CWI

Universiteit Antwerpen

The ASTRA Tomography Toolbox

5 April 2016

More on ASTRA usage

CWI

Universiteit Antwerpen

Today

- Introduction to ASTRA
- Exercises
- **More on ASTRA usage**
- Exercises
- Extra topics
- Hands-on, questions, discussion

CWI

Universiteit Antwerpen

Constraints

SIRT with constraints

You can add box constraints to SIRT:

```
cfg = astra_struct('SIRT');
cfg.ProjectionDataId = sino_id;
cfg.ReconstructionDataId = rec_id;
cfg.ProjectorId = projector_id;
cfg.option.MinConstraint = 0.0;
cfg.option.MaxConstraint = 1.0;

alg_id = astra_mex_algorithm('create', cfg);

astra_mex_algorithm('iterate', alg_id, 100);
```

CWI

Universiteit Antwerpen

Geometries

CWI

Universiteit Antwerpen

Flexible geometries

- ASTRA supports:
  - 2D: Parallel beam, fan beam
  - 3D: Parallel beam, cone beam

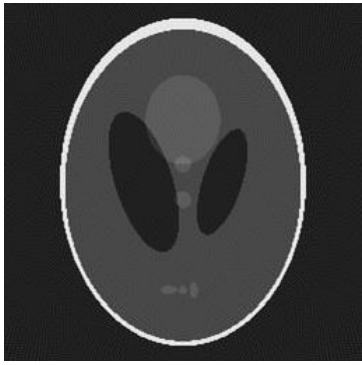
- All with fully flexible source/detector positioning

Flexible geometries

Example uses:

- Misalignment in experimental setup
- Dual axis datasets
- Laminography
- Single particle analysis
- Diffraction contrast tomography

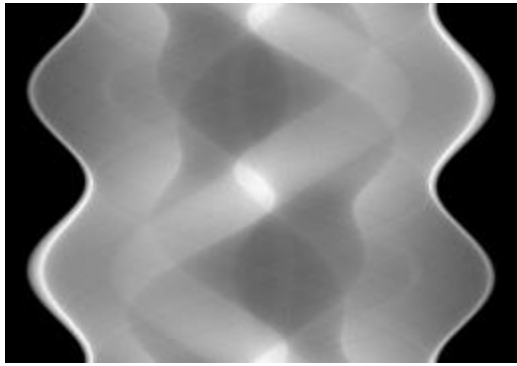
Fan beam



```
% 180 angles, 256 detector pixels, fan beam
% Source-origin distance 2000
angles = linspace2(0, 2*pi, 180);
proj_geom = astra_create_proj_geom('fanflat', 1, 256, ...
                                   angles, 2000, 0);

% (Virtual) detector placed on origin.
% There is no concept of behind/in front of the detector.

proj_id = astra_create_projector('line_fanflat', ...
                    proj_geom, vol_geom);
```

