Aspects of using a portal X-Ray to confirm patient position

Neil Muller

3rd April 2006

Joint Work with

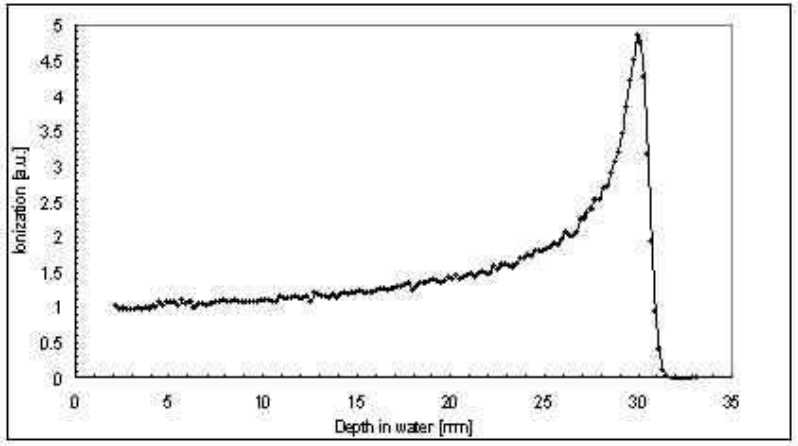
Leendert van der Bijl, Jantine Frahn and Evan de Kock

TALK OUTLINE

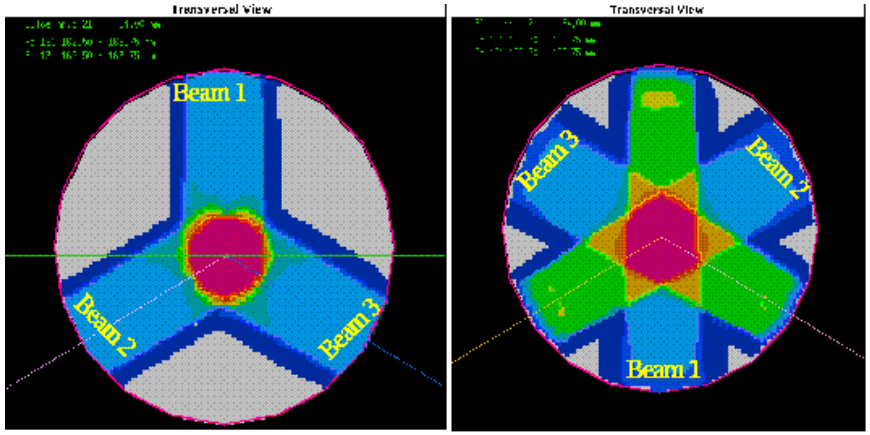
- Proton Therapy Overview
- Patient Positioning for Proton Therapy at iThemba Labs
- The role of the Portal X-Ray system
- Image Quality issues
- Image Comparison Methods
- Verification against multiple DRRs
- Further Work

PROTON THERAPY OVERVIEW

- Protons have nice properties for radiotherapy
- Non-linear dose distribution - Bragg's Peak



- Can Localise Dose



- Much more expensive then conventional X-Ray Therapy

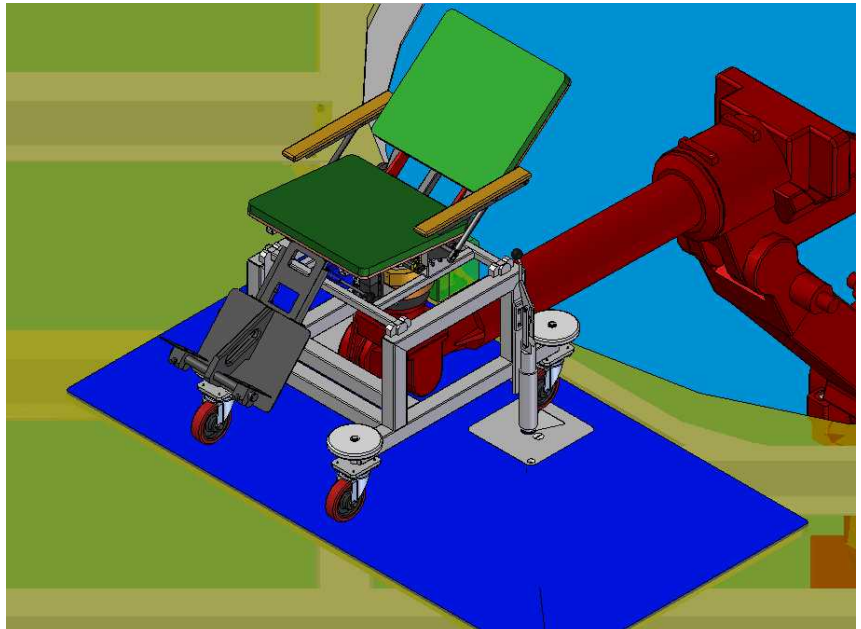
- Need to position patient accurately with respect to proton beam

