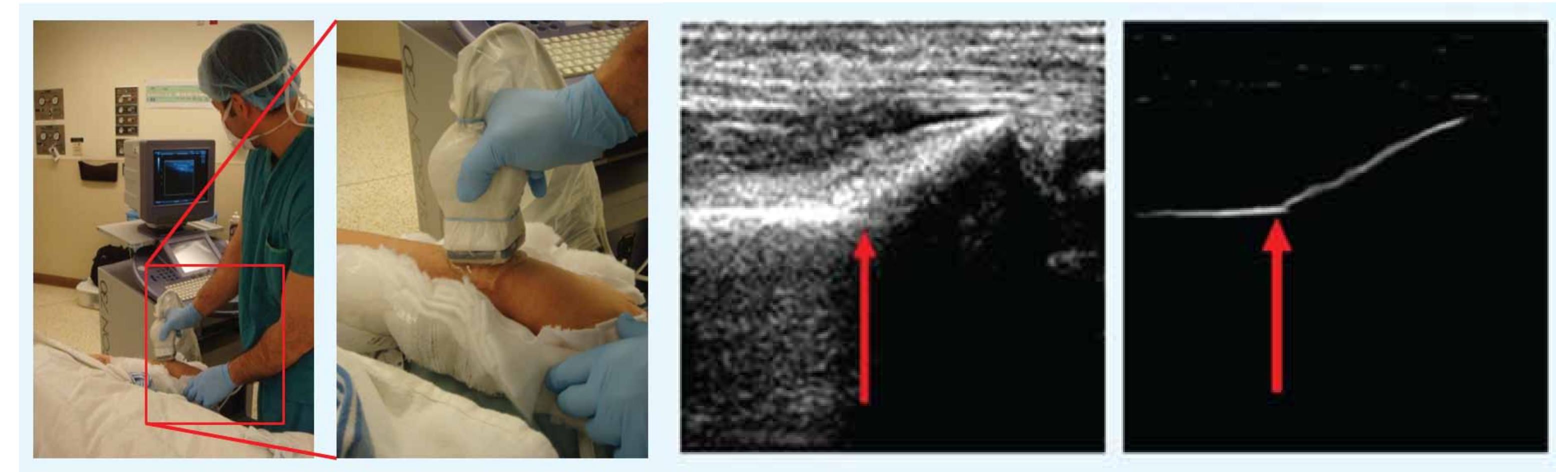
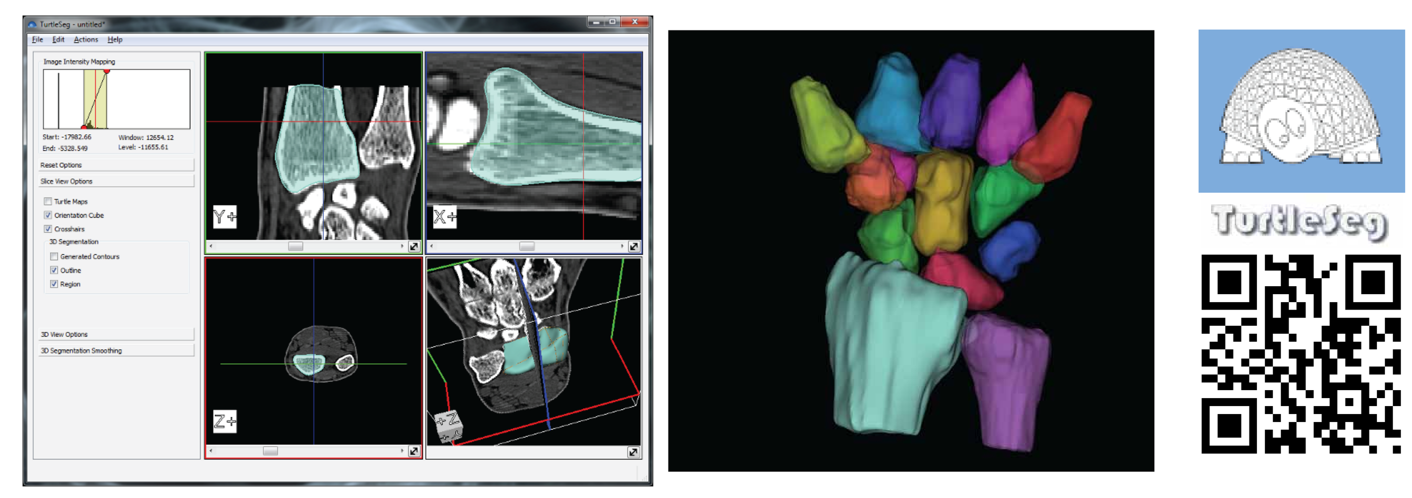
Biomedical Signal and Image Computing Laboratory

