Image-guided Sentinel Lymph Node Biopsy based on Augmented Reality

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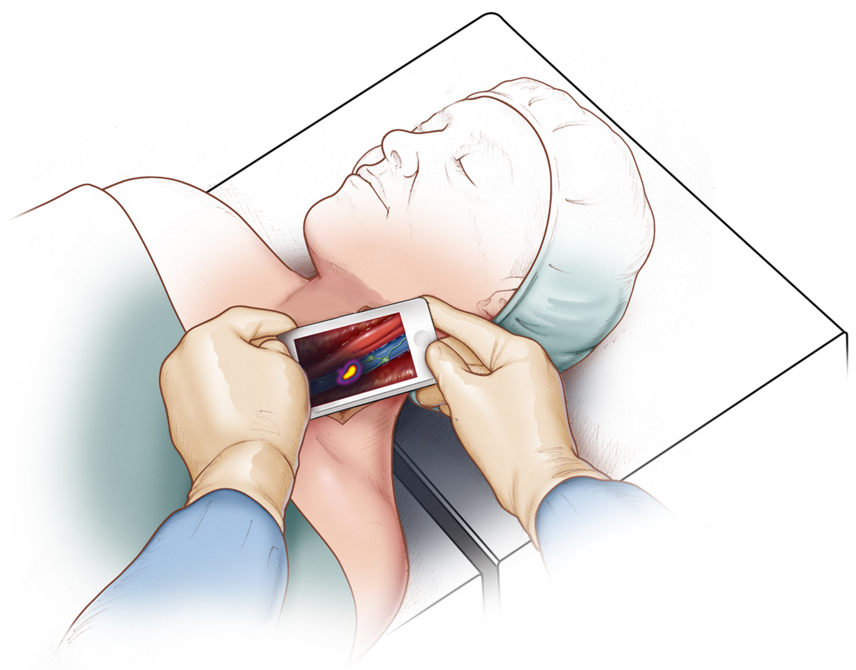
Introduction

Morbidity from head and neck cancer is high and a complete removal of lymphatic tissue together with the tumor is often conducted. However, such interventions are *unneeded* in 70 % of the patients. **Sentinel lymph node biopsy**, based on radioactive tracer liquid injected near the tumor, is a technique to improve staging of the malignancy and to avoid overtreatment.



Based on our previous works [1] we are able to fully reconstruct and visually **represent the tracer distribution** of a calibration target **without** the need of **SPECT/CT** related data [2]. Such information is then made available to the operator on a tablet computer display.

This poster describes a *prototype* of an **augmented reality (AR) device** that will be able to support the surgeon to visually identify tracer enriched lymph nodes for the biopsy.

