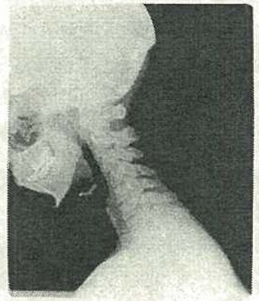
UTS

University of Ballarat

Invitation to Participate



Research Workshop on Automated Medical Image Analysis

Sponsored by
ARC Special Research Initiatives Program

Organised by
University of Ballarat
and
University of Technology, Sydney

31st July & 1st August 1998

Mid City Motor Inn, Ballarat

CENTRE FOR BIOMEDICAL TECHNOLOGY

School of Engineering

Organisers

Prof. Anthony Maeder, School of Engineering, University of Ballarat

Prof. Binh Pham, School of Information Technology & Mathematical Sciences, University of Ballarat

Dr. Michael Braun, School of Applied Physics, University of Technology, Sydney

Dr. Michael Eckert, School of Electrical Engineering, University of Technology, Sydney

Sponsors

ARC Special Research Initiatives Program

Supporters

University of Ballarat

- Image & Video Research Infrastructure Facility
- Research Centre for Intelligent Tele-imaging
- Fiona Elsie Cancer Research Centre

University of Technology, Sydney

- Centre for Biomedical Technology

Australian Pattern Recognition Society (Victorian Branch)

APRS

Contact Details

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Please return to:
ARC Workshop, School of Engineering, University of Ballarat, PO Box 663, Ballarat Victoria 3353 .... Fax: (03) 5327 9137

Expression of Interest

I plan to attend the Workshop. Please send registration form ☐

I would like to receive further details on the Workshop ☐

Please note my mailing details for future related activities ☐

Name: ____________________

Address: ____________________

Tel: __________ Fax: __________ Email: __________

Research Interests ____________________

____

What's behind the technology?

- Nuclear medicine:
  gamma camera imaging; X-ray CT (transmission tomography); emission tomography (SPECT and PET); MRI

- Inverse problem formulated

  Radon-transforms (CT); Poisson point processes (SPECT, PET, dynamics)

- *Physics* specification
  camera *geometry* and transport physics

- Algorithms

  Filtered back projection (FBP) with Radon transform model
  Large systems of (linear) equations
  Shepp-Vardi EM algorithm

