

# **ERC: Engineering Research Center for Computer-Integrated Surgical Systems and Technology**

## **IREE Supplemental Award**

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*ABSTRACT: We present a summary of our stay in Germany sponsored by the NSF IREE. We detail in broad terms the scope of our research while in Germany and discuss the connections for collaboration we made during our stay. During our time in Germany, we were hosted by the TU-Munich and professor Dr. Darius Burschka.*

### **INTRODUCTION**

Under award of the NSF IREE grant to Johns Hopkins University we, Daniel Abretske and Daniel Mirota, traveled to and researched in Munich, Germany from May 25, 2007 to September 1, 2007. While in Germany, we collaborated with both our advisor from JHU, Dr. Greg Hager, as well as Dr. Darius Burschka of TU Munich (TUM). TU Munich, one of the premiere technical universities in Germany, has a wide range of interesting projects under investigation. Their work in computer vision and robotics ranges from autonomous robotics interacting with humans to visual aerial mapping of the surrounding areas and buildings via video. More importantly, they have several researchers who are interested in medical imaging and related works.

While visiting TUM, our primary research focus was the continuation of previous work in visual tracking in the sinus cavity for minimally invasive surgery. The work has been divided into two primary areas: 3D registration of camera position to preoperative CT scans, and the estimation of camera motion from visual region tracking. In addition to this continuance of work, we also toured other labs at TUM to explore active research in other areas and had many discussions about the field of robotics and vision. In particular, our discussions focused heavily on multi-sensor data fusion, robotic localizations, and group behaviors.

Our primary reason for traveling to Germany was to build connections with other researchers at TUM who have been working on, or are interested in medical imaging and medical robotics. By forming these connections, we hope to bring about joint projects between our two universities, leveraging the resources available at both sties. In

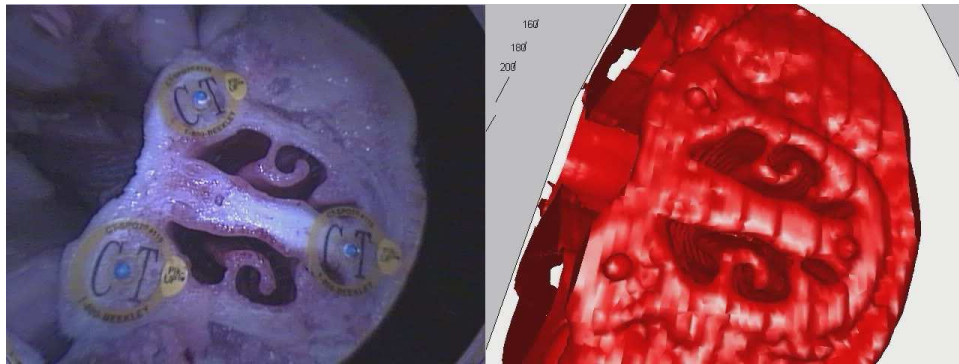
particular, we wish to combine TUM's expertise in multi-sensor fusion with our work in medical imaging and access to vast amounts of medical video footage.

