated treatment planning of spinal metastases - A comparison to manual planning of Volumetric Modulated Arc Therapy for conventionally fractionated irradiation.

Buergy D[1], Sharfo AW[2], Heijmen BJ[2], Voet PW[3], Breedveld S[2], Wenz F[4], Lohr F[4], Stieler F[4].

⊕ Author information

PLoS One. 2016 Dec 29;11(12):e0169202. doi: 10.1371/journal.pone.0169202. eCollection 2016.

Validation of Fully Automated VMAT Plan Generation for Library-Based Plan-of-the-Day Cervical Cancer Radiotherapy.

Sharfo AW[1], Breedveld S[1], Voet PW[1], Heijkoop ST[1], Mens JM[1], Hoogeman MS[1], Heijmen BJ[1].

⊕ Author information

Int J Radiat Oncol Biol Phys. 2014 Apr 1;88(5):1175-9. doi: 10.1016/j.ijrobp.2013.12.046. Epub 2014 Feb 11.

Fully automated volumetric modulated arc therapy plan generation for prostate cancer patients.

Voet PW[1], Dirkx ML[2], Breedveld S[2], Al-Mamgani A[2], Incrocci L[2], Heijmen BJ[2].

A posteriori MCO - Validation

Radiotherapy and Oncology 128 (2018) 343–348

Contents lists available at ScienceDirect

Radiotherapy and Oncology

journal homepage: www.thegreenjournal.com

ELSEVIER

Prostate cancer

Fully automated, multi-criterial planning for Volumetric Modulated Arc Therapy – An international multi-center validation for prostate cancer

Ben Heijmen [a,*], Peter Voet [b], Dennie Fransen [a], Joan Penninkhof [a], Maaike Milder [a], Hafid Akhiat [b], Pierluigi Bonomo [c], Marta Casa
Frank Lohr [f], Livia Marrazzo [c],
Gabriele Simontacchi [c], Volker

[a] Erasmus MC Cancer Institute, Erasmus University
Universitaria Careggi, Radiation Oncology, Florence
Wien, Austria; [e] St James's Institute of Oncology – St
Radiation Oncology, Germany

RESEARCH ARTICLE

Intercenter validation of a knowledge based model for automated planning of volumetric modulated arc therapy for prostate cancer. The experience of the German RapidPlan Consortium

Carolin Schubert[1], Oliver Waletzko[2], Christian Weiss[3], Dirk Voelzke[4], Sevda Toperim[1], Arnd Roeser[5], Silvia Puccini[4], Marc Piroth[5], Christian Mehrens[6], Jan-Dirk Kueter[7], Kirsten Hierholz[3], Karsten Gerull[7], Antonella Fogliata[8], Andreas Block[6], Luca Cozzi[8]*

iterative constraint adaptation [9], use of a particle swarm optimizer for automated selection of objective function weights, and automated iterative fine-tuning of cost functions [12]. Only in two studies were plans compared for >50 patients. Reported improvements in plan quality with autoplanning were overall modest. The only report on a multi-center comparison of manual- vs. autoplanning for prostate cancer is by Schubert et al. [10], using a DVH prediction model generated in a single center which was validated in six other centers. Automatically generated plans had reductions in rectum and bladder D_{mean} of 0.6 and 0.8 Gy respectively, while for both OARs high doses were worse for autoVMAT.

In a previous study [6] *apriori*MCO autoplanning was tested for prostate cancer by comparison with manual planning performed by the most competent manual planner in the center whose task was to generate the best possible manual plans without any constraint in planning time. Quality differences between manVMAT and autoVMAT were negligible.

This paper describes a large international multi-center validation of *apriori*MCO comparing autoVMAT and manVMAT plans for prostate cancer. In contrast to [6] manVMAT plans were generated with routine clinical planning, so not by the best planner without planning time restrictions. The *apriori*MCO algorithm

GPS- Validation protocol

The importance of tuning process for the automated Genetic Planning Solution for prostate radiotherapy treatment

Duration: 1 year
C. Fiandra, 31 January 2019

Background

Plan automation is a popular topic today with several commercial strategies already available in order to reduce the inter-planner variability, the planning time allocated for the optimization process and finally to improve the overall plan quality.

The goal of this study was to compare Genetic Planning Solution (GPS, Tecnologie Avanzate, Torino) for Automated Treatment Planning with manual planning on RayStation platform for prostate treatment in a multicenter setting taking inter-institute variability of dose/fractionation, volume and delivery technique into account.

Hypothesis

Due to the intrinsic variability of the dose and fractionation requirements by clinicians among different centers, a generic automated treatment planning approach needs to be tuned to the specific clinical requirements of each center. But, due to the presence of many anatomical districts and radiotherapy techniques, this tuning may be laborious and may represent a limit for a wide use of such automatic software. So, we want to test the hypothesis GPS can even obtain good results in other institutes (equal or better quality than manual planning) without center specific tuning.

Aims

The objective of this study is to highlight the differences in the use of GPS with or without the help of specific tuning for each centre. This process will be carried out by means of planning comparison respect to the manual planning first (Phase 1), involving 10 Italian centers that don't have experience with any autoplanning solution. Then, a second phase (Phase 2) will involve a centre (Erasmus, Rotterdam, The Nederland) with many years of experience in the use of automated treatment planning system solution.