Goal: discuss better incorporation of Physics

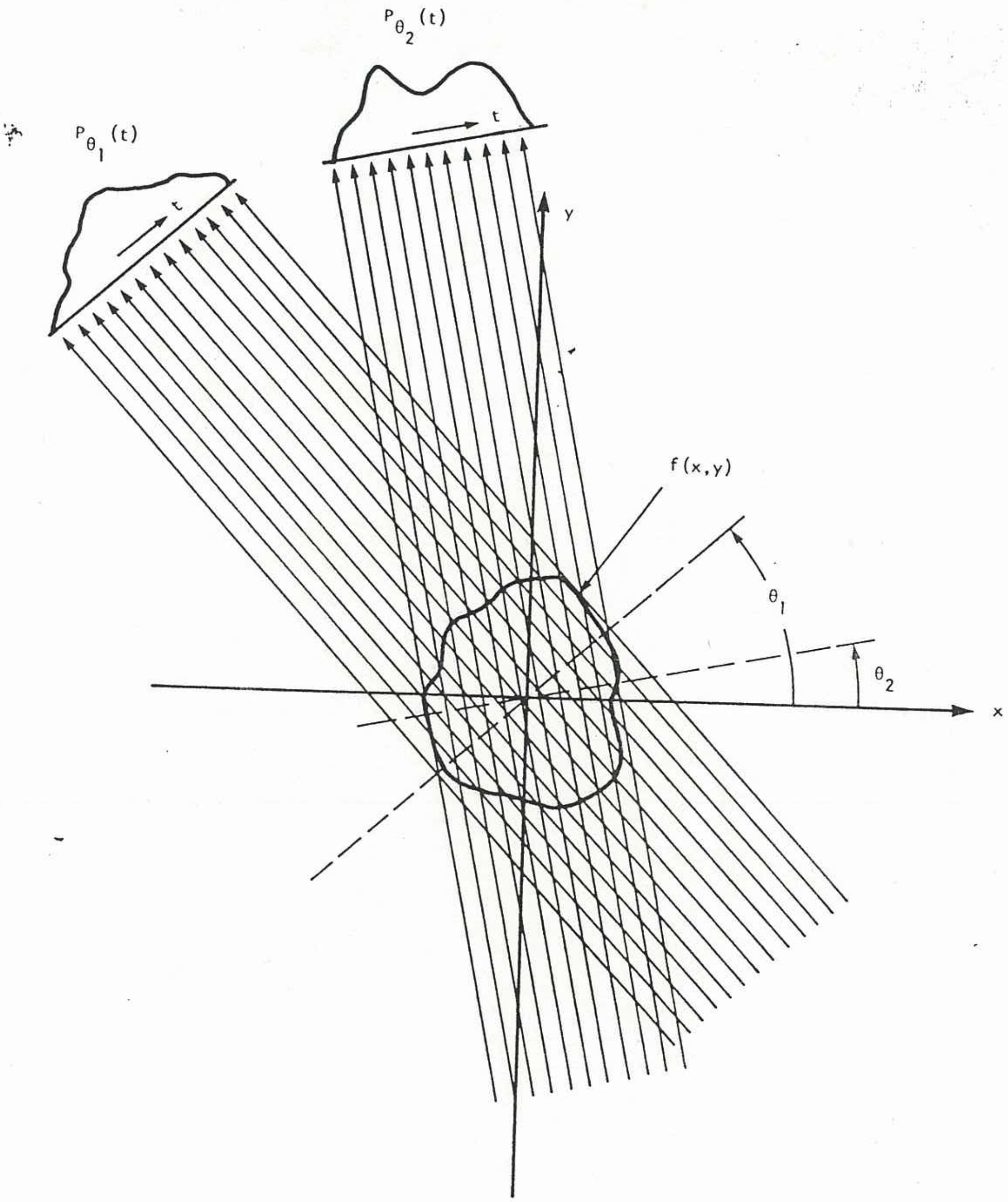


Fig. 2 This figure illustrates parallel projections.

shadows of denser regions of ~~tissue~~ material.