### **RESEARCH ACTIVITIES AND ACCOMPLISHMENTS OF THE INTERNATIONAL COOPERATION**

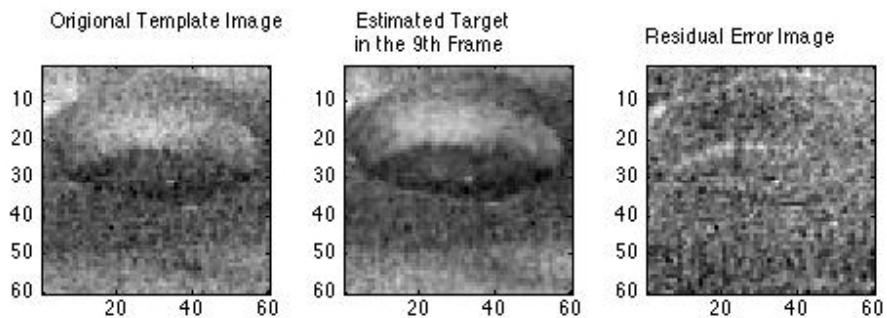
While in Germany, we focused on continuing our research into sinus CT-endoscope registration and motion estimation. The work began at Johns Hopkins University under the aegis of a R21 NIH grant supporting both our work and collaboration with surgeons to develop a protocol for the use of our work in an OR setting. A major point of the NSF IREE was to expose other researchers to our current work and form potential collaboration points for future exploration. To that end, we worked with Dr. Burschka on expanding our existing work and developing new directions to progress along, while meeting with other researchers to learn of their work and discuss our own. From these discussions, the idea emerged of creating a more general framework to continue our work, as well as a broad range of ideas ranging from robotic control to illumination based reconstructions. In many senses, the great discussions we had with other researchers were almost more important to our goals in traveling to Germany than the simple act of continuing our research. In particular, these discussions have greatly inspired one of us in the area of robotic cooperation and the other is applying for German Academic Exchange Service (DAAD) Research. Our work was related to the goals of the ERC in creating systems for the integration of computers and surgical tools.

Since we were continuing work, at the start of our stay we informally presented our current projects to our host and his students. Our goal was to introduce our work, seeding the interest of our German colleagues, as well as familiarize our counterparts with our interests. TUM and DLR (German Aerospace Center) offered an excellent speaker series on various topics within robotics and computer vision. We took full advantage of these opportunities to converse with colleagues about the different speakers. In particular, one talk on the role of biological system in robotics we found particularly inspiring. In addition, we took part in numerous lab tours of TUM and DLR, giving us a further view into the research of both institutes. Though the talks and tours were major interactions, we also had more personal work directly with Professor Burschka through weekly meetings and discussions over lunch or coffee breaks.

Our most tangible accomplishments for the summer include the refinement of our region tracker, as illustrated in Figure 2, the start of a new extension to the tracker, and the creation of tools to build a 3D model flythrough from CT, seen in Figure 1.



**Figure 1: A CT segmentation of the porcine sinus passage and the 3D model**



**Figure 2: An example tracker region and tracker output for a porcine sinus**

### **BROADER IMPACTS OF THE INTERNATIONAL TRAVEL**

Our time in Germany resulted in many contacts between ourselves and researchers at TUM. We are also currently hosting a student from TUM working on his Master's Degree. It is our hope that not only has our time in Germany helped us connect individually with researchers at TUM, but that those same researchers will be inspired to connect with other researchers here at JHU. We know that we will be continuing our correspondences with TUM. In the following paragraphs, we each detail our own personal experiences in Germany and the impacts they had on us.

**Dan Abretske:** While in Germany, I engaged in many cultural exchanges by visiting beer gardens, museums; traveling to many German cities such as Berlin, Stuttgart, Heidelberg and Köln; visiting the DLR; and practicing my German language skills with native German speakers. Beer gardens and German pubs are a large facet of the Munich lifestyle, and a night out dining and drinking with other researchers can be surprisingly

enlightening. It is my hope that some of these discussions will become realities in the future through cross-university research collaborations. Museums such as the Deutches Museum and the Mercedes-Benz Car Museum gave me an interesting perspective of German engineering in last two hundred years, as well as the cultural impact both technology and companies have had on the German culture. Visiting the Modern Art museum in Munich was also an interesting exercise in both style and design over the ages. My visit to the DLR took place as part of a group tour and was quite exciting. We were exposed to a number of projects in robotics, ranging from space-based teleoperation to robotic surgical assistance tools. The apex of my travels in Germany was when I attended the ADAC WRC Rally Races in Trier. In addition to the races themselves, Trier is one of, if not the, oldest settlement in Germany, with ruins such as the Porte Negra dating from Roman times.