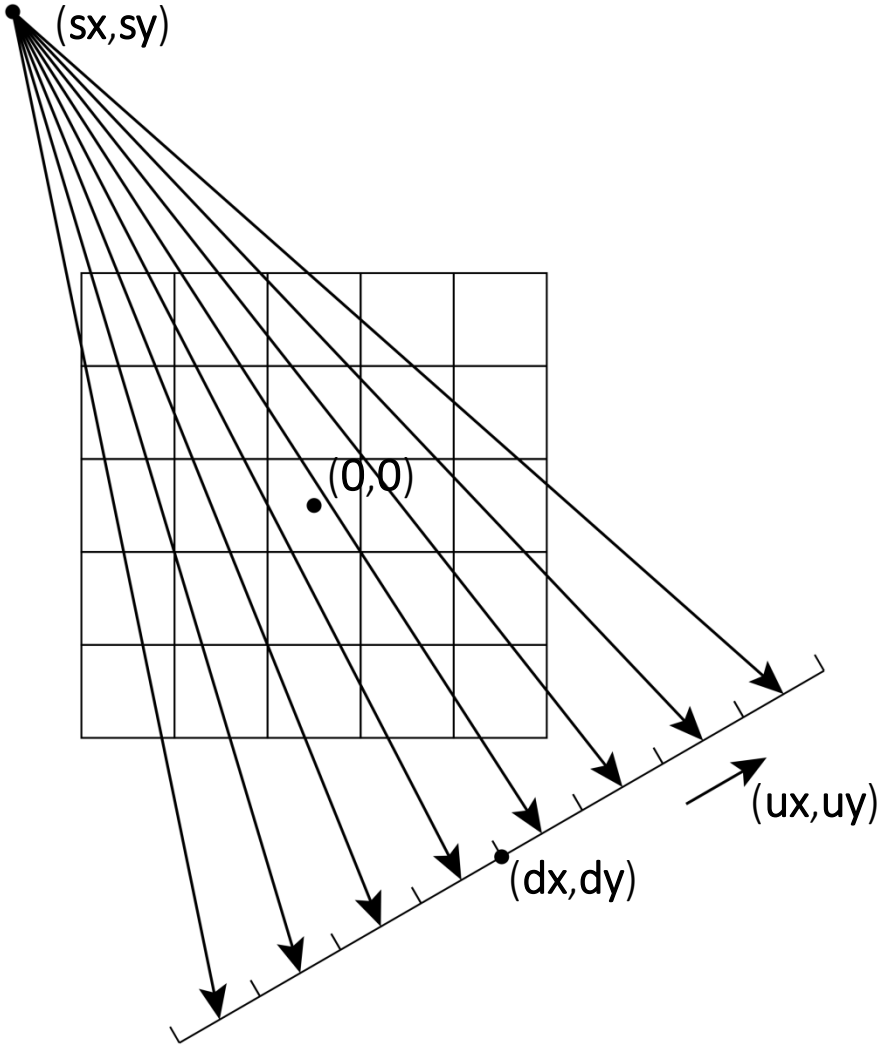


Fan beam – vector form

Three 2D parameters per projection:

s, d, u

These form a 6 element row vector.



CWI

Universiteit Antwerpen

Fan beam – vector form

```
% One projection angle
vectors = zeros(1, 6);
angle = 0.1;
source_dist = 2000;

% source
vectors(1,1) = sin(angle) * source_dist;
vectors(1,2) = -cos(angle) * source_dist;

% center of detector
vectors(1,3) = 0;
vectors(1,4) = 0;

% vector from detector pixel 0 to 1
vectors(1,5) = cos(angle) * 1.0;
vectors(1,6) = sin(angle) * 1.0;

proj_geom = astra_create_proj_geom('fanflat_vec', 256, vectors);
```

CWI

Universiteit Antwerpen

Parallel beam

- A bit embarrassingly, there is no equivalent for 2D parallel beam projections when using the CPU code.
- Will be in the next release.

CWI

Universiteit Antwerpen

SPOT Operator

SPOT Operator

- Contributed by Folkert Bleichrodt (CWI)

- Creates a MATLAB object that ``behaves like a matrix''.

SPOT Operator

```
vol_geom = astra_create_vol_geom(256, 256);
proj_geom = astra_create_proj_geom('parallel', 1, 384, ...
                                   linspace2(0, pi, 180));

% Create SPOT Operator
W = opTomo('strip', proj_geom, vol_geom);

P = phantom(256);

% Forward projection
s = W * P(:);

imshow(reshape(s, astra_geom_size(proj_geom)), []);

% Reconstruction using MATLAB's lsqr
x = lsqr(W, s, 1e-4, 200);

imshow(reshape(x, astra_geom_size(vol_geom)), []);
```

