WARTHE

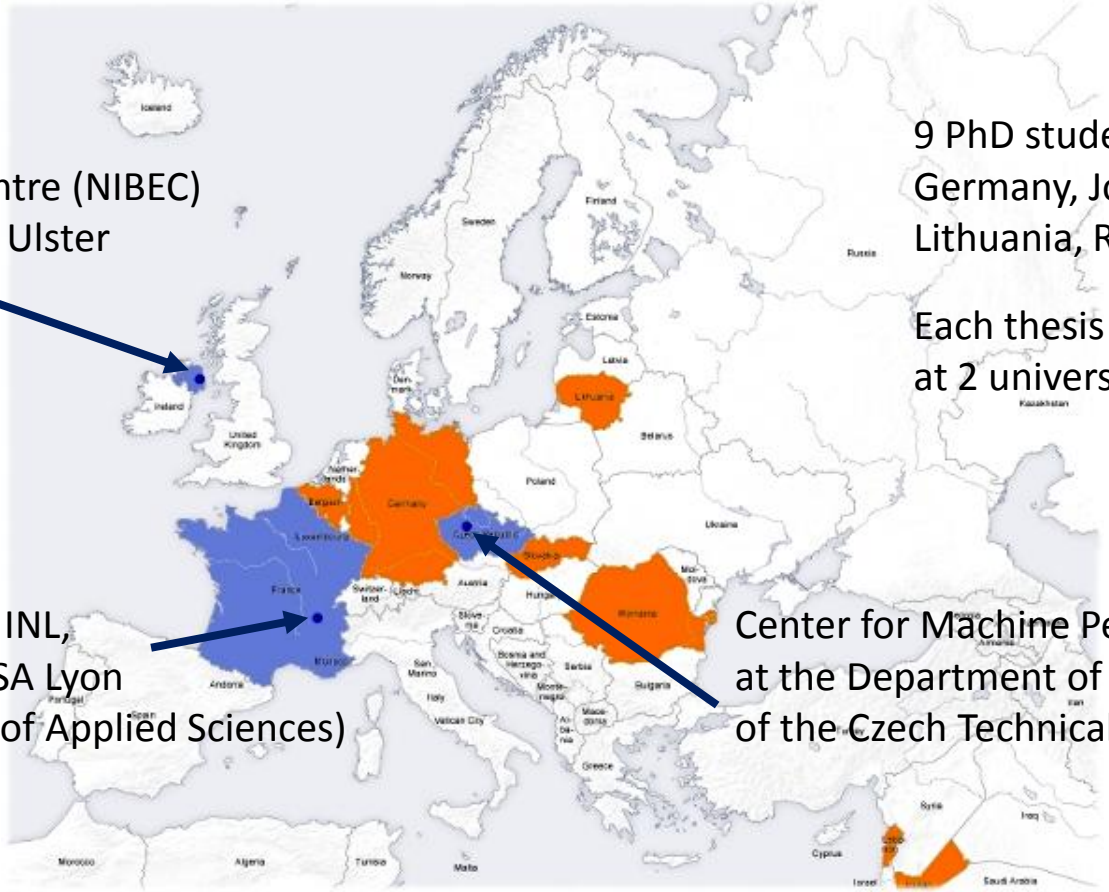
Wide Area Research Training in Health Engineering

MARIE CURIE ACTIONS

Multidisciplinary research training in the field of health engineering, in particular electronic health, medical imaging, biomedical engineering, and ambient intelligence as applied to prevention, continuous monitoring and care of patients

Northern Ireland
Bio Engineering Centre (NIBEC)
at the University of Ulster

University of ULSTER



9 PhD students from Belgium, Germany, Jordan, Lebanon, Lithuania, Romania & Slovakia

Each thesis is co-supervised at 2 universities

AMPERE, CREATIS, INL,
LIRIS & MIPC at INSA Lyon
(National Institute of Applied Sciences)

INSA LYON

Center for Machine Perception (CMP)
at the Department of Cybernetics
of the Czech Technical University in Prague

www.warthe.eu

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WARTHE - Wide Area Research Training in Health Engineering