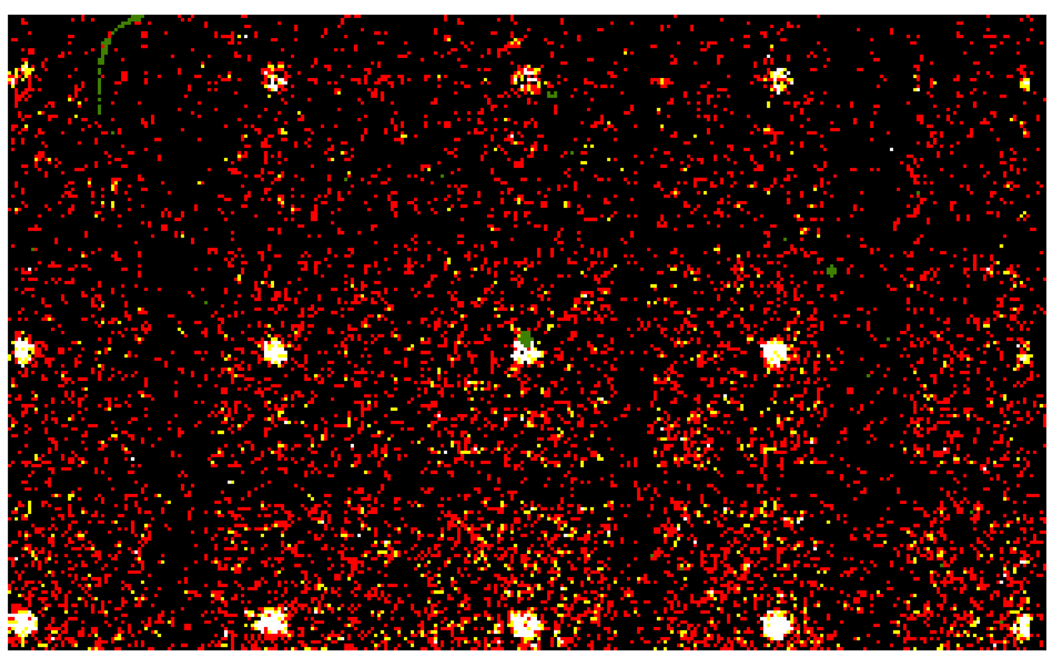
Activity reconstruction

Reconstruction of the tracer activity is achieved by tackling the challenges imposed by the **Inverse Problem Formulation**.

- The Forward Problem: $\mathbf{A}(\dot{v}) = \dot{y}$
- The Inverse Problem: $\dot{y} = \mathbf{A}(\dot{v})$

where $\mathbf{A}$ is the model, $\dot{v}$ are the parameters, and $\dot{y}$ are the measured data.

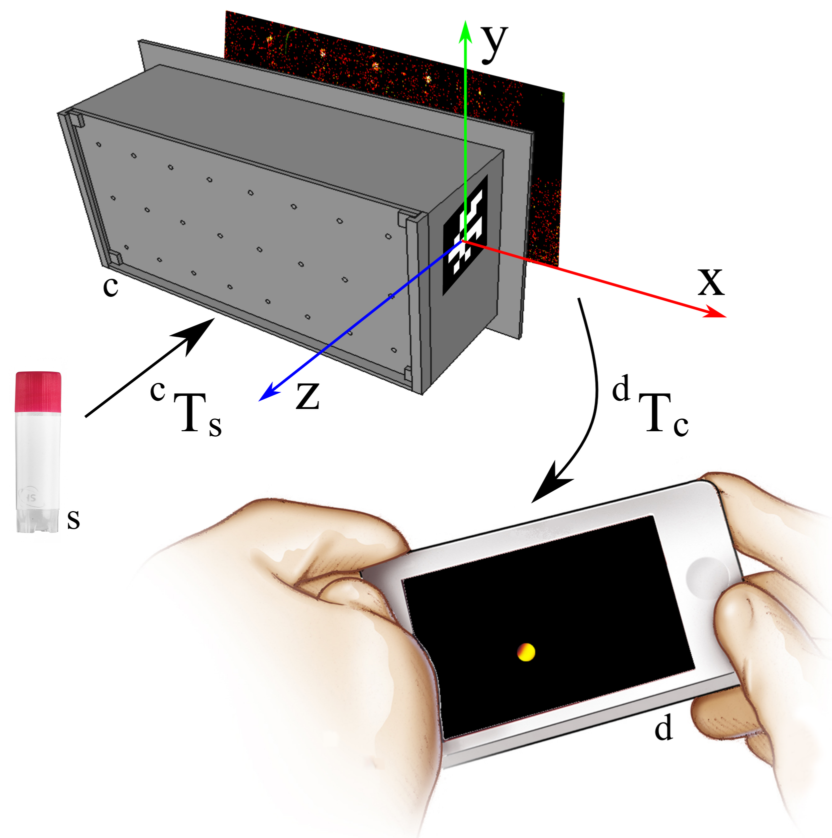
As the detector image is known ($\dot{y}$), a possibly good estimate of the unknown tracer distribution ($\dot{v}$) inside the patient can be achieved. Thanks to the design of our multi-pinhole collimator ($\mathbf{A}$), disparity information is exploited to support a solution to this ill-posed problem.



Detector image

Above a projection of a single centered activity point source, produced by the multi-pinhole collimator. Disparity can be observed by the *outward shift* of the source projection on the different small subimages of each pinhole.