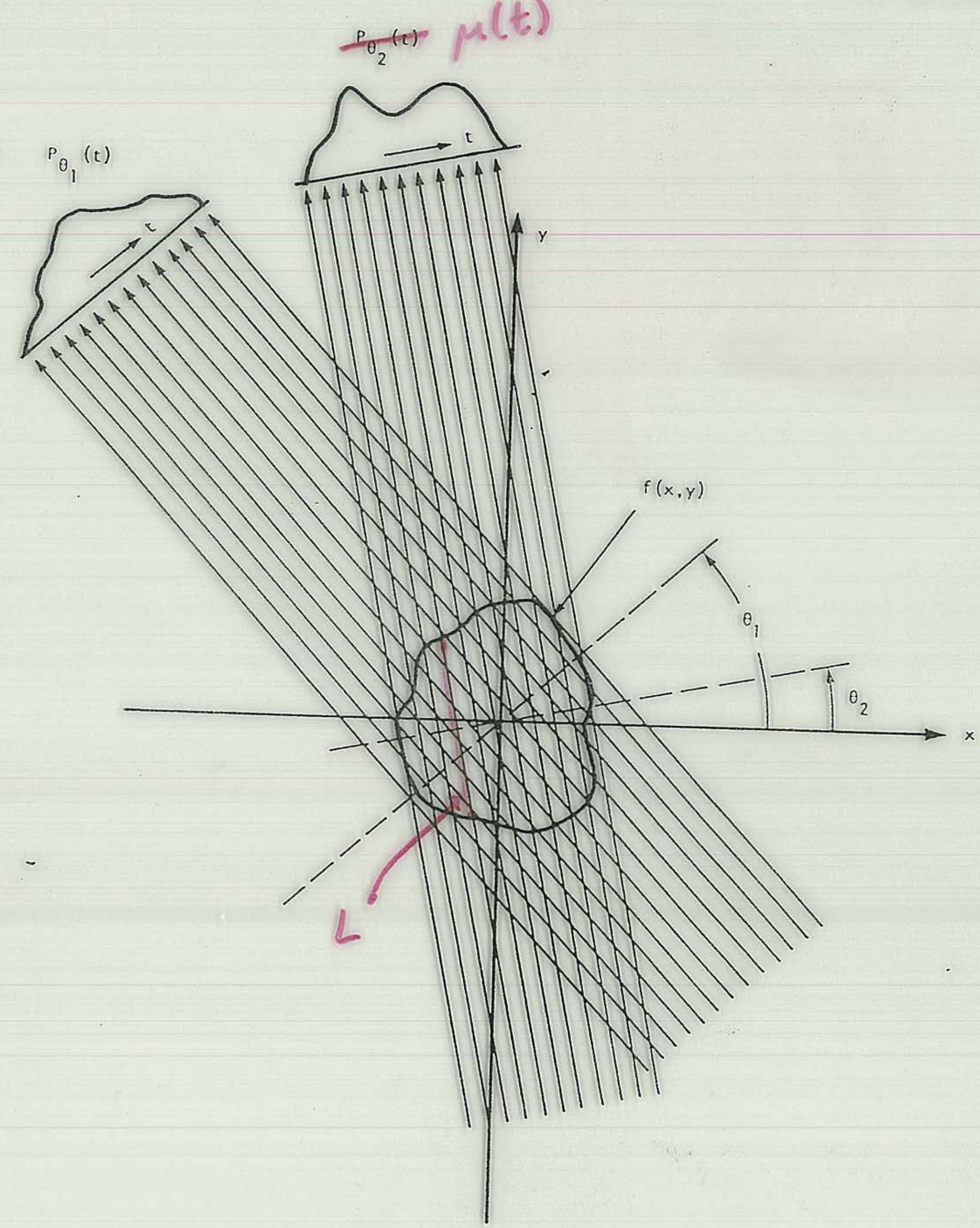


Fig. 2 This figure illustrates parallel projections.

$$\mu(t) = \int_L f(x,y)\,ds$$

TOMOGRAPHY

Continuous formulation

1. transmission

initial intensity of rays passing through

$$I = I_0 \exp[-\int_L h(s)\,ds] \tag{1}$$

attenuated by density h.

or

$$-\log g(t) = -\log\left(\frac{I}{I_0}\right) = \int_{L_t} h(s)\,ds\,, \tag{2}$$

2. SPECT

some kind of atten. as ray passes out

$$g(t) = \int_{L_t} \exp[-\int_{L_{st}} h(u)\,du]\, f(s)\,ds \tag{3}$$

activity at location s inside body.

3. PET

$$g(t) = \exp\left[-\int_{L_t} h(u)\,du\right] \int_{L_t} f(s)\,ds\,. \tag{4}$$

Linear equations are formed by approximating line integrals by a weighted (ray) sum:

	y_t	x_s	$a(s,t)$
T	$-\log g(t) = -\log \frac{I}{I_0}$	$h(s)$	pixel/ray weights δ_{st}
$SPECT$	$g(t)$	$f(s)$	$\delta_{st}\ \exp[-\int_{L_{st}} h(u)\, du]$
PET	$g(t)$	$f(s)$	$\delta_{st}\ \exp\left[-\int_{L_t} h(u)\, du\right]$

Note:

g is assumed to be an observable distribution; when subject to noise, measured projections y_t are assumed to form a Poisson point process with intensity g. The distributions specified in discrete form as x are unknown.

Attenuation hazard (density) h is
the *unknown* parameter in Transmission,
but is assumed *known* for Emission.

Observed distribution: Poisson point process intensity g.

