Focus Group **Intra-Operative Therapy**

Prof. Michael Friebe (IDTM GmbH & Univ. of Magdeburg) | Rudolf Diesel Industry Fellow
Philipp Matthies | Doctoral Candidate
Prof. Nassir Navab, Computer Aided Medical Procedures & Augmented Reality, TUM

Michael Friebe

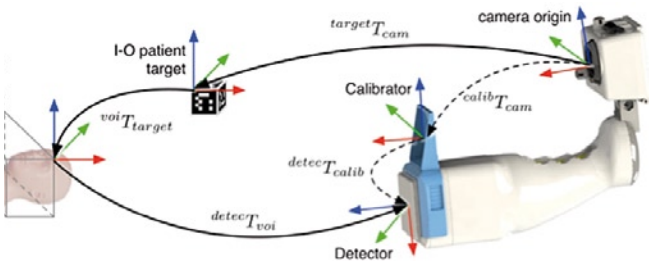
Oncology therapies benefit greatly from diagnostic imaging that is available for the actual procedure monitoring. However the images are mainly acquired prior to a surgery, and live updates are done with systems different from the ones used for the high-resolution and high-contrast images.

Intraoperative and minimally invasive procedures require another imaging functionality, which registers and follows instruments to the images to allow guidance of the tool exclusively with the real-time imaging or with pre-operative imaging data that is used at the surgical table (“tracking”).

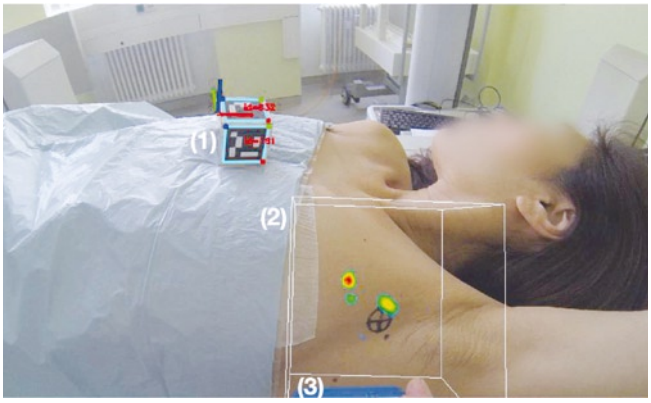
Our goal in the last three years was to develop new intraoperative therapy devices that allow minimally invasive tumor removal under imaging guidance and a subsequent tumor bed radiation to ensure that all cancer cells are killed while at the same time reducing the total tissue volume that is removed. Needed are diagnostic systems, ideally combining molecular information with high-resolution anatomical imaging data (e.g., SPECT with ultrasound or X-ray); tracking systems that follow and register the tools and imaging systems to each other; and finally the actual therapy devices, which also need to be tracked and image-registered. We came up with several new approaches in 2015.

Tracking systems are used in many medical scenarios for the localization of devices or the patient, for example in intra-operative nuclear imaging. Commonly used outside-in tracking systems often suffer from line of sight issues (e.g. human body is blocking the path between object and camera). To overcome that problem we developed a combination of an inside-out tracking technique with a hand-held mini gamma camera and an image reconstruction pipeline to provide 3D SPECT-like (single photon emission computed tomography) images in a compact flexible setup suitable for interventions. The system setup involves the marker cube and the mobile gamma detector with attached video camera. Black arrows mark the coordinate system transformations between the video camera, calibrator, gamma detector, volume of interest, and patient target ([1] and figure 1). This approach eases the interventional procedure in terms of hardware used and line of sight requirements and provides the desired molecular/anatomical imaging in combination of handheld SPECT with Ultrasound imaging [2]. We believe that this new tracking approach can be used for many other applications that require tool to image or image to image registration.

