Image-guided Sentinel Lymph Node Biopsy based on Augmented Reality

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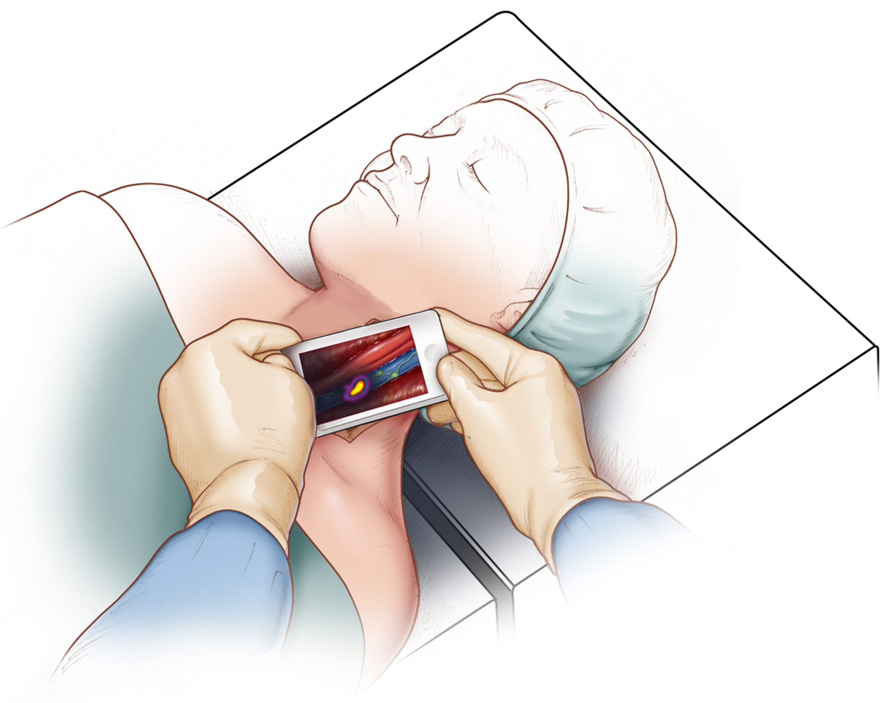
Introduction

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 for 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.

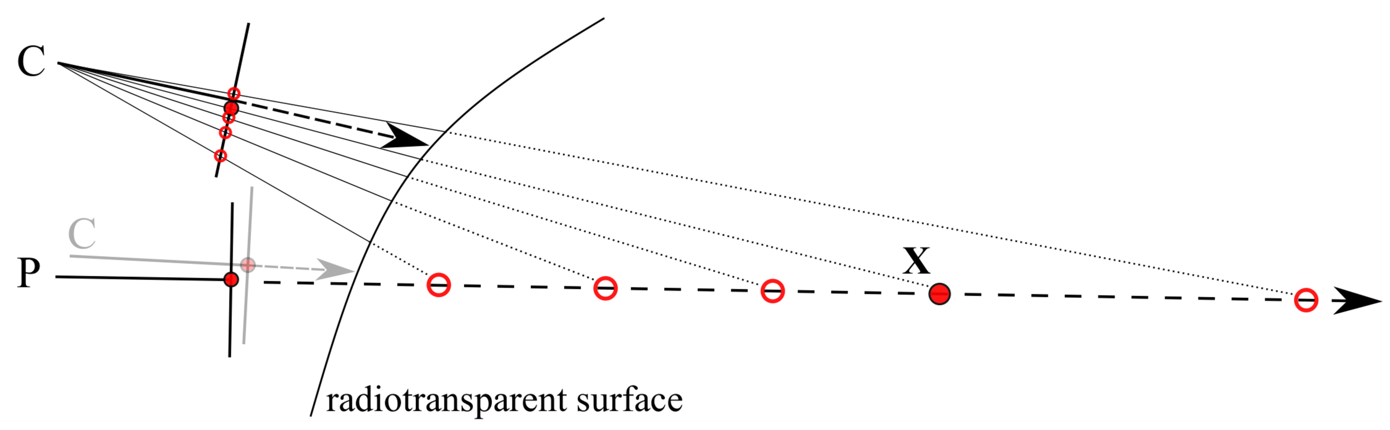


An initial vision of our proposed augmented reality device is to improve surgeon orientation and **identification of the first draining lymph node** during the biopsy by 2D-to-2D mapping, displayed on a tablet computer.