**Dan Mirotu:** Similar to Dan, I also took full advantage of being in Germany, taking part in both the culture and environment available, by visiting museums, beer gardens, and the DLR. I traveled to different parts of the German speaking world, including weekend trips to Hamburg, Cologne, Basel and Salzburg, allowing practice of my German language skills with native speakers. City living in Munich was a highlight of this experience. I enjoyed the European lifestyle immensely; the availability, convenience, and reliability of mass transportation was a wonderful change from the traffic-jammed streets of Baltimore. Especially fascinating was the DLR visit. The DLR allowed us to see all of the current, advanced research in robotics taking place, from their robotic arm that catches a ball to 3D reconstructions of the Germany Alps. The most memorable part of the travels was hiking in the Karwendel Mountains on the German-Austrian border and staying in a huette (a mountain cabin). Additionally, my time in Germany has inspired me to apply for a German Academic Exchange Service (DAAD) Research Grant to continue future collaboration between JHU and TUM.

## DISCUSSION AND SUMMARY

While our research had many overlapping components and goals, we feel it is best to split our sections and discuss the specifics separately.

**Dan Abretske:** This summer I continued my work in region tracking for motion estimation of endoscopic sinus cavity video. I focused primarily on video collected from the porcine sinus, while using an optical tracker to acquire ground truth motion estimates. My main efforts were focused on compositional homography-based trackers [2]. However, these trackers can only handle single regions; and unfortunately, the numerical decomposition of the homography for motion estimation does not give a single unique answer [1]. Part of this summer was spent investigating ways to overcome this shortfall by combining estimators into a joint region tracker. In addition to my primary research, I spent the month of August considering the interaction of swarms of aerial robotic systems, as well as the fusion of multiple data feeds.

**Dan Mirolta:** This summer's research had three accomplishments: creation of a sinus video reconstruction framework, a validation method of the camera to CT registration, and the initial stages of an investigation into a registration algorithm. Of these three tasks, the sinus video reconstruction framework took the most effort. This task, of the software engineering realm, involved the analysis of [3] and the modularization of this research prototype. The creation of validation techniques for the camera to CT registration was the most significant step forward, allowing for the realization of video fly-throughs of CT data. The last task began my current research project: the registration of a 3D point-cloud(with unknown scale) created by video reconstruction techniques to a CT surface. The method I am pursuing has it's inspiration in [4].

Combining our voices once again, we feel that the IREE system could be improved primarily in the communication between the award organizers and recipients. It was unclear which conference we would be attending at the outset of our travels. Additionally, it would be nice if the NSF had a system in place for enrollment in and/or information about fast language learning courses for the destination country included as part of the IREE award.

### ACKNOWLEDGEMENTS

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### REFERENCES

1. O. Faugeras, F. Lustman "Motion and Structure From motion in a Piecewise Planar Environment," *IEEE Transactions on Patter Analysis and Machine Intelligence*" 2(3): 485-508, 1998
2. S. Baker, I. Matthews, "Equivalence and Efficiency of Image Alignment Algorithms," *IEEE Conference on Computer Vision and Pattern Recognition*, Vol. 1, December 2001.
3. H. Wang, D. Mirolta, G. Hager, M. Ishii, "Anatomical Reconstruction from Endoscopic Images: Progress and Prognosis of Quantitative Endoscopy, " Accepted for publication in *American Journal of Rhinology*, September 2007
4. A. Fitzbibbon, "Robust Registration of 2D and 3D Point Sets," *British Machine Vision Conference*, 2001, 662-670

## BRIEF BIOGRAPHIES OF RESEARCHERS

**Daniel Abretske** received his B.S. degree in Computer Science and Mathematics from Rose-Hulman Institute of Technology in 2004. He received his M.S. in Computer Science from Johns Hopkins University in 2007 and is currently pursuing a Ph.D. His research interests include computer vision and graphics for real world scene analysis and visualization, as well as a budding interest in robotics, control and embedded programming.

**Daniel Mirola** received his B.S. degree in Computer Science from Stevens Institute of Technology in 2006. He received the ASEE National Co-Op Student of the Year Award in 2006 for his work at Siemens Corporate Research in Princeton, N.J. He is currently pursuing a Ph.D. at Johns Hopkins University. His research interests include computer vision, medical image analysis, as well as computer-aided surgical systems.