Image from www.nextgenmd.org/vol2-5/robotic_surgery.html

3D Reconstruction & Deformable Surface Tracking

for Minimally Invasive Robotic Surgery on the Beating Heart

Tanja Schilling
schillin@cmp.felk.cvut.cz

Supervisors

Tomáš Pajdla
CMP, CTU Prague

Patrick Clarysse
Creatis-LRMN, INSA-Lyon

September 15, 2009
4th Summer School on Surgical Robotics in Montpellier, France

Medical Background:
Totally Endoscopic Coronary Artery Bypass Graft

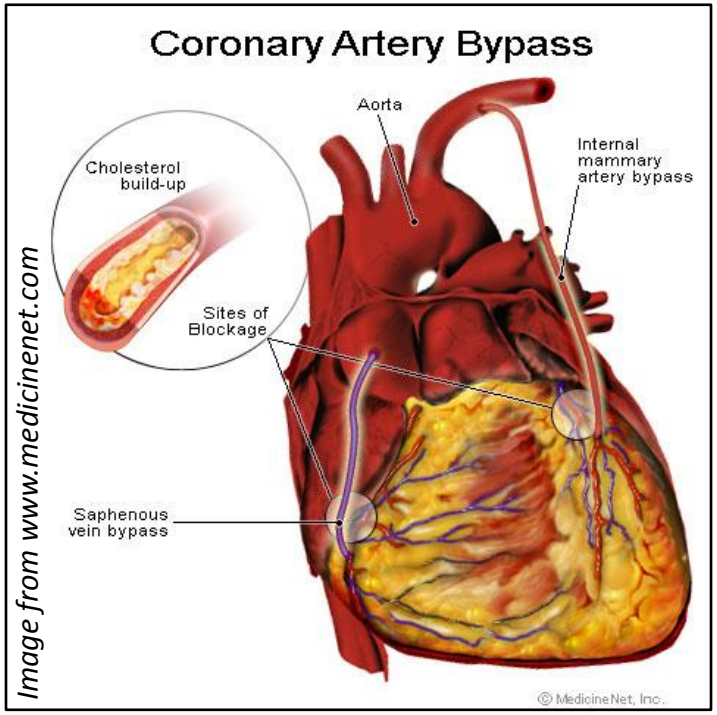


Image from www.medicinenet.com

Coronary artery disease: Obstructed coronary arteries → Limited blood supply to heart muscle → Heart attack

Coronary artery bypass (CAB) surgery: Arteries or veins are grafted from aorta to coronary arteries to bypass obstructed area

- CAB surgery is the most often performed cardiac procedure
- Usually performed on arrested heart using cardio-pulmonary bypass (CPB) by open surgery

Severe complications associated with CPB → **Avoiding CPB & sternotomy** with telemanipulation systems for MIS: **Totally endoscopic coronary artery bypass graft on the beating heart**

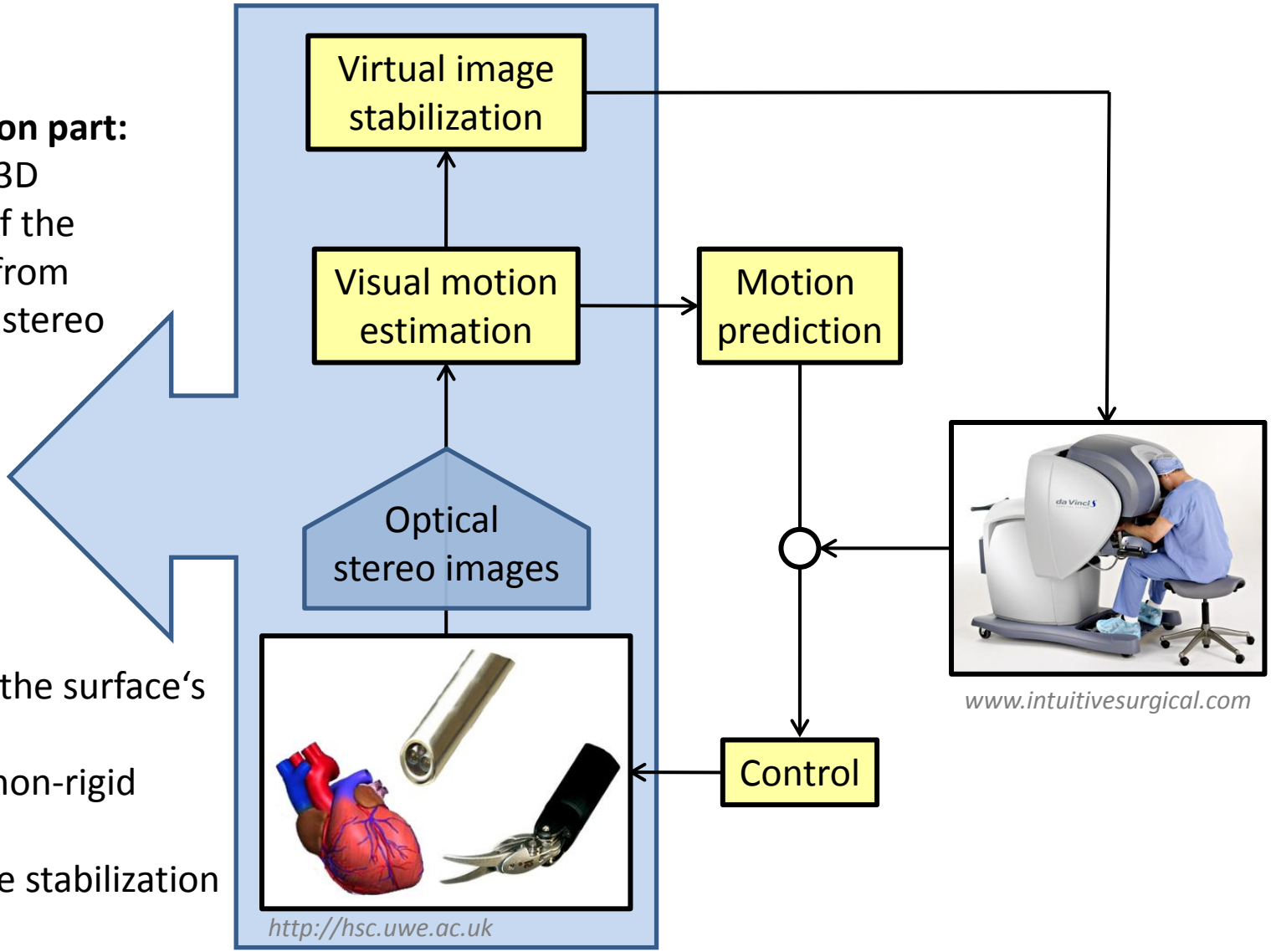
Difficulties for the surgeon:

- Limited space
- Lack of tactile feedback
- **Motion of the heart**

Video provided by Dr. U. Kappert, Cardiovascular Institute at the University Hospital Dresden, Germany

Motion Compensation – Problem Description

Computer vision part:
Assessing the 3D deformation of the heart surface from a sequence of stereo images