BiSICL at a Glance

- The Biomedical Signal and Image Computing Lab (BiSICL) is a multidisciplinary research facility at UBC dedicated to computational research in biomedical imaging.
- We focus on close and direct collaboration with local and international clinicians and on-site presence spanning literally from the lab to the bedside.
- **Mission**: Create, develop, and translate innovative techniques for automated processing, analysis, understanding, and visualization of medical imaging.
- **Research:**
  - Robotic Assisted Minimally Invasive Surgery for abdominal cancer,
  - Interventional 3D ultrasound in orthopedic surgery,
  - Fused Functional and Structural Analysis for neuro-imaging, and
  - Simulation of patient specific data (swallowing)



Bone Localization in 3D Ultrasound: BiSICL graduate Dr. Hacihaliloglu scanning a patient in the OR prior to surgery for distal radius fracture reduction (left), Localization of the fracture using phase-symmetry (right) **[MICCAI 2008]**



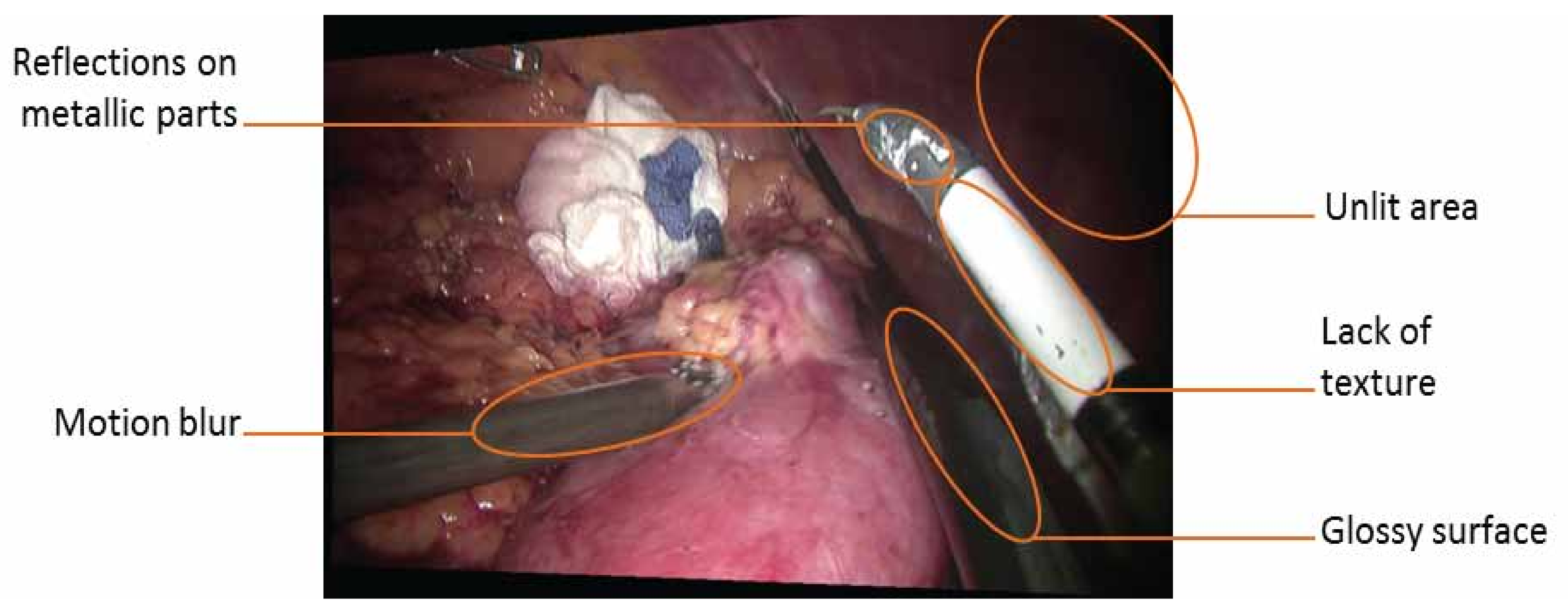
Active learning for interactive image segmentation: BiSICL's TurtleSeg software being used to segment the CT image of the distal radius (left) and the wrist (right) **[MICCAI 2011]** , available for download: **http://www.turtleseg.org**