EM algorithm

- *Development*
  Dempster, Laird, Rubin 1978 - EM formulation and properties
  Shepp-Vardi 1982 - introduced EM in tomography
- *When do we stop?* Convergence when: *fitted* projections agree with with *observed* counts!
  Chart Likelihood, CSQ minimum.
  EM = Expectation / Maximization

NOISE

Inverse problem with $N<\infty$ photons emitte

(x_i, y_i) $i=1,\dots,N$

leads to recorded data "histogram" g_N

A natural assumption for binned data

is ~~the~~ independent Poisson with density

<u>Ex</u>

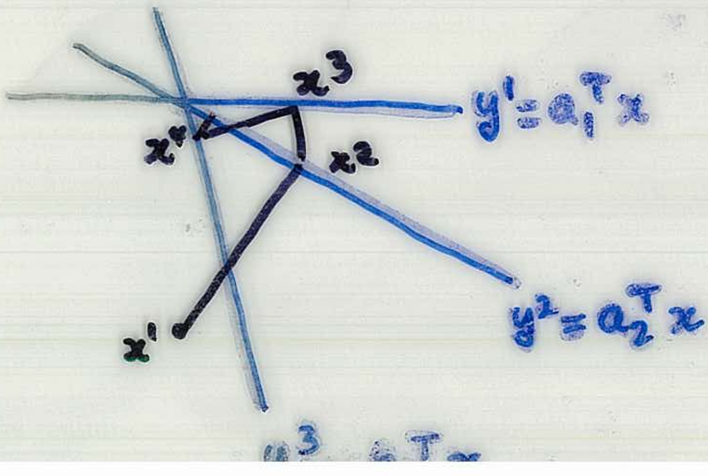
The discretized tomography model

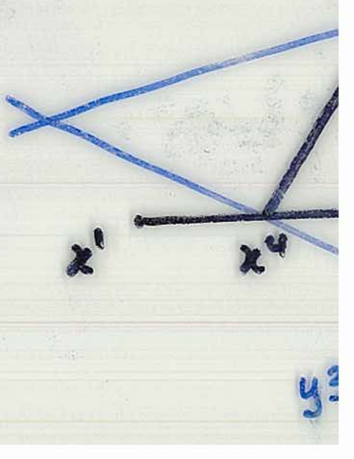
is $y_t \sim \text{Poisson}(\mu_t)$

with

$$\mu = Ax.$$

- EM continues to increase Likelihood func
- Block-iterative methods (OS-EM) cy





Key Benefits:

- Generality in modelling Physics: DDR, scatter.
- Extensions of EM: patient movement, dynamics

STATISTICAL CONTRIBUTIONS

1. *Geometry:* of PET (Shepp and Vardi, 1982), SPECT (Lange & Carson 1983, Weir and Green 1994)
2. *Regularization:* encouraging local smoothness (Geman 1984)
3. Fusing images (e.g. MRI *anatomy* with SPECT *function*, Ardekani 1995)
4. Dynamics - mapping body metabolism; time changing emissions: a point process in space-time (O'Sullivan 1993)

TAC, curve fitting for local metabolic parameters

COMPUTING EM

Iterative, each iteration of two steps:

1. *Project* the current source estimate $f^n(v)$ to produce *fitted* projection data $g^n(u)$.
2. *Backproject* the ratio between *observed* and *fitted* projections, $g(v)$ and $g^n(v)$, to determine multiplicative corrections.

THE BLOCK-ITERATIVE KACZMARZ ITERATION

- Have proven convergence to the uni[...] solution of the linearized ~~regul~~ MPL es[...] equations (with fixed W_k)

- use successive projections onto lin[...] spaces corresponding to ~~the~~ succe[...] data subsets — the partition o[...]

- are expected to provide fast convergence ?

RE COMPUTATION OF WEIGHTS IN FISHER SCORIN[...]

"No consensus about number of cycles .."

"The first iteration is usually the best ..

"Great accuracy in weights is not necessa[...]

see discussion in Carrol & Rupert
"Transformation & Weighting in R[...]