SPOT Operator

```
% Create SPOT Operator
W = opTomo('strip', proj_geom, vol_geom);

% Wavelet regularization (using SPOT and SPGL1)
B = opWavelet2(256, 'Haar', [], levels);

y = spgl1(W*B', s, [], 200, [], options);

imshow(reshape(y*B', [256 256]), [])
```

CWI

Universiteit Antwerpen

Matrices

CWI

Universiteit Antwerpen

System matrix (2D)

```
% s009_projection_matrix.m sample

vol_geom = astra_create_vol_geom(256, 256);
proj_geom = astra_create_proj_geom('parallel', 1.0, 384, linspace2(0,pi,180));

% For CPU-based algorithms, a "projector" object specifies the projection
% model used. In this case, we use the "strip" model.
proj_id = astra_create_projector('strip', proj_geom, vol_geom);

% Generate the projection matrix for this projection model.
% This creates a matrix W where entry w_{i,j} corresponds to the
% contribution of volume element j to detector element i.
matrix_id = astra_mex_projector('matrix', proj_id);

% Get the projection matrix as a Matlab sparse matrix.
W = astra_mex_matrix('get', matrix_id);

% Manually use this projection matrix to do a projection:
P = phantom(256)';
s = W * P(:);
s = reshape(s, [proj_geom.DetectorCount size(proj_geom.ProjectionAngles, 2)])';

% Because Matlab's matrices are stored transposed in memory compared to C++,
% reshaping them to a vector doesn't give the right ordering for multiplication
% with W. We have to take the transpose of the input and output to get the same
% results (up to numerical noise) as using the toolbox directly.
```

CWI

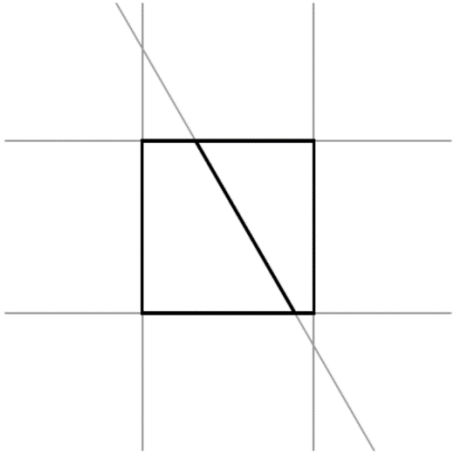
Universiteit Antwerpen

Discretization

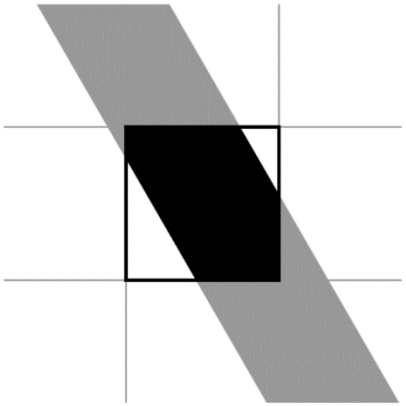
Projectors

For 2D CPU parallel beam, ASTRA has different discretizations:

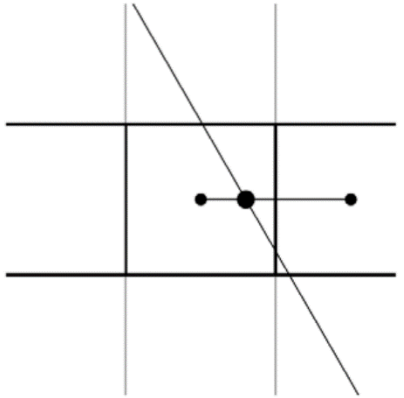
```
proj_id = astra_create_projector('line', proj_geom, vol_geom);
```



'line'



'strip'



'linear'
(Joseph kernel)

CWI

Universiteit Antwerpen

Today

- Introduction to ASTRA
- Exercises
- More on ASTRA usage
- **Exercises (see workshop webpage for PDF, part 2)**
- Extra topics
- Hands-on, questions, discussion