Robotic Assisted Partial Nephrectomy

- A new project in collaboration with Qatar Robotic Surgery Center and Cleveland Clinic
- Ultimate goal is the seamless fusion and visualization of pre-operative and intra-operative imaging modalities in real-time
- First step is to reconstruct the imaged surgical scene topology captured by the binocular camera in 3D

Robust Dense Stereo-Vision Reconstruction

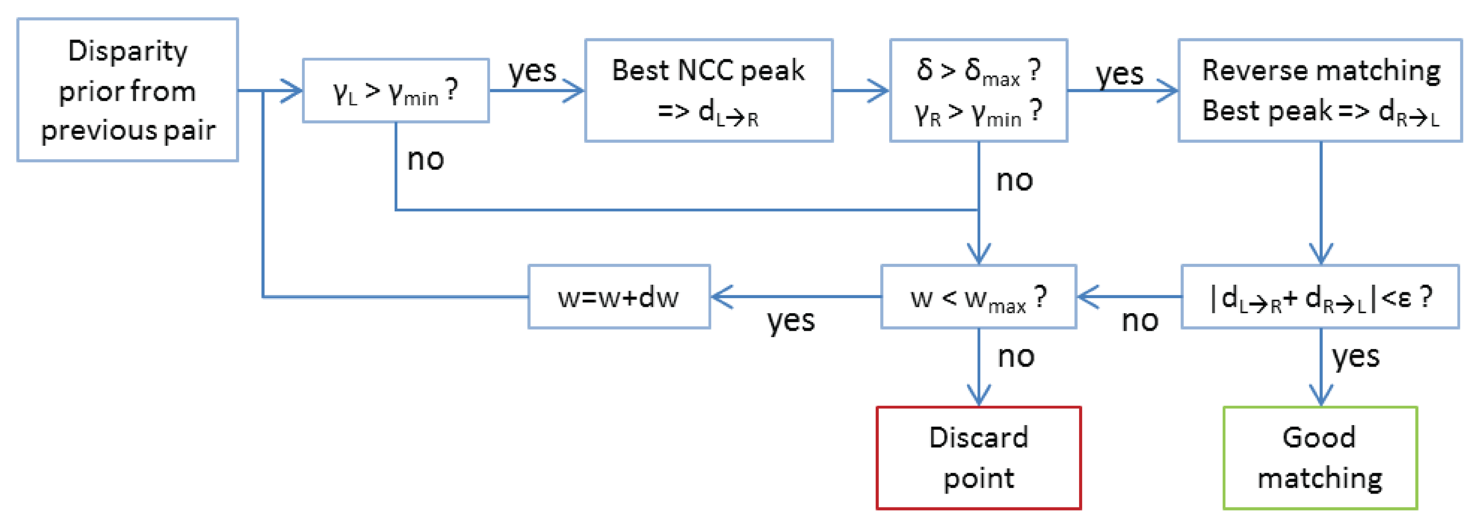
- We have proposed a simple yet powerful approach for dense matching **[MICCAI's MVC 2012]** between the two stereoscopic camera views and for reconstruction of the 3D scene.
- Our method adaptively and accurately finds the optimal correspondence between each pair of images according to three strict confidence criteria that efficiently discard the majority of outliers.



Stereo-Matching Woes: Example image depicting a scene captured during a partial nephrectomy procedure. Commonly encountered artifacts are highlighted in orange.

