Radiation Therapy Training with X3D

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Outline

- Background - Radiation Therapy / Proton Therapy
- Patient Treatment Planning
- 3DRTT Project
- Implementation
- Assessment & Results
- Conclusion
Radiation Therapy

• 28.7 million people worldwide living with cancer and an estimated

• 7.6 million cancer deaths, accounting for 13% of all deaths worldwide [World Health Statistics].

• Radiation Therapy is the use of radiation to treat most cancers by delivering high-energy radiation (X-Rays) from clinical linear accelerators or radiation inserts.
Radiation Therapy (US Market)

• Varian Medical Systems (Market Cap - $ 8.5 Billion)
  Treatment planning software + delivery systems

• Philips Medical Systems (Market Cap – $ 27.5 Billion)
  Treatment planning software + delivery systems

• CMS (Market Cap - $ 3.5 Billion)
  Treatment planning software
External Beam Radiation Therapy

- Radiation destroys cells ability to reproduce producing damage at the chromosome level

- Internal vs External Beam Radiation Therapy (EBRT)

- EBRT must be applied repeatedly to the target volume, sometimes several dozens times

- 10,000 linear accelerator-based radiation therapy systems ($ 14 Billion)
Proton Beam Therapy

• An alternative to EBRT

• Worthwhile considering when:
  ➢ the organs at risk are extremely proximal to the target volume
  ➢ it is difficult to arrange to irradiate the target volume without also irradiating the organs at risk.

• Proton therapy can be used for treating occular melanoma, chordoma, soft tissue sarcoma of the retroperitoneum, paranasal tissues and head and neck GBMs and meningiomas.
Patient Treatment Planning (1)

General Flow of External Radiation Therapy Treatments

CT scanner

CT Slices + Radiation Therapy (RT) info

Treatment Planning System (TPS): dose calculation and visualization

Beam Delivery

Record and Verify System (RV): makes sure all parameters are properly transferred to/from linac
Patient Treatment Planning (2)

• A **computerized** plan is generated for each patient

• People involved: Radiation Oncologists, Physicists, Dosimetrist.

• Goal: determine the best treatment options for the patient which includes the type/range of radiation to be delivered, **Patient Setup Issues**.
Patient Treatment Planning (3) - Systems

Varian Trilogy™

Novalis by BrainLab™
Patient Treatment Planning (4) - Collisions

Many add-ons that are used during EBRT and can generate **collisions** with the hardware components or patient.

- stereotactic head frames
- head extensions
- wing boards
- breast boards
In many cases the collimator is touching the couch, and **Replanning** is required.

**Beam Parameters:**

- Gantry = 245°
- Couch = 350°
- Collimator = 0°
- VRT = 10.0
- LAT = 0.0
- LNG = 60

"A typical situation from our clinic" – M.D. Anderson Cancer Center Orlando

Needs a new paint job!

Damage caused by collisions (collimator)
Patient Treatment Planning (6) - Collisions

• Summary of issues with EBRT systems:

  • Currently available treatment planning systems offer little or no information for the treatment planner on possible collision scenarios during the planning process.

  • Collision scenarios are found by RTTs during visual treatment verification checks.

  • Computer Controlled Radiation Therapy (CCRT) requires precise knowledge of the relative positions of all linac components with respect to the patient and to each other.

  • The system-patient dynamics must be verified before treatment initialization while patient volume (external shell is unknown).
Ninja tool used in 2005 to check for collisions ...
3D Radiation Therapy Training project

3drtt.org
3DRTT Motivation

We would like to:

1. Generate a realistic and interactive 3D simulation of the treatment system with as much detail and resolution as possible (customized for a specific EBRT system)

2. Simple, user friendly interface; virtually move different LinAc components gantry, table, collimator, etc. as if you were in the room using a hand pendant

3. Visualize the beam path, the lasers, and the actual patient external geometries/surfaces on the couch together with add-on/immobilization devices

4. Deploy the simulation on the Internet for remote collaboration, using minimal software configurations and costs

5. Use the simulation for: training students and medical personnel, patient information and ultimately in clinical scenarios embedded in the existing planning systems.
3DRTT™ Simulator

- 3D Radiation Therapy Training: Varian 23ix
Varian Trilogy™ & Novalis™ (BrainLab™)
CT data provide limited surface information. To map out the entire collision space we need 3D surface model of the entire patient in the treatment position.

Possible solutions:

A- Whole body CT of the patient!

B- 3D surface rendering
Patient specific shell data (2)

• Patient specific CT data in the simulator (CT to 3D)

• Automatic shell generation in combination with Vision RT
3D Radiation Therapy Training project - implementation

3drtt.org
3DRTT Simulator - Implementation

• **Software Architecture (3-Tier Scalable)**
  • Client-Side: X3D Player in Web-Browser
  • Middle-Tier: Apache Tomcat Server with JSP (Java Server Pages) capability
  • Back-End: 3D database extension capability.
  • GUI (Graphical User Interface) Dual
  • JSP based (servlet engine)
  • X3D event based

• **3D Linac Model: Varian 23ix**
  • Initially developed from CAD drawings
  • Later developed in 3DStudio Max (LINAC has approx. 12000 polygons) from manual measurements and digital photography
  • Gantry and table were cross-scaled through manual measurements
  • Adopted IEC 1217
Implementation - Accurate 3D Modeling

3D Laser Scans ➔ point cloud ➔ 3D Processing ➔ optimized polygonal model ➔ X3D Objects

Processing scans:

• registration
• filtration
• wrapping
• smoothing
• decimation
• conversion to X3D
Implementation - ECMA Scripting

ECMAScript \( \rightarrow \) functions  \( \rightarrow \) Interactive X3D Model
Assessment & Results - 3DRTT Simulator
- 3D Radiation Therapy Training -

1. **Web-based** simulator (using latest X3D technology standards)

2. Friendly GUI (Graphical User Interface)

3. **Easy setup** and is platform independent

4. Uses **freely available software components** (browser, X3D player)

5. To experience **immersive 3D visualization** use red/blue glass pair
Assessment & Results - 3DRTT Simulator
More on Accuracy ...

• Measurements (5 mm accuracy)
  • in the real environment
  • in the virtual environment (simulator)
Related Publications


Thank you

- Strategic partnerships & sponsors
  - M.D. Anderson Cancer Center, FL
  - Memorial Hospital Savannah, GA
  - Joseph Candler Savannah, GA
  - Varian Medical Systems (Eclipse™)
  - Philips Medical Systems (Pinnacle™)
  - Siemens Medical Solutions (ARTÍSTE™)

- Patent 2008

www.3drtt.org

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