

Balázs P Vágvölgyi Mr

PROFESSIONAL INTERESTS

Image/Video Processing and Computer Vision; 2D/3D Medical Imaging; Real-time Data Processing and Analysis; Computer Assisted Surgical Systems; Parallel Processing; Software Development; System Design.

EXPERIENCE

3/2006-Present Software/Research Engineer
Johns Hopkins University, ERC-CISST/LCSR, Baltimore MD, USA

My current employer, the Engineering Research Center for Computer-Integrated Surgical Systems and Technology (ERC-CISST, <http://www.cisst.org>) is a multi-disciplinary research institution funded by the National Science Foundation (NSF) and hosted by the Johns Hopkins University (JHU). The institute develops surgical systems that integrate novel computer and human/machine interface technologies that will revolutionize surgical procedures, extending the surgeon's abilities to achieve better outcomes at lower costs. ERC-CISST/LCSR is one of the world's most acknowledged and influential research institutions on surgical robotics. As a member of the senior engineering staff my responsibility is to contribute to the engineering research and facilitate the implementation of novel medical applications. Based on my previous experience, I am mainly involved in the real-time computer vision aspects of various projects. Our objective is to interpret the visual information obtained from 2D and/or 3D image sources and help physicians during interventional procedures.

Reference: Peter Kazanzides, Assistant Research Professor, ERC-CISST/LCSR (pkaz@jhu.edu)
 Gregory D. Hager, Professor, ERC-CISST Research Director (hager@cs.jhu.edu)
 Russell H. Taylor, Professor, ERC-CISST Director (rht@jhu.edu)

PROJECTS

CISST Software Infrastructure Development (ERC-CISST)

(Key words: Collaborative Cross-Platform Development, Video Pipeline, Multithreading, Open Source, C++ Templates, STL, POSIX, Win32, X11, DirectShow, V4L2, LibDC1394, QtKit, CMake, CVS)

The CISST software package (<https://trac.lcsr.jhu.edu/cisst>) is a collection of libraries designed to ease the development of computer assisted intervention systems. My main contribution to the package is the computer vision and image processing pipeline that provides a platform independent interface (Windows, Linux, Mac OS X) for handling image sources, processing video, and visualizing results.

Microsurgical Workstation (ERC-CISST, Wilmer Eye Institute of the Johns Hopkins Hospital)

(Key words: System Design and Development, C++, Microsurgery; Vitreo-Retinal Surgery; Video Microscopy; Computer Vision, Distributed Systems, Component Based Software Engineering, VTK)

The Microsurgical Workstation BRP Project is one of the largest projects of the CISST lab currently. It involves the contribution of several medical and engineering faculty members and number of graduate students. As part of the engineering staff I am responsible for designing and managing the development of the surgical visualization system and its components. Due to the extreme precision required during microsurgery accuracy and real-time operation of the assisting computer system are paramount. In the same time the system serves as a testbed for a major system integration project which aims to connect all diverse computerized surgical devices in a distributed, component based architecture.

Surgical Assistance Workstation [1][2][5][19] (ERC-CISST, Intuitive Surgical Inc.)

(Key words: System Design and Development, C++, Robotics, Computer Vision, Distributed Systems, Component Based Software Engineering, VTK)

Built on the CISST software package, the Surgical Assistant Workstation (SAW) (https://www.cisst.org/saw/Main_Page) provides a software framework, that enables the integration of new research with a tele-surgical robot system such as the daVinci. Although the daVinci System (with its research interface) was a primary motivator, the SAW framework contains a generic robot interface and can therefore be used with other robot systems. The framework consists of real-time robot control, tracking, real-time computer vision, and 3D visualization functions.

Context Aware Surgical Assistance for Mentoring [1][2][6][7][8][12][13][20] (ERC, TATRC US Army)

(Key words: Stereo, Dynamic Programming, 2D-3D Registration, Real-Time Computer Vision, Augmented reality, Visualization)

Minimally invasive surgery (MIS) is a technique whereby instruments are inserted into the body via small incisions (or in some cases natural orifices), and surgery is carried out under video guidance. While advantageous to the patient, MIS presents numerous challenges for the surgeon due to the restricted field of view presented by the endoscope. One means of overcoming some of these limitations is to present the surgeon with additional visual information. The objective of the project was to develop a system that provides the surgeon with a three-dimensional information overlay registered to pre-operative or intra-operative volumetric data. The novelty of the system lies in its use of stereo video data to perform the registration without recourse to an external tracking system. A prototype version of the system for augmenting the surgical view during laparoscopic kidney procedures has been demonstrated on video sequences recorded during animal and human surgeries.

