Compressed Sensing on Multi-pinhole Collimator SPECT Camera for Sentinel Lymph Node Biopsy

Carlo Seppi, Uri Nahum, Peter A. von Niederhäuser, Simon Pezold, Michael Rissi, Stephan K. Haerle and Philippe C. Cattin

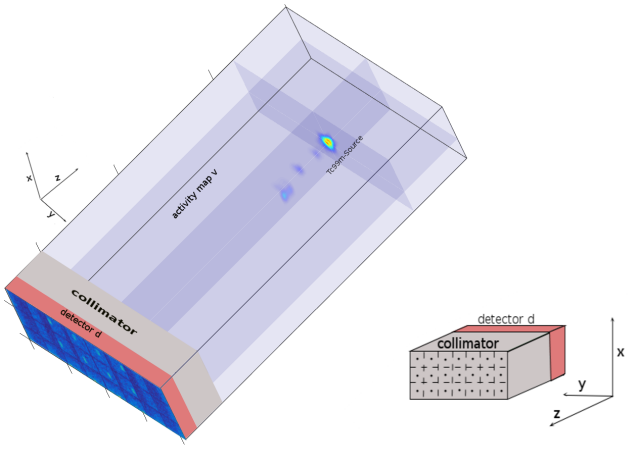
Center of medical Image Analysis & Navigation (CIAN)
Department of Biomedical Engineering, University of Basel

Motivation

Standard procedure for cancer in the head and neck includes a complete surgical removal of the lymph nodes, which is needed in less than 30% of the cases.
Finding the exact position of the sentinel lymph nodes will be helpful for less invasive surgical biopsy and exclude regional spread of the cancer.

Material

Using a **multi-pinhole collimator** [1] to reconstruct the activity map of the radioactive tracer, using a **single image** of the detector.



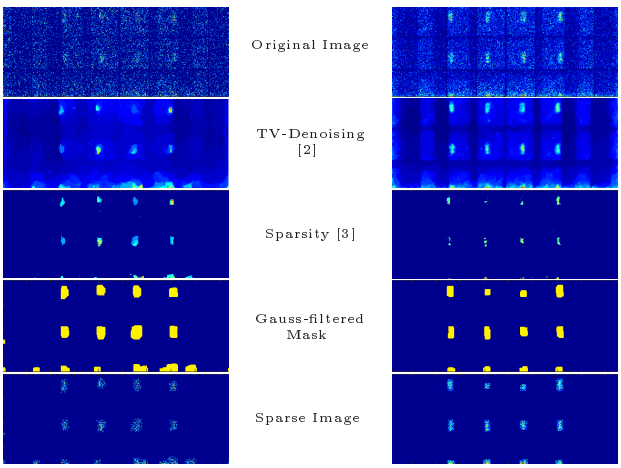
- *Detector's* resolution is 487×195 pixels of the size $172\,\mu m \times 172\,\mu m$
- *Collimator:* Tungsten, $86.9\,mm \times 36\,mm \times 36\,mm$, 24 pinhole compartments

Image Processing

Detector's image is not sparse:

- Solving linear system would take long & be inaccurate
- Difficult to use geometric properties of the collimator

$\Longrightarrow$ Use a pipeline of image processing to get sparsity



Methods

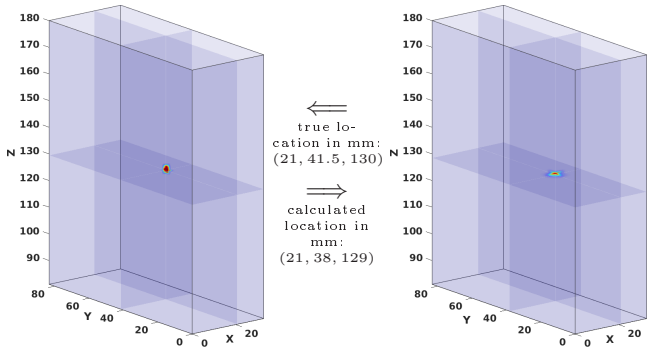
Inverse Problem Let $\mathbf{A}$ be an linear operator, which projects an activity map $\mathbf{v}$ on the detector $\mathbf{d}$ such that $\mathbf{Av} = \mathbf{d}$.
For a given detector image $\mathbf{d}^{true}$ we solve:

$$\min_{v} ||\mathbf{v}||_{1,w} \quad \text{s.t.} \quad ||\mathbf{Av} - \mathbf{d}^{true}||_2 \leq \epsilon$$

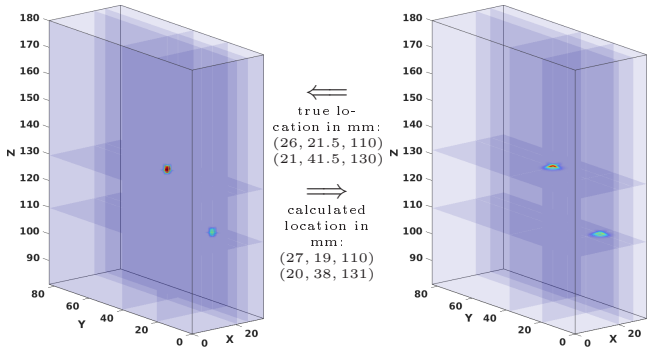
using WSPGL1. [4]

Results

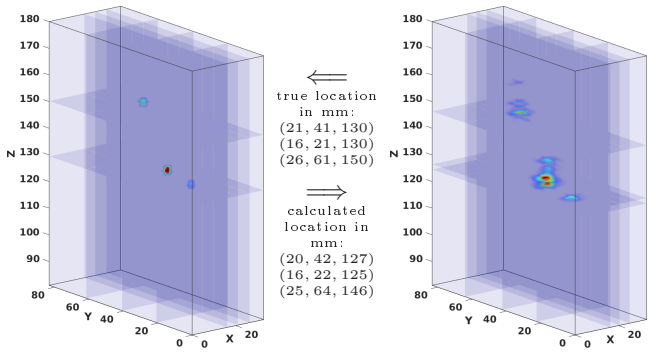
Visualization of our experiment with one source:



Visualization of our experiment with two sources:



Visualization of our experiment with three sources:



References

[1] P. von Niederhäusern et al., "Medical Imaging and Augmented Reality" 2016.

[2] A. Beck and M. Teboulle, "Fast Gradient-Based Algorithms for Constrained Total Variation Image Denoising and Deblurring Problems" 2012.

[3] M. Grote et al. "Adaptive eigenspace method for inverse scattering problems in the frequency domain" 2017.

[4] H. Mansour, "Beyond l1-norm minimization for sparse signal recovery" 2012.