Challenges for Dense Reconstruction

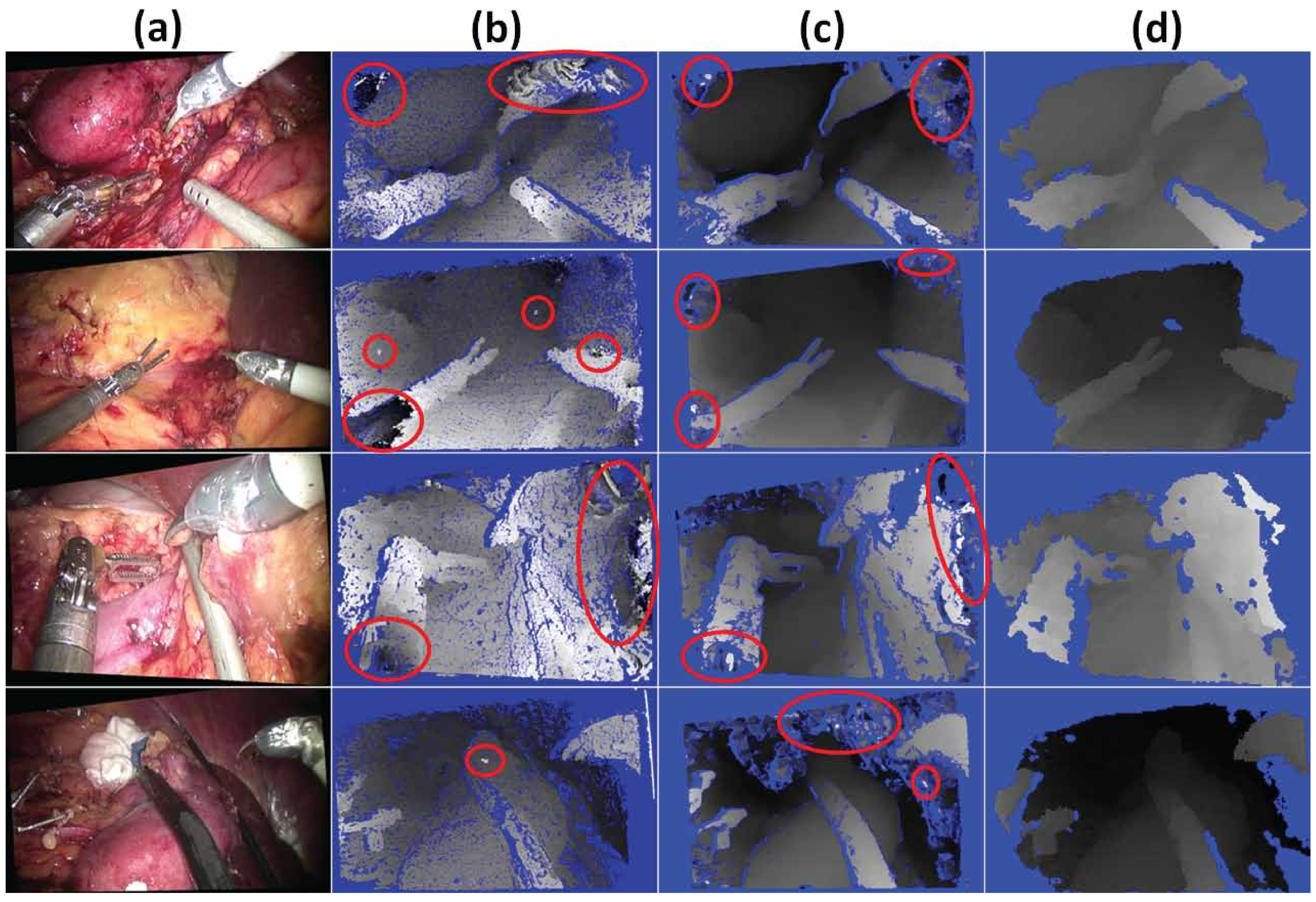
- Current computer vision algorithms for 3D stereo reconstruction are mostly designed for static scenes reflecting simple geometries or shapes within environments where reflection and lighting is relatively ideal
- Conversely, in abdominal MIS, the environment is mostly composed of soft tissue and organs that significantly deform due to the surgeon's actions as well as breathing and cardiovascular activity
- Intra-abdominal also tissue presents complex reflections, due to the non-Lambertian nature of the surfaces, as well as irregular shapes, highly variable textures, and various distortions
- Further complications are caused by surgical instruments occluding a significant portion of the underlying tissue



Novel Robust Matching Method: Block diagram of our proposed dense matching method

Proposed Solution and Results

- Using a normalized cross correlation similarity metric between patches from the left and right images, we define three confidence criteria for outlier rejection.
- First, an effective gradient dispersion metric γ is used to estimate the strength of local spatial structure to address lack of discriminative features.
- Second, the quality of a matching is quantified by the difference of similarity score between the two highest peaks in the NCC profile. If this difference δ is too small, the match is deemed uncertain, and the patch size, w, is increased.
- Third, an inverse matching consistency is enforced by calculating disparities through right-to-left ($d_{R\to L}$) and left-to-right ($d_{L\to R}$) patch-matching. If the difference between the two disparity measurements is greater than the very small threshold ε, the window size is increased.



Robust Stereo-Matching Results: Comparison with state-of-the-art methods using clinical data from a DaVinci S surgical robot. (a) Original image, (b) Depth map from [Stoyanov 2010], (c) [Roehl 2012], and (d) our method. Our method successfully excludes outliers (highlighted in red).

References

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Collaborators

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THINKING OF THE WORLD

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UBC a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA

QRSC Qatar Robotic Surgery Centre

الصندوق القطري لرعاية البحث العلمي
Qatar National Research Fund
Member of Qatar Foundation