Visual Haptic Feedback [3][4][9] (ERC-CISST Haptic Exploration Laboratory)

(Key words: Tele-Operation, Real-Time Video Overlay, Stereo, Augmented Reality, VTK, TCP/IP, 3D Calibration of the Vision System and the Robot)

Currently the daVinci tele-operated surgical robot lacks the ability to provide haptic feedback for the surgeon. In the Haptic Exploration Laboratory we have developed a system that measures the forces exerting upon the slave manipulator and visualizes the force magnitude on the stereoscopic display of the master console. The augmented reality overlay is rendered in 3 dimensions on top of the live endoscopic video and it is registered to the 3D robot frame, thus the overlay closely follows the position of the surgical tool tip.

Data Acquisition System [11] (ERC-CISST)

(Key words: Windows, MFC GUI, Multi-Channel Video Capture, External Trackers, daVinci)

Recording live surgical data from a variety of data sources represent significant challenges. First, the raw amount of lossless data requires a high performance pipeline that is capable of handling multiple uncompressed multi-channel video and tracking streams simultaneously. On the other hand, the labeling of different streams has to be done at acquisition time so that the streams remain synchronized even after hours of continuous recording. Synchronization is crucial for successful post-processing of multi-modality data set. I developed a recording system that consist of a high performance Windows workstation, image acquisition boards and a speciality software that is capable of interfacing with external optical (Polaris, OptoTrak) and electro magnetic (Aurora) trackers, video capture sources, and the daVinci surgical robot. The developed software and the workstation has already been used to successfully record hundreds of hours of live surgeries, in order to analyzing the ‘Language of Surgery’ in a related research project.

3/2008-5/2008

HTML, DOM, Javascript Software Development

Freeware Web Applications for Apple’s iPhone & iPod Touch

I developed three Web Applications for Apple’s handheld devices. Like all other Web Applications, each of these games run inside the Safari web browser. For the projects I have implemented a full featured 3D graphics engine in Javascript using the HTML5 *Canvas* element. At the time of their release these

games represented a previously unknown category (3D vector graphics) in terms of graphics on these devices. The applications proved to be very popular and they are listed on Apple's website and a number of other technology blogs and portals on the Internet. "Rubik's Cube 3D" (<http://www.vagvolgyi.com/rubikscube/>) was "Staff Pick", "Featured" and "Most Popular Web Application" for a week on <http://www.apple.com/webapps/>. "Stunt Car 3D" (<http://www.vagvolgyi.com/stuntcar/>) also won the recommendation ("Staff Pick") award. Each "Tap-a-Brick 3D" (<http://www.vagvolgyi.com/tab3d/>), "Stunt Car 3D", and "Rubik's Cube 3D" got praising reviews on technology and gaming websites all around the world. As of March 2010, approximately 500,000 people have tried these games online.

2/2003-2/2006

Image Quality Systems Engineer

General Electric Healthcare, Budapest, Hungary

GE Healthcare (GEHC, <http://www.gehealthcare.com>) is the global market leader of medical imaging systems. As a Systems Engineer in the Image Quality (IQ) System team in the digital vascular X-ray imaging modality my task was to simulate, analyze, evaluate, and improve the image quality of the most sophisticated fully digital medical imaging systems (Innova 2000, 2100, 3100, 4100). This work incorporates the extensive knowledge of medical imaging equipments and advanced digital image processing algorithms. The engineering work is carried out under strict quality regulations using the Six Sigma methodology.

Reference: Francois De Gaulmyn, Vascular Systems Manager (francois.degaulmyn@med.ge.com)

PROJECTS

Vascular X-ray Imaging Pipeline Simulator

(Key words: Cross-Platform Development, C++, FLTK GUI, Image Processing)

The imaging pipeline of GE Healthcare's flat-panel vascular X-ray systems consists of a series of image processing algorithms to correct detector irregularities and to enhance the visibility of X-ray images. During the IQ verification process the imaging algorithms need to be tested and evaluated for FDA approval. One of my main responsibilities at GEHC was to maintain and further develop the cross-platform Image Processing Simulator software used for verification. The software was thoroughly tested and development process was fully documented in order to be auditable.

