BU PhD STUDENTSHIPS 2017

PROJECT DESCRIPTION

PROJECT DETAILS
Project Title
Dynamic Real-time 3D Reconstruction of Deformable Objects for Augmented Reality Techniques and Applications
Project Summary
Real-time 3D scene reconstruction is a challenging problem with many potential applications in computer graphics, virtual reality, augmented reality and medical imaging. In image-guided and robotic assisted surgery, 3D in-situ scene reconstructions combined with virtual reality and augmented reality techniques can overcome limitations of the narrow and incomplete field of view and the lack of depth perceptions in Minimally Invasive Surgery (MIS). Augmented reality of realistic 3D reconstructed MIS scene will provide additional visual information to surgeons with depth cue. The state of the art computer graphics and vision algorithms, however, are mostly designed for static scene reconstruction with rigid objects that have rich surface features. In image-guided minimally invasive surgery, smooth soft tissue surfaces without clear features but large deformations pose huge challenges in 3D scene reconstructions and augmented reality applications. This project will develop efficient and accurate dynamic reconstructions of 3D deformable objects to overcome the static scene limitations of current techniques; evaluate the techniques in the context of medical MIS application and procedural content generation in games. The research results will advance the state of the art technology in real-time in-situ 3D reconstructions of intraoperative surgical scene, which can then provide realistic complete 3D visual information, significantly extending restricted 2D representations into a large visible 3D space during the procedures. There is also a large scope for the algorithm and the computational framework developed in this project to be applied to general virtual reality and augmented reality applications, which is highly demanding in creative digital industry, such as procedural content generation using 3D reconstruction in computer games. Research Methodologies: 1. Develop a state of the art dynamic fusion algorithm and a non-template based framework for dynamic deformable scenes by extending and exploring the feature-based sparse ORB-SLAM framework for Monocular as well as stereoscopic MIS scenes. 2. Develop novel algorithm with BoW (Bag of Word) vocabulary built from MIS database to generate optimized parameters for the better use in the challenging MIS scenes; 3. Propose a filtering framework to reconstruct smooth 3D surface by removing noise and outliers to achieve accurate surface reconstruction close to the latest state of the art semi-dense point cloud algorithm. 4. Evaluate our algorithm and the proposed framework in simulated ground truth video sequence and in-vivo video with augmented reality application. 5. Integrate the stereo vision with virtual reality headset Oculus Rift for real-time dynamic scene reconstructions and fusion in 3D game environment for procedure content and mixed reality applications. Research Output and Contributions: This project will produce: 1. A body of knowledge in vision based real-time 3D reconstruction for virtual reality and augmented reality applications, especially for image-guided and robotic assisted surgery.

2. A new augmented reality framework to overcome the limitations of small incisions, indirect and limited field of view via computer screen as well as the lack of depth perception during MIS, enabling high precision intrinsic procedures.

3. Novel computational methods for providing depth cues in monocular and stereoscopic scenes through visual Simultaneous Location and Mapping and varies surface reconstruction technologies.

Academic Impact

The project aims to make substantial research contributions to the field of vision based real-time dynamic 3D reconstructions through exploration of novel algorithms, innovative computational framework and extensive testing. The research topic presents a cross-cutting field that connects well established and prestigious research disciplines in computer vision, computer graphics and virtual reality with challenging applications such as medicine and digital games. The research contributions will address one of the grand challenges of the field and result in significant publications in a number of high impact journals such as ACM Transactions on Graphics, the International Journal of Medical Robotics and Computer Assisted Surgery, the IEEE conference on computer vision and pattern recognition. Academic impact also includes training a new researcher in this rapid advancing field of vision based content creation.

The research activities will promote interdisciplinary research collaborations, establishing links with the UK leading research centres such as the Centre for Medical Image Computing and Department of Computer Science at UCL, and close research collaborations with international research group through matched funding for PhD supervision. There is also great potential to develop external research grants and industry collaborations (Innovate UK, EPSRC, and H2020).

Societal Impact

Real-time accurate vision based 3D reconstruction technology can be used in image-guided surgery to improve the quality of procedures, thus resulting significant patient benefit. The project will contribute to a wide range of community and societal objectives, primarily through enhanced patient outcomes and quality of treatment. Virtual reality and augmented reality applications using this technology can lead to cost efficient procedural content generation.

The project will have impact on a number of stakeholders including health and digital industries. There is a significant demand in more effective image-guided and robotic assisted surgery by providing accurate visual feedback during complex procedures to overcome the limitations and constraints of image-guided surgery. Whilst in creative digital industries, such as games and virtual reality, effective procedural content generation is in big demand in order to enrich user experiences and reduce the bottleneck of cost on content creations. Both medical and robotics sectors and creative digital industry are increasingly significant sectors in the UK industry.