PROTON THERAPY AT ITHEMBA LABS

- iThemba Labs uses fixed beam line
- Position patient with respect to beam
- Noninvasive - Use mask attached to patient
- Use stereo vision techniques to locate mask
- Retro-reflective markers on the mask easily visible

THE PATIENT POSITIONING SYSTEM

- Existing system - motorised chair, user-driven positioning process
- New system - automate vision, use chair attached to robot arm to position patient
- Also monitor patient during treatment to detect motion
- 9 cameras, positioned to maximise visibility of patient mask
- Use suitable subset of these to observe patient

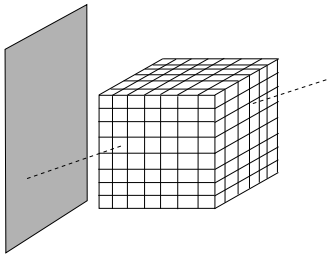


THE BIG ASSUMPTION

- Observe mask, not patient
- Mask is removed and replaced between treatment sessions
- Cannot reliably assume that mask position is completely repeatable
- Need some alternative system to resolve this

PORTAL X-RAY SYSTEM

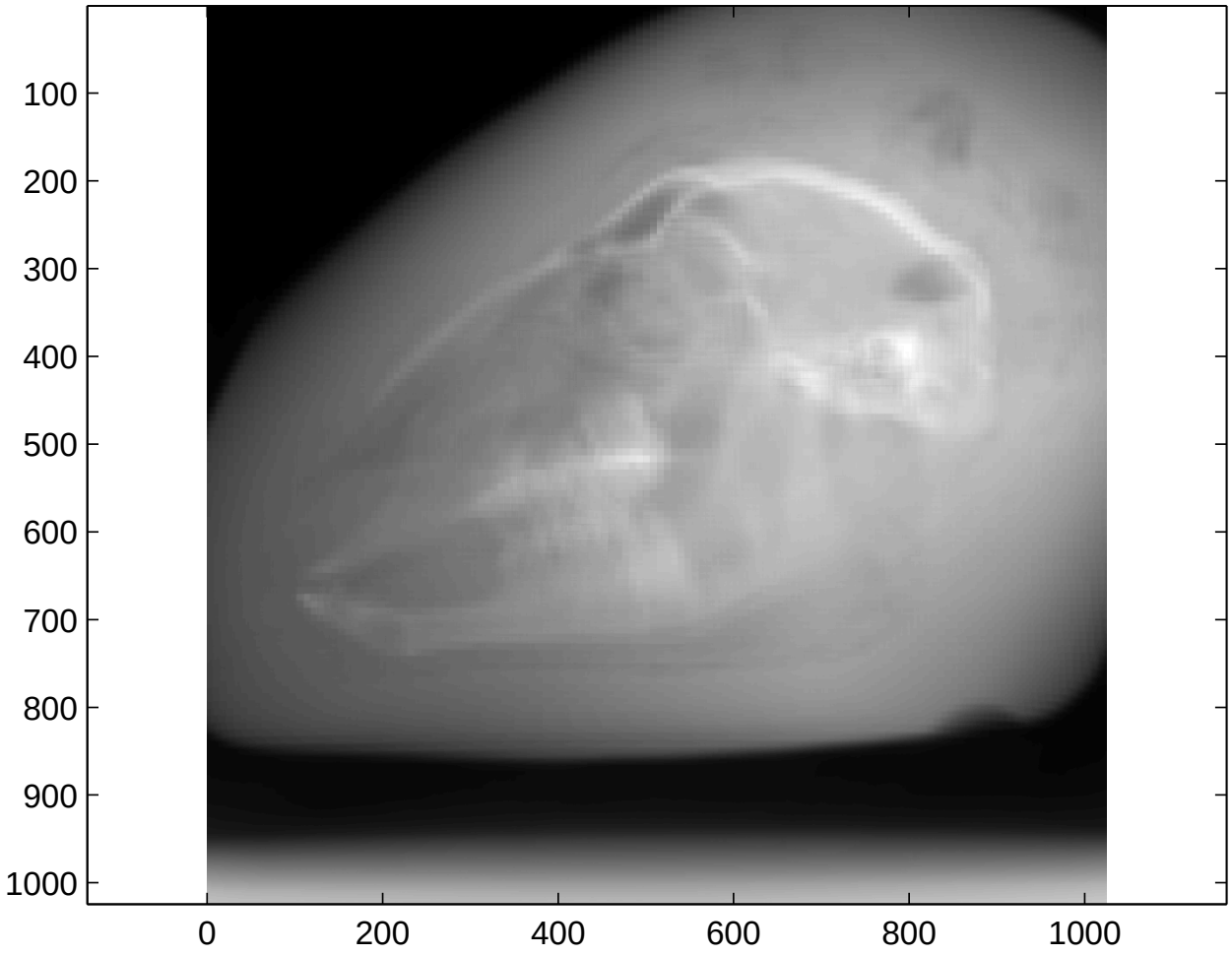
- Take x-ray along the beam line when patient is in position
- Can predict expected x-ray view from mask position
  - Digital Reconstructed Radiograph or DRR