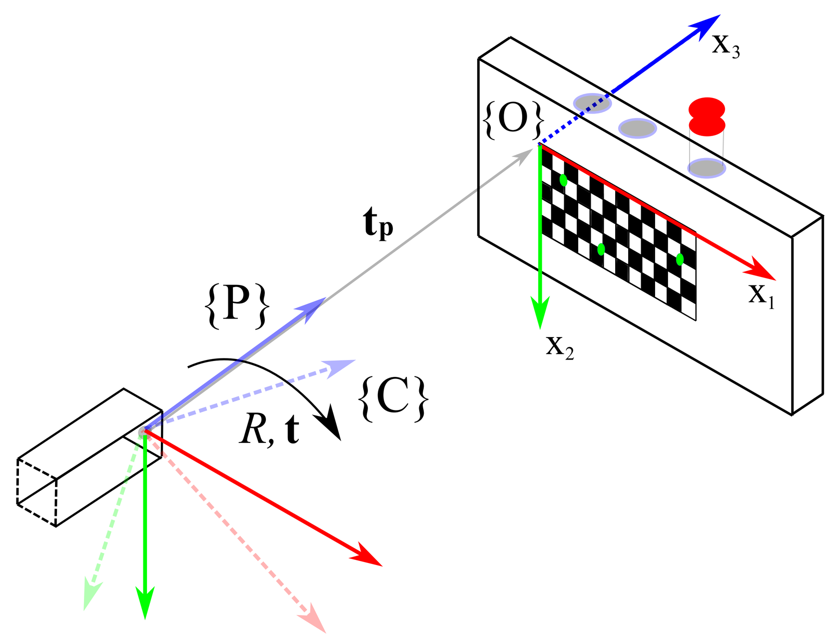
This poster describes a **calibration scheme** to axis align **micro cameras inserted into collimator pinholes** for small augmented reality gamma detector devices.

Methods (1)

Perspective projection is achieved by using pinholes. This is a valid assumption for the optical and the gamma regime, given a suitable collimator design [1]. **View axis alignment** between the pinhole (P) and the camera (C) needs to be as close as possible and co-calibrated in order to reduce the augmentation error.



The pinhole pose wrt to the target origin **O** is known (solid arrows). The **pose of the camera** (dashed arrows) **needs to be determined** using a checkerboard detection algorithm. The relative rotation R and translation $\mathbf{t}$ between pinhole and camera can then be calculated. The vial (red cap) contains radioactive liquid released through exit pupils (green circles) to assess the calibration.



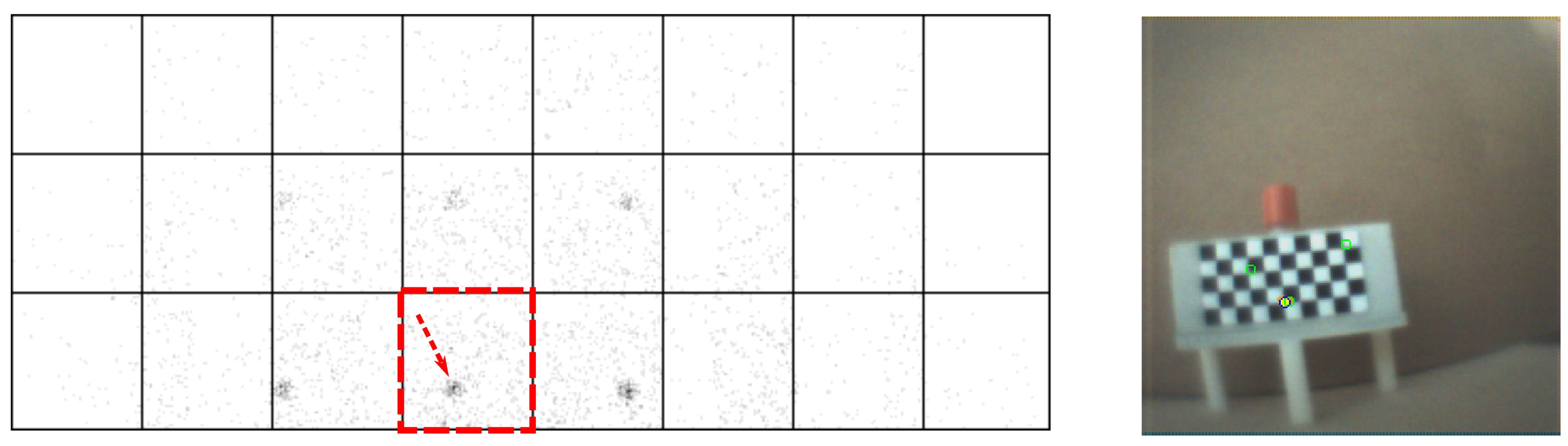
Methods (2)