Activity representation

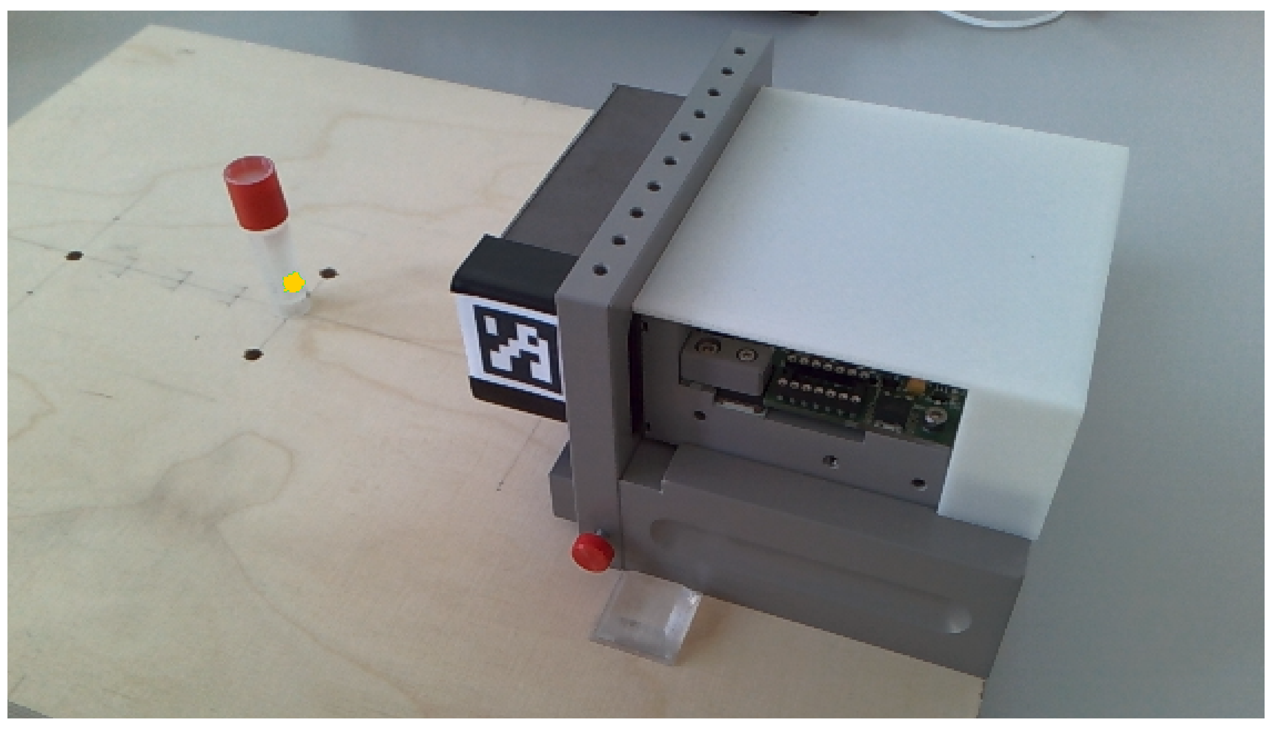


A common coordinate system (center of the black/white marker) of the source (**s**), the collimator (**c**) and the display unit (**d**) is *optically* determined and used to relate the activity to the AR device by

$$ {}^{d}T_{c} \, {}^{c}T_{s} \, \mathbf{A}(\dot{v}) \, . $$

The accuracy of ${}^{c}T_{s}$ is directly related to the quality of the solution to the Inverse Problem.

Results



Augmented video image (orange blob)

Conclusion

An early prototype based on *optical* markers shows promising results and awaits testing with real experimental data.

Next steps are the development of a *calibration scheme* to relate the coordinate system with the layout of the detector and the evaluation of 3D-to-3D *voxel-based* mapping algorithms to improve the visual representation of the activity.

References

[1] von Niederhäusern, P.A., Maas, O.C., Rissi, M., Schneebeli, M., Haerle, S.K., Cattin, P.C.: Augmenting Scintigraphy Images with Pinhole Aligned Endoscopic Cameras: A Feasibility Study. Springer Intl. Publishing (2016)

[2] Seppi, C., Nahum, U., von Niederhäusern, P.A., Pezold, S., Rissi, M., Haerle, S., Cattin, P.C.: Compressed sensing on multi-pinhole collimator SPECT camera for sentinel lymph node biopsy. Springer Intl. Publishing (2017)