- Compare to observed x-ray to determine if alignment correct
- Current system - manual comparison of DRR and X-Ray.

DRR Quality

- Typical to use ray-tracing approach using CT-Cube
- Simple ray-tracing approach simplifies X-Ray setup
  - Monoenergic beam - no beam hardening
  - point source
  - no beam scattering
- Model beam-hardening with correction term based on path length
- Ignore X-Ray scatter as small effect
- DRR of lower resolution than X-Ray


100
200
300
400
500
600
700
800
900
1000
0
200
400
600
800
1000

Comparison Methods

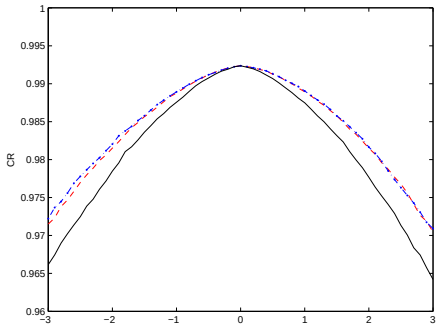
- Large literature on image comparison, especially for medical images
- Need robustness against noise as X-Ray and DRR differ
- Most popular methods are suitable, main difference is speed
- Using Correlation Ratio as easy to implement and quite fast

THE PROBLEM WITH COMPARISON

- Single comparison: Comp(X-Ray, DRR) = X?
- Meaning of X is unclear
- Comparison doesn't answer the right question
- Interested in detecting small misalignment
- Want to know if any nearby alignment is more similar to current X-Ray view

USING MULTIPLE DRR'S

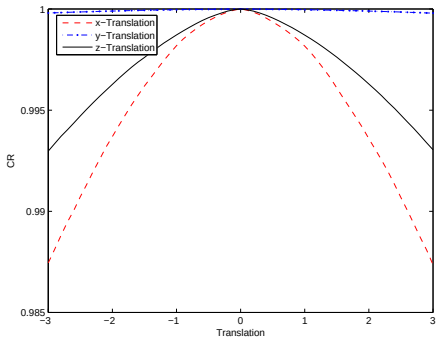
- Comparison methods all have nice peak at correct alignment



- Generate set of nearby DRR's
- Compare observed X-Ray to entire set
- Accept if predicted view is local maximum

Accuracy Issues

- 6 degrees of freedom for misalignment (3 translation, 3 rotation)
- Similarity measures not equally sensitive to all of these



- Translation along beam axis hard to resolve
- Fortunately this is considered less important

FUTURE WORK

- Described approach only gives yes/no decision
- Idea 1: Similarity surfaces quite smooth - use optimisation approaches to search for best set of DRR parameters
  - Will give correction for mask misalignment
  - Requires fast calculation of DRRs - ongoing project
- Idea 2: Use multiple X-Rays to resolve translation along beam axis
  - Rotate patient near treatment point to acquire additional views
  - Improves accuracy

CONCLUSIONS

- Additional verification necessary for patient positioning
- Multiple DRR approach allows accurate decision of in/out of position
- Future work will give correction to account for misalignment