Vascular X-ray Image Quality Verification

(Key words: FDA Compliance, System Design Verification, Testing)

As an integral part of the FDA compliant development process, the products have to be verified at the end of each development milestone. Being member of the IQ team, I participated in the IQ verification process of several product. The process involved the evaluation of the automatic X-ray exposure management algorithms and imaging pipelines.

Vascular X-ray Image Optimization Management [14]

(Key words: Calibration, Statistical Analysis, X-ray Exposure Management)

The Image Processing Pipeline of the X-ray systems is optimized by an automatic logic that is customized for each hardware configuration. In order to provide the best possible image quality, the system status and exposure parameters are constantly monitored and the logic continuously fine-tunes the imaging pipeline. For new hardware configurations the optimization logic needs to be modified based on image quality measurements and statistical analysis. I was responsible for performing the IP optimization process for several product revisions.

On-site Engineering Support for Installed Base and Pilot Systems

(Key words: Meeting Customers and Clinical Specialists, Troubleshooting, System Evaluation)

During my years at GEHC, I have provided on-site support in multiple instances when IQ expertise was required for troubleshooting. In one occasion I represented the system design team during the installation and the first clinical tests of an Innova 2100 pilot system in a hospital in Virginia, USA.

9/1998-2/2003

Systems/Research & Development Engineer
Tateyama Laboratory Hungary, Budapest, Hungary
Tateyama System Laboratory, Toyama, Japan

Tateyama Laboratory Hungary Ltd. is a member of the Tateyama Kagaku Group based in Toyama, Japan (<http://www.tateyama.jp/eng/index.html>). The group is formed by 10 companies in Japan, Malaysia, Hungary, and Thailand. The Hungarian division was responsible for research and development on the fields of Automated Manufacture of Industrial Robots, Office Automation and Video Surveillance Systems. I joined the R&D team as an intern graduate student in 1998 and was hired officially in 2001 as a full-time employee and team leader. I was responsible for managing the development team, carrying out image processing (IP) development for surveillance systems and research unique IP algorithms for future products. During my years at Tateyama, I spent months at the Japanese operations (mostly in Toyama) in several occasions for direct collaboration in various projects. Moreover I am the co-author of three Japanese patents on panoramic image processing and on motion detection on video.

Reference: Tsuneo Morita, Managing Director (morita@tateyama.hu)

PROJECTS

Digit-Eye Video Surveillance System

(Key words: Image Processing, Motion Detection, Multi-Channel Video, Video Database Indexing, Web Server Development, C++, Windows, MFC GUI, DirectShow, SourceSafe, HTML, HDML, WAP)

The Digit-Eye video surveillance system had two versions. One of them was designed as a home surveillance and security solution running on any Windows personal home computers. It featured multiple USB camera video sources, automatic motion detection, video recording of suspicious activities, video log Playback interface, mobile phone notifications, and a Web based detection log with screen captures and event descriptions. The other version aimed to provide a reliable, distributed surveillance solution for small enterprises by supporting at most 16 professional quality cameras and frame grabbers. Its feature set included all of the home version's with some additional enterprise features, for example multiple layers of permissions for system administration. My responsibilities in the small development team were extensive from designing the imaging pipeline and image processing algorithms, through the user interface design, to actual C++ coding.

Panoramic Image Manipulation [21][22]

(Key words: Optical Calibration, Image Rectification, Image Processing, C++, Java, Windows, PalmOS)

The company was continuously developing novel applications for its patented Panoramic Annular Lens and for its PalmOS software business. As the leader of the R&D team I was involved in several feasibility studies and product developments, most of them related to computer vision/image processing. Such as optical calibration, image rectification, low-bandwidth video streaming, mobile imaging, and panoramic video processing.

