**Motivation & Idea**

- **Computed Tomography (CT):**
  - Diagnosing various health conditions and devising treatment plans
  - Health risks such as cancer due to exposure to the X-ray radiation

- **Sparse-view CT:** the target is radiated with fewer projection angles
- **Reconstruction of a tomographic image** \( x \) from a measured sinogram \( f \)

\[ f = Rx + n, \]

- **Exploration of the space of consistent reconstructions**
  - Radon transform matches with the measured sinogram
  - Corresponding to semantically different interpretations, obtained from a pre-trained CT image classifier

**Method**

- **Data Consistent Reconstruction:**

\[
\min_{x \in \mathbb{R}^3} \frac{1}{2} \| Rx - f \|_2^2 + \lambda_1 \sum_i H_i(N_i(x)) - m
\]

- **Transformations:** Utilize transformed (scaling, rotation) versions \( T_j(x) \), to produce realistically looking CT reconstructions

\[
\hat{x}(m) = \arg\min_{x \in \mathbb{R}^3} \frac{1}{2} \| Rx - f \|_2^2 + \lambda_1 \sum_i H_i(N_i(T_j(x))) - m + \lambda_2 TV(x)
\]

- **Soft Cropping:** To avoid visible artifacts in around the cropping boundary, the gradient descent update can be written as

\[
x^{k+1} = x^k - \eta (\nabla E_i(x^k) + G \odot \nabla E_2(x^k))
\]

- **Training Suitable Classification Network:** Training of a classification network \( N_h \) adversarially using the Fast Gradient Sign Method

**Realistic Solution Space**

- **Reconstructions of different malignancies (controlled by \( m \))**
- **Space of underdetermined CT reconstructions** (\( p = 50 \)) decreasing \( m \)
- **Filtered Back-projection** increasing \( m \)
- **Strong changes of \( m \): visually unrealistic**
- **Small changes of \( m \): realistic images & significant changes in the appearance of the nodule**

**Investigation on the Residuals**

- **Reconstruction:** Tendency to allow larger variations in the reconstruction for fewer projection angles. For many projections, strong deviations can lead to severe artifacts.

\[
\begin{array}{cccc}
\text{m} = 0.2 & \text{m} = 0.8 & \text{m} = 0.2 & \text{m} = 0.8 \\
p = 50 & p = 100 & p = 200 & p = 100
\end{array}
\]

- **Residual:** A modification in the nodule is easier to recognize for more projection angles. For fewer projection angles it is possible to modify the nodule without any sign of the exploration.

\[
\begin{array}{cccc}
p = 50 & p = 100 & p = 200 & p = 300
\end{array}
\]

- **Data consistency loss & the distance of the interior and the exterior error**

\[
\begin{array}{cccc}
0.02 & 0.05 & 0.08 & 0.02 \\
0.05 & 0.08 & 0.08 & 0.08
\end{array}
\]

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