Seven graduate students from the CISST ERC had the opportunity, through the CISST ERC International Research, Education, and Engineering program (IREE), to spend a summer abroad to collaborate with four laboratories at the Technical University of Munich (TUM). These include the Computer Aided Medical Procedures and Augmented Reality Laboratory (CAMP), the Minimally-Invasive Interdisciplinary Therapy and Intervention Lab (MITI), Micro Technology and Medical Device Technology (MIMED), and Institute of Automatic Control Engineering. These

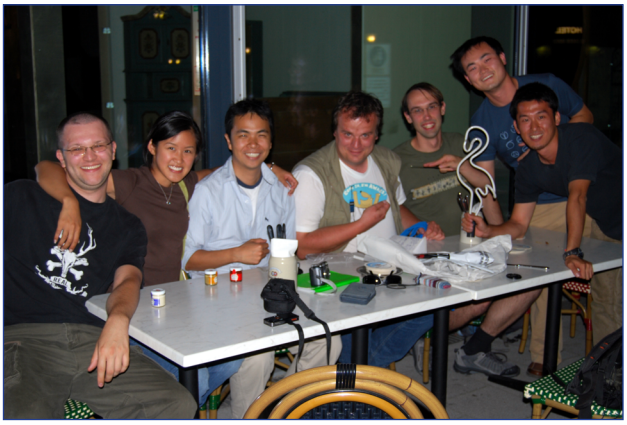

Fig. A11

collaborations' goal was to take the first steps toward a more formal joint exchange program with TUM. The visit, which was organized by Professor Hager (CISST ERC) and Professor Burschka (TUM), included both scientific and cultural elements. Brief descriptions of three of the scientific projects are as follows:

Surgical Skill Evaluation: The goal of this project was to collect synchronized video data from laparoscopic cholecystectomy procedures. To accomplish this, we designed a four-camera live surgery recording system. The first two cameras were Allied Vision Technologies (AVT) Guppy cameras constituting a stereo video system that

Fig. A12

focuses on the patient's chest and abdominal area. Sterile color markers are attached to laparoscopic tools to assist in tool tracking, identification, and orientation extraction. The third camera is the mono-endoscope already used in laparoscopic cholecystectomies. This provides information about the motions of the tools and tissue inside the abdominal cavity. The fourth camera has a complete view of the operating room. By the end of our research experience, our team successfully recorded a test surgery and two live cholecystectomies. Arrangements were made with the CAMP lab at TUM to continue recording data for further collaboration.

A daVinci Tool Control: This project was created to develop a stand-alone actuation and control unit for the daVinci Surgical System's

Fig. A13

CISST ERC IREE: Collaboration with the Technical University of Munich

EndoWrist instruments. The developed device serves as a platform for the development of new daVinci surgical instruments and surgical procedures using existing instruments without the master robots. The joint effort from MIMED (TUM) and CISST ERC (JHU) resulted in an inexpensive software and hardware solution that is easily replicated, and can be used in a surgical environment for instrumentation research. We hope that this platform will lead to future collaboration between the two research centers and other surgical robotics research teams.

Fig. A14

Parameter Estimation During Teleoperation: The goal of this work was to estimate the mechanical properties of soft tissues during teleoperation. This knowledge will be used to return realistic force feedback to human operators so that they feel the interaction force as if they are directly touching the remote environment. Moreover, the obtained environment model can be used for surgical simulation, evaluation of environment states during an operation, and visual sensory substitution to help surgeons detect tumor locations. To identify unknown parameters of the environment, we collaborated with TUM researchers to develop a means of logic-based switching for rapidly convergent parameter estimation. We have solved theoretical problems of the multi-estimator and conducted experiments to test the performance of several estimation techniques.

Fig. A15

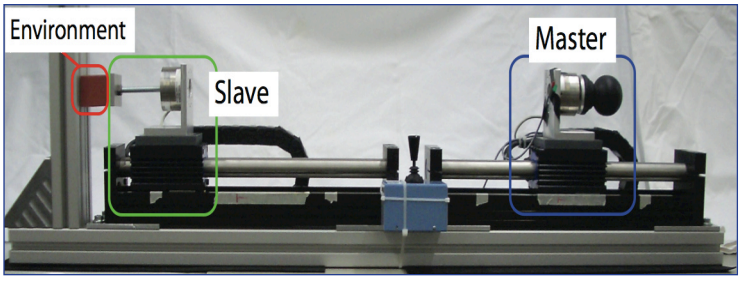

Fig. A16