The **mapping of information** from the gamma camera (p_1, p_2) to the optical camera (c_1, c_2) is given by the following transformation. The depth priors (z_p, z_c) are either measured [2] or estimated. Rotation R and translation $\mathbf{t}$ are given by the calibration.

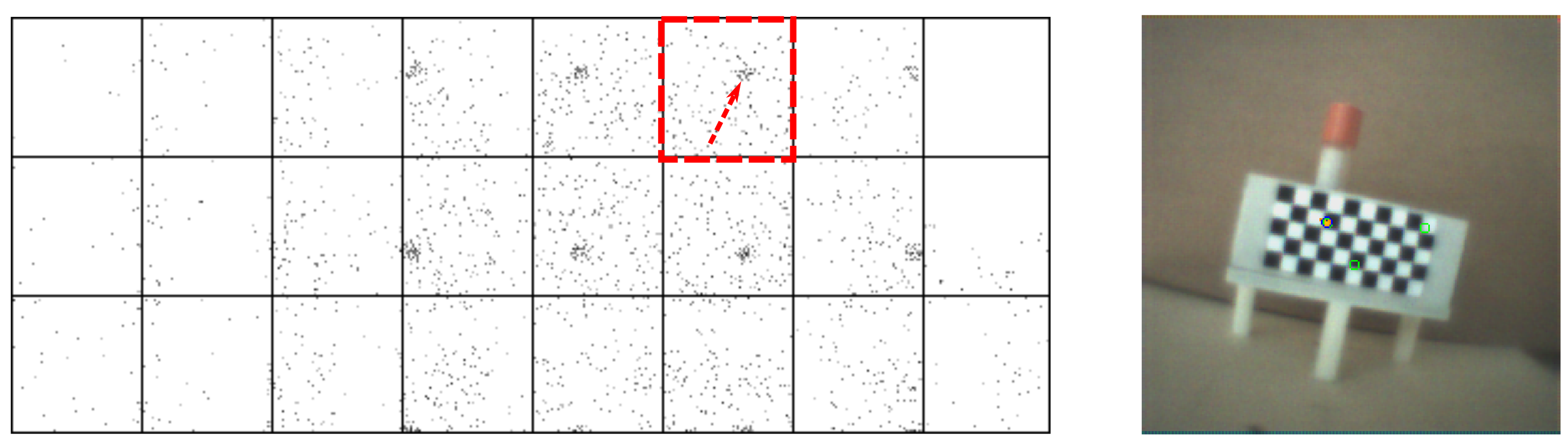
$$\begin{pmatrix} c_1 \\ c_2 \\ 1 \\ 1 \end{pmatrix} = \begin{bmatrix} \frac{1}{z_c} I_3 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} R & \mathbf{t} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} z_p I_3 & 0 \\ 0 & 1 \end{bmatrix} \begin{pmatrix} p_1 \\ p_2 \\ 1 \\ 1 \end{pmatrix}$$

Results

The above transformation is applied to the activity image patch (red box) collimated by a pinhole. The maximum activity is indicated by arrows. **Optical image augmentation** (yellow, orange blobs) at known exit pupils (green circles) of the radioactivity is presented for two pinhole/camera pairs.



pinhole/camera pair 20, activity distance 110 mm



pinhole/camera pair 06, activity distance 130 mm

Conclusion

Using **calibrated pinhole/camera pairs** to augment optical images with gamma detector data for sentinel lymph node biopsy is **promising**. This warrants further development of the method. As the background signal from the tracer near the tumor is high, challenges in image processing remain.

Next steps in the development are the evaluation of 3D-to-3D voxel-based mapping algorithms for immersive augmented reality and improving the collimator designs to constrain unwanted background photons.

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)