On the therapy tool side we continued our work using small X-ray tubes based on carbo-nanotube technology for intraoperative radiation delivery and subsequent tumor bed radiation. We also developed a new catheter that employs two ballons that are expanded using the cavitary access path to the site where the tumor was removed. Rather than using a gamma emitting X-ray tube a beta emitting liquid based on 188 Rhenium was filled into the outer of two ballons, while the inner one filled with water or air presses the outer balloon to the tumor bed tissue ([3] and figure 2). This technique can be combined with a newly developed tumor removal catheter for solid tumors in the size up to 2cm diameter or even for larger volumes like the prostate [4].



1 | Visualization of freehand SPECT reconstruction in augmented reality view. The patient target (1) is tracked and the volume of interest is rendered (2) in front of the gamma camera (3).



Prototype assembly

Stainless steel tube with inner plastic tube, inner balloon, outer balloon

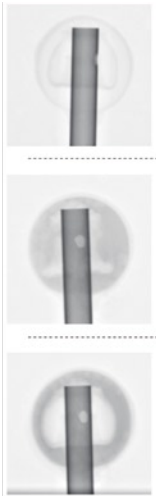
Prototype of the new brachytherapy balloon catheter

ITM Rhenium applicator

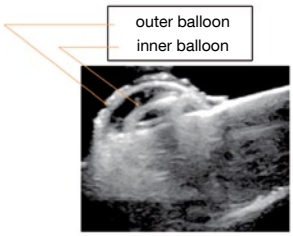
Possible handheld applicator

Results

X-Ray Images of the filling of the brachytherapy balloon catheter



This first prototype and setup shows that an approach using Rhenium-188 for intracavitary or interstitial radiation therapy delivery that could be feasible (mainly for small tumors) for delivering a radiation boost of around 20 Gy in 3mm from the balloon surface in an acceptable time (around 30 minutes).



Ultrasound catheter image

2 | Double-balloon catheter that accesses the intracavitary path of the minimally invasive tumor removal. The inner balloon is filled with water or air and presses against the tumor bed. The outer balloon is subsequently filled with a beta(-) radiation liquid (188 Rhenium) and will deliver a tumor bed dose of around 30Gy in 20 minutes. The catheter can be tracked and imaged via ultrasound and X-ray.

The focus group activities will continue in close collaboration between the chair of Prof. Nassir Navab at TUM-CAMP and the chair of catheter technologies and image guided surgeries of Prof. Michael Friebe at the Otto-von-Guericke-University in Magdeburg, Germany. Joint lectures for Master students of both universities have been initiated two semesters ago and will continue even though 2015 was the final year of the focus group INTRAOPERATIVE THERAPY. Many thanks to TUM-IAS for allowing this exciting form of collaborative research.

Selected Publications:

[1] P. Matthies, B. Frisch, J. Vogel, T. Lasser, M. Friebe, N. Navab Inside-Out Tracking for Flexible Hand-held Nuclear Tomographic Imaging IEEE Nuclear Science Symposium and Medical Imaging Conference, San Diego, USA, November 2015

[2] M. Friebe, M. Horn, S. Paepke, E. Klein, T. Wendler Hybrid interventional imaging for non-surgical sentinel lymph node staging International journal of computer assisted radiology and surgery : a journal for interdisciplinary research, development and applications of image guided diagnosis and therapy. - Berlin : Springer; Vol. 10.2015, Suppl. 1, S. S36

[3] M. Friebe, A. Boese Image guided double-balloon brachytherapy concept International journal of computer assisted radiology and surgery : a journal for interdisciplinary research, development and applications of image guided diagnosis and therapy. - Berlin : Springer; Vol. 10.2015, Suppl. 1, S. 183-184

[4] A. van Oepen, A. Boese, M. Friebe Minimally invasive tumor extraction combined with subsequent intraoperative radiation IGIC 2015 : 2. Image-Guided Interventions Conference, 2. - 3. November 2015, Mannheim ; Abstractband - Vorträge. - Mannheim

Publications by this Focus Group can also be found on page XXX.