AM performance with multi-component tissue model

Data means:

\[ g(y) = \sum_E I_0(y, E) \exp\left[ -\sum_X h(y|x) \mu(x, E) \right] + \beta(y) \]

\[ \mu(x, E) = \sum_{i=1}^I \mu_i(E) c_i(x) \]

\( \mu_i(E) \) — linear attenuation coefficient \([\text{mm}^{-1}]\)

\( c_i(x) \) — specific gravity \([\text{unitless}]\)

AM update step:

\[ \hat{c}_i^{(k+1)} = \hat{c}_i^{(k+1)}(x) - \frac{1}{Z_i(x)} \ln \left( \frac{\tilde{b}_i^{(k)}(x)}{\hat{b}_i^{(k)}(x)} \right) \]
Multi-component experiment setup

\[ \mu_1(E) - \text{Styrene} \]

\[ \mu_2(E) - \text{Ca Chloride} \]

<table>
<thead>
<tr>
<th>Substance</th>
<th>True ( c_1(x) )</th>
<th>True ( c_2(x) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>0.9036</td>
<td>0.1357</td>
</tr>
<tr>
<td>Lucite</td>
<td>1.14</td>
<td>0.0583</td>
</tr>
<tr>
<td>Muscle</td>
<td>0.9399</td>
<td>0.1390</td>
</tr>
<tr>
<td>Ethanol</td>
<td>0.7999</td>
<td>0.0337</td>
</tr>
<tr>
<td>Teflon</td>
<td>1.4194</td>
<td>0.4878</td>
</tr>
<tr>
<td>X</td>
<td>0.0300</td>
<td>2.8613</td>
</tr>
</tbody>
</table>
Multi-component experiment setup

\[ g(y) = \sum_E I_0(y, E) \exp\left[-\sum_X h(y|x)\mu(x, E)\right] + \beta(y) \]
AM performance with multi-component tissue model

AM reconstructed images
100 iterations (22OS)
AM performance with multi-component tissue model

\[ \hat{\mu}^{(100)}(x, E) \text{ vs. } \mu(x, E) \]
Dual Energy AM Algorithm

\[ g_j(y) = \sum_E I_{0,j}(y, E) \exp \left[ - \sum_X h(y|x) \mu(x, E) \right] + \beta_j(y), \quad j \in \{1, 2\} \]

AM-DE update step: \[ \hat{c}_i^{(k+1)} = \hat{c}_i^{(k+1)}(x) - \frac{1}{Z_i(x)} \ln \left( \sum_j \hat{b}_{ij}^{(k)}(x) \right) \]
Alternative Dual Energy methods

Basis Vector Model (BVM)\* \rightarrow ESSRL Implementation

\[
\begin{bmatrix}
\mu_x^{(1)} \\
\mu_x^{(2)}
\end{bmatrix} =
\begin{bmatrix}
\mu_1^{(1)} & \mu_2^{(1)} \\
\mu_1^{(2)} & \mu_2^{(2)}
\end{bmatrix}
\begin{bmatrix}
c_1 \\
c_2
\end{bmatrix}
\]

unknown coefficients
pre-computed

Calibration phantom:

- 2 water
- styrene
- CaCl\(_2\)

AMDE experiment results

Noiseless data
200 iterations
(22OS)
AMDE experiment results

Noiseless data
1000 iterations
(22OS)
AMDE experiment results

Noiseless data
2000 iterations
(22OS)
Relative error (%) in component images

$\hat{C}_1^{(200)}(x)$

$\hat{C}_2^{(200)}(x)$

$\hat{C}_1^{(1000)}(x)$

$\hat{C}_2^{(1000)}(x)$
Relative error (%) in component images

\( \hat{C}_1^{(200)}(x) \)

\( \hat{C}_2^{(200)}(x) \)

\( \hat{C}_1^{(2000)}(x) \)

\( \hat{C}_2^{(2000)}(x) \)
AMDE experiment results
Relative error vs. iteration

\hat{\mu}^{(200)}(x, E) vs. \hat{\mu}^{(1000)}(x, E)

- Muscle
- Ethanol
- Teflon
- Substance X
- Lucite
- Water

Energy (keV) vs. Relative error (%)
AMDE experiment results

Cost function vs. iteration
Alternative Method experiment results

BVM-FBP

BVM-AM1
Data with noise
AMDE results

200 (22OS) iterations

1000 (22OS) iterations
Data with noise

Alternative method results

BVM-FBP

BVM-AM1