Research results will benefit these industries to boost their business potential and capacity and through knowledge transfer (KTP) projects.

Training Opportunities

The PhD student will gain following core research skills by completing this project:

1. Research skills in computer vision and computer graphics technologies via developing real-time dynamic 3D reconstruction of deformable objects. This includes skills in literature review of latest research publications, skills in studying advanced computational algorithms on 3D real-time graphics and software development;

2. Knowledge of applying the technologies in advanced medical applications;

3. Research skills in writing publications for international conference and high impact journals;

4. Research presentation and communication skills in both academic community and public engagement through presentations and deliver talks at national and internal events;

5. Skills in conducting team research project within a multi- and inter-disciplinary team, collaborating, communicating and interacting with people within or outside the University;

6. Research ethics training offered by the University and the awareness of research ethics.

SUPERVISORY TEAM	
First Supervisor	Professor Wen Tang
Additional Supervisors	Professor Feng Jun (Northwest University, China) Dr Jian Chang (NCCA, FMC)
Recent publications by supervisors relevant to this project	1) Tang, P., Huang, D., Wang, Y., Gong, R., Tang, W. and Ding, Y. (2016) Position Based Balloon Angioplasty. ACM SIGGRAPH VRCAI. 2) L. Chen, W. Tang, N. W. John and T. R. Wan (2017): Monocular Laparosopic Scene 3D Surface Reconstruction and Augmented Reality based on Visual SLAM. Journal of Computer Assisted Radiology and Surgery, Under review 3) L. Chen, T.W.Day, W. Tang, and N.W.John (2017) Augmented Reality in Medicine: A review of Current Trends. Computer graphics Forum, Under review 4) Tang, W., Wan, T. and Donjing Huang (2016) Interactive Thin Elastic Materials. Computer Animation and Virtual Worlds. Journal of Visualization and Computer Animation 27(2): 141-150. 5) Tang, W. and Wan, T.R. (2014) Constrained Soft Tissue Simulation for Virtual Surgical Simulation. IEEE Transactions on Biomedical Engineering, 61 (11). 6) Tang, W., Wan, T., Gould, D., How, T. and John, N.W. (2012): A Real-time Nonlinear Elastic Approach to Simulating Guide-wire and Catheter Insertions Based on Cosserat Rod. IEEE Transactions on Biomedical Engineering, 59 (8). 7) Chang, J., Yang, X., Pan, J., Li, W., Zhang, J.J., (2011), A fast hybrid computation model for rectum deformation, The Visual Computer, 27(2), pp. 97-107 8) Pan, J. J., Chang, J., Yang, X., Liang, H., Zhang, J. J., Qureshi, T., ... Hickish, T. (2014). Virtual reality training and assessment in laparoscopic rectum surgery. The International Journal of Medical Robotics and Computer Assisted Surgery. DOI: 10.1002/rcs.1582 9) Wang Hong Yu, Feng Jun, Xie Zhuo, Chen Bao Ying, Breast Masses Diagnosis based on a Weighted Ensemble Framework for Group Semantic Feature Vectors (WeGav), Journal of Medical Imaging and Health Informatics，2016 10) Han Xiaoxu ,Feng Hongwei ,Bu Qirong ,and **Feng Jun**，Image Dehazing base on Two-peak channel prior, ICIP,2016 11) Li Zhan,Geng Guohua，Feng Jun，Peng Jin Ye，Wen Chao，Multiple instance learning based on positive instance selection and bag structure construction, Pattern Recognition Letters. 2014,40(1):19–26 12) Peng Du, Horace H.S. Ip , Bei Hua, Jun Feng , Using surface variability characteristics for segmentation of deformable 3D objects with application to piecewise statistical deformable model, Visual Computers,pp: 493-509 , 2011 2011,12 13) Jun Feng and Horace H. S. Ip, A Multi-resolution Statistical Deformable Model (MISTO) for Soft-Tissue Organ Reconstruction, Pattern Recognition 42 (7) (2009), pp. 1543-1558

INFORMAL ENQUIRIES
To discuss this opportunity further, please contact Wen Tang via email: wtang@bournemouth.ac.uk
ELIGBILITY CRITERIA
Studentship candidates must demonstrate outstanding academic potential with preferably a 1st class honours degree and/or a Master's degree with distinction or equivalent Grade Point Average. An IELTS (Academic) score of 6.5 minimum (with a minimum 5.5 in each component) is essential for candidates for whom English is not their first language. In addition to satisfying basic entry criteria, BU will look closely at the qualities, skills and background of each candidate and what they can bring to their chosen research project in order to ensure successful completion. **Additional Eligibility** Degree in Computer Science
HOW TO APPLY
Please complete the online application form by **Sunday 18 June 2017**. Further information on the application process can be found at: www.bournemouth.ac.uk/studentships