Experimental design

The study will be shaped in 3 phases

Phase 1a: a plan provided by a standard version of GPS equal for all centers, will be compared with the clinical delivered distribution of dose obtained by each center with manual use of RayStation platform; because the GPS solution is flexible, each center will be free to apply its specific clinical protocol in terms of fractionation and dose level in the field of prostate cancer.

Phase 1b: in which the ten patients submitted for comparison on Phase1, will be used for tuning of the GPS for each specific center. A second planning comparison will be evaluated on others ten patients with the GPS tuned in terms of sparing of different Organ at risks.

Phase 2: following the same steps of Phase 1, will be carried out with the automated solution Erasmus-iCycle provided by Erasmus MC with and without tuning.

Evaluation of plans will be carried out by means of pair-wise dose-volume histogram comparison as well as with the preference of different experienced Radiation Oncologists.

GPS- Validation protocol

Expected results

Answers to the following questions:

1. Can GPS with a generic tuning be used for clinical planning in various treatment centers? The research will quantify plan quality differences between clinical plans that were manually generated and GPS plans.
2. To what extent can GPS with center-specific tuning (further) improve on the the quality of manually generated plans?

To highlight the importance of tuning process for GPS software with a group of centers representative of the Italian manual practice as well as with a well-established automatic solution in the field of prostate radiotherapy treatment planning.

GPS- Validation protocol

		PTV	
	centro	dose1	dose2
1	**IFO**	62	
2	**Molinette**	70,2	61,1
3	**Mauriziano**	72	63,6
4	**Novara**	67,5	56,25
5	**IEO**	37,5	
6	**Napoli**	64,5	54
		72	64,5
		72	54
7	**Siena**	76,5	61,2
		74,25	66
		80	60
		78	58,5
		70	
		72	
		76	
8	**Meldola**	66	
9	**Mestre**	67,5	
		74	
		69,75	
		72	

GPS- Validation protocol

2019 AAPM Annual Meeting

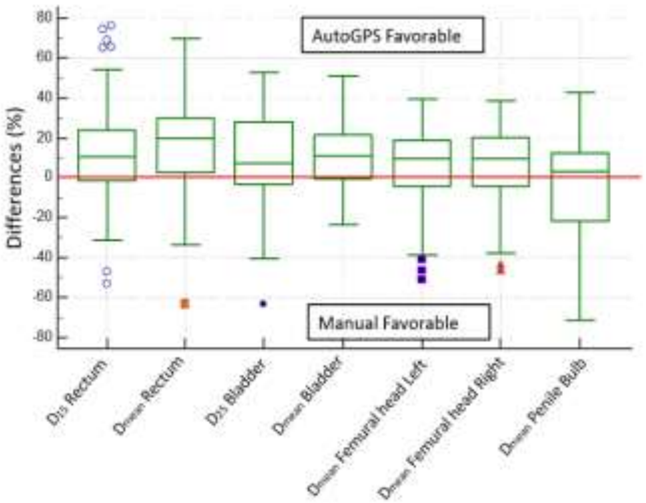
PROFFERED INSTRUCTIONS

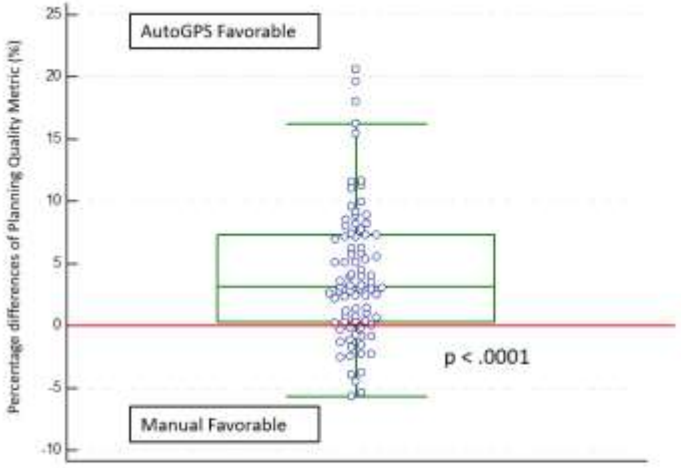
AMOS 2019 AAPM Annual Meeting (Abstract Home)

Abstract# 44074

Click on the HEADINGS below to edit your information.

Heading	Details	CheckList
Title:	[illegible]	√
Category Request Presenting Mode:	[illegible]	√
Taxonomy:	[illegible]	√
Keywords:	[illegible]	√
Authors: Edit Authors Profile:	[illegible]	√





Summary

- Many literature data on RP. **Clinically** acceptable results if the model is good, but validation outside institution is under investigation

- AP is well consolidated automatic planning system in many specific institutions and clinical situations. No multicentric experience are reported

- Not being pareto optimal plans RP and AP may also be used as «worm start» of the optimization process

- They shorten treatment planning time and reduce plan quality variation

- A priori MCO approach is labor intensive, but gives pareto optimal plan potentially superior to others approach

Summary – Physicist role

- Pilot during take off and landing
- Provides specific skills for evaluating the plan in conjunction with the Physicians because a Clinician evaluation is often needed
- Definition of metrics to evaluate the plan
- Extra time for physicist to work on more complex case, or other challenging new available instruments (DIR validation for example)
- Automation of planning necessary for future scenarios of online adaptive replanning

Thank you for your attention!!