EDUCATION

Computer Science (IT/Image Processing)

Master's Degree, 2000

PhD studies [15][16][17] (till 2001, not completed)

University of Pannonia (formerly University of Veszprém), Veszprém, Hungary

Advisor: Tamás Szirányi, Professor (<http://www.sztaki.hu/~sziranyi/>)

TEACHING EXPERIENCE

Image Processing/Computer Vision course, lectures, 2000-2001

Image Processing/Computer Vision course, laboratory exercises, 1999-2001

AWARDS

University Scholarship for Excellence, 1999-2000

First prize and the special prize of the Hungarian Chamber of Trade and Commerce, 1999
 On the Conference of the Science Ring of Students for “Real-time motion analysis on panoramic video streams”.

COURSES

Surgery for Engineers 2008
 Johns Hopkins Hospital, Minimally Invasive Surgical Training Center, Baltimore, MD

Six Sigma DMAIC and Design for Six Sigma Green Belt Certification, 2004
 General Electric Healthcare, Budapest, Hungary

Medical Ionizing Radiation (X-ray) Safety Training 2004
 General Electric Healthcare, Budapest, Hungary

MEMBERSHIPS

IEEE (Institute of Electrical and Electronics Engineers) Member since 2006
IEEE Computer Society Member since 2009

SKILLS

SKILL NAME	SKILL LEVEL	LAST USED	EXPERIENCE
Systems Engineering	Experienced	Currently used	7 years
Six Sigma	Green Belt	2 year ago	3 years
Image Processing, Computer Vision	Experienced	Currently used	11 years
Medical imaging	Experienced	Currently used	6 years
ANSI C/C++, POSIX	Experienced	Currently used	11 years
Objective-C	Beginner	Currently used	< 1 year
Visual C++ Win32, MFC	Experienced	Currently used	9 years
Xcode (Mac OS X)	Experienced	Currently used	3 year
Pascal	Intermediate	6 years ago	4 years
Assembly (x86, MMX)	Intermediate	5 year ago	5 years
TCP/IP (Winsock32, Berkeley Sockets)	Intermediate	Currently used	4 years
Multithreading (Win32, POSIX)	Experienced	Currently used	6 years
DirectShow	Experienced	Currently used	5 years
LibDC1394 & Video4Linux2	Intermediate	Currently used	3 years
Quicktime Kit (Mac OS X)	Beginner	Currently used	< 1 year
CMake	Intermediate	Currently used	4 years
VTK	Beginner	Currently used	2 year
CVS, Subversion	Experienced	Currently used	5 years
Matlab	Beginner	Currently used	3 years
Latex	Intermediate	Currently used	3 years
HTML, CSS, Javascript, DOM	Intermediate	Currently used	6 years

JOURNAL ARTICLES

- [1] Balazs Vagvolgyi, Carol Reiley, Greg Hager, Russell Taylor, Li-Ming Su. Augmented Reality Using Registration of 3D Computed Tomography to Stereoscopic Video of Laparoscopic Renal Surgery, *The Journal of Urology*, April 2008 (Vol. 179, Issue 4, Supplement, Pages 241-242)
- [2] Li-Ming Su, Balazs Vagvolgyi, Rahul Agarwal, Carol E. Reiley, Russell Taylor, Gregory Hager. Augmented Reality During Robot-assisted Laparoscopic Partial Nephrectomy: Toward Real-Time 3D-CT to Stereoscopic Video Registration, *Urology*, April 2009 (Vol. 73, Issue 4, Pages 896-900)

