Multimodality Imaging in Radiation Oncology:

Marc I Kessler PhD AAPM 2003

Registration and Fusion

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The Landsat Program













Marc L Kessler, PhD

Pickett / UCSF



Hamilton / U Chicago









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- Rigid / Affine
- > Piecewise Rigid (& Limited FOV)
- > Full 3D / 40 Warping
- > Finite Element Models

What is F?
Affine Assumption
y=mx+b in three dimensions
$\mathbf{x}_{b} = \mathbf{A} \mathbf{x}_{A} + \mathbf{b}$ up to 12 DOF
Otherwise Spatially variant function
Thin-plate spline lots of DOF





attach coordinate system to patient
 frames / fiducials

Retrospective

- > patient intrinsic
 - anatomy / shape / image intensities



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Prospective



... attach a coordinate system to the patient!

... stereotactic radiosurgery



Apply a minimization algorithm to determine the parameters (DOF)

that minimize this metric







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$$H(I_A, I_B) = H(I_A) + H(I_B) - MI(I_A, I_B)$$

The mutual information of two image datasets is a maximum when they are geometrically registered ...

... MI can be used as a metric

'48 Shannon - Bell Labs / '95 Viola - MIT



Mutual Information

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The entropy or information content of an image with a frequency distribution p(X), is defined by:

$$H(X) = E_X [\log_2 p(x)]$$
$$= \int_X p(x) \log_2 \frac{1}{p(x)}$$

























Mutual Information $H(I_A, I_B) = H(I_A) + H(I_B) - MI(I_A, I_B)$

The mutual information of two image datasets is a maximum when they are geometrically registered ...

... MI can be used as a metric

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CT / MR

PET / CT

MR / PET

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- > Rigid / Affine (if we're careful !)
- Full 3D / 4D Warping
- > Finite Element Models
- Piecewise Rigid (& Limited FOV)

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Reproduce patient orientation as closely as possible using an *immobilization* device



Custom-molded Styrofoam cradle



Thorax Board Sinmed BV



crop spurious PET data

window/level datasets



Auto-segmented boundaries from CT mapped to PET



Allow Spatial Variant Transformations Thin-Plate Splines, Finite Element Models, etc Mayer / UM





Thin-plate Spline Transformation and Mutual Information Metric

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Take into account physical tissue properties

Brock / UM





Global Rigid

Full Warping Too Much ?











Limited Field-of-View



























Display datasets as "color gels"



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- **Target Volume Definition**
 - Magnetic Resonance Imaging
 soft tissue contrast
 - Positron Emission Tomography
 tumor metabolism

















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- > Techniques are now available to register 3D image data from different modalities
- Registered data can be fused to create more complete models of the patients
- > Accuracy on the order of image resolutions reported ...

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- Measure improvement in therapy realized by incorporation of additional image information
- Correlation of post-therapy radiologic findings with pre-therapy computed dose distributions
- Extend techniques to better handle non-rigid organ motion ... morphometrics