CONFERENCE PRESENTATIONS & POSTERS

- [3] Tomonori Yamamoto, Balazs Vagvolgyi, Kamini Balaji, Louis L. Whitcomb, Allison M. Okamura. Tissue property estimation and graphical display for teleoperated robot-assisted surgery, *IEEE ICRA (International Conference on Robotics and Automation) 2009*: 4239-4245
- [4] James Gwilliam, Mohsen Mahvash, Balazs Vagvolgyi, Alexander Vacharat, David Yuh, Allison Okamura. Effects of haptic and graphical force feedback on teleoperated palpation, *IEEE ICRA 2009*: 677-682
- [5] Balazs Vagvolgyi, Simon DiMaio, Anton Deguet, Peter Kazanzides, Rajesh Kumar, Christopher Hasser, and Russell Taylor. The Surgical Assistant Workstation, *Workshop on Systems and Architectures for Computer Assisted Interventions at MICCAI (Medical Image Computing and Computer-Assisted Intervention) 2008*, New York, NY
- [6] Balazs Vagvolgyi, Gregory Hager, Russell Taylor, and Li-Ming Su MD. Video to CT Registration for Image Overlay on Solid Organs, *Workshop on Augmented environments for Medical Imaging including Augmented Reality in Computer-aided Surgery at MICCAI 2008*, New York, NY
- [7] Balazs Vagvolgyi, Gregory Hager, Russell Taylor, and Li-Ming Su MD. Augmented Reality Using Registration of 3D Computed Tomography to Stereoscopic Video of Laparoscopic Renal Surgery, *AUA (Annual Meeting of the American Urological Association) 2008*, Orlando, FL
- [8] Balazs Vagvolgyi, Gregory Hager, Russell Taylor, and Li-Ming Su MD. Augmented Reality Using Registration Using 3D CT to Stereoscopic Video of Laparoscopic Renal Surgery, *EUS (Annual Meeting of the Engineering & Urological Society) 2008*, Orlando, FL
- [9] Mohsen Mahvash, James Gwilliam, Rahul Agarwal, Balazs Vagvolgyi, Allison Okamura, David Yuh MD, and Li-Ming Su MD. Force-Feedback Surgical Teleoperator: Controller Design and Palpation Experiments, *IEEE Haptics Symposium 2008*, Reno, NV
- [10] Ioana Fleming, Sandrine Voros, Balazs Vagvolgyi, Zach Pezzementi, James Handa MD, Russell Taylor, and Gregory Hager. Intraoperative Visualization of Anatomical Targets in Retinal Surgery, *IEEE WACV (Workshop on Applications of Computer Vision) 2008*, Copper Mountain, CO
- [11] Carol Reiley, Henry Lin, Balakrishnan Varadarajan, Balazs Vagvolgyi, Sanjeev Khudanpur, David Yuh, and Gregory Hager. Automatic Recognition of Surgical Motions Using Statistical Modeling for Capturing Variability, *MMVR (Medicine Meets Virtual Reality) 2008*, Long Beach, CA
- [12] Balazs Vagvolgyi, Carol Reiley, Gregory Hager, Russell Taylor, Adam Levinson MD, and Li-Ming Su MD. Toward Direct Registration of Video to Computer Tomography for Intraoperative Surgical Planning During Laparoscopic Partial Nephrectomy, *WCE (World Congress of Endourology) 2007*, Cancun, Mexico

- [13] Gregory Hager, Balazs Vagvolgyi, and David Yuh. Stereoscopic Video Overlay with Deformable Registration, MMVR (Medicine Meets Virtual Reality) 2007, Long Beach, CA
- [14] Berry Belanger, Farid Betrouni, Paritosh Dhawale, Priya Gopinath, Pal Tegzes, Balazs Vagvolgyi. Development of next generation digital flat panel catheterization system: design principles and validation methodology, SPIE 2006, San Diego, CA
- [15] Laszlo Czuni, Balazs Vagvolgyi, Tamas Sziranyi, Tamas Greguss. A Compact Panoramic Visual Sensor for Intelligent Applications, ACCV (Asian Conference on Computer Vision) 2000, Taipei, Taiwan
- [16] Ivan Kopilovic, Balazs Vagvolgyi, Tamas Sziranyi. Application of Panoramic Annular Lens for Motion Analysis Tasks: Surveillance and Smoke Detection, ICPR (International Conference on Pattern Recognition) 2000, Barcelona, Spain
- [17] Ivan Kopilovic, Balazs Vagvolgyi, Tamas Sziranyi. Smoke-detection and Motion Sensitive Video Surveillance Using Panoramic Annular Lens, KEPAF 2000, Noszvaj, Hungary

OTHER PUBLICATIONS

- [18] Series of articles on Digital Image Processing in the Hungarian video professional magazine "Videopraktika", 2003-2005

PATENTS AS CO-INVENTOR

- [19] US PATENT #20090036902 (patent pending):
Interactive User Interfaces for Robotic Minimally Invasive Surgical Systems
- [20] US PATENT #[JHU C10368] (patent pending):
Novel Real-Time Visualization of Deformable Surfaces in Video
- [21] JAPANESE PATENT #2003-308526:
Method and Device for Vertical Distortion Correction in Expansion of Annular Image into Panoramic Image
- [22] JAPANESE PATENT #2003-303342:
Method and Apparatus for Detecting Reference Position of Annular Image by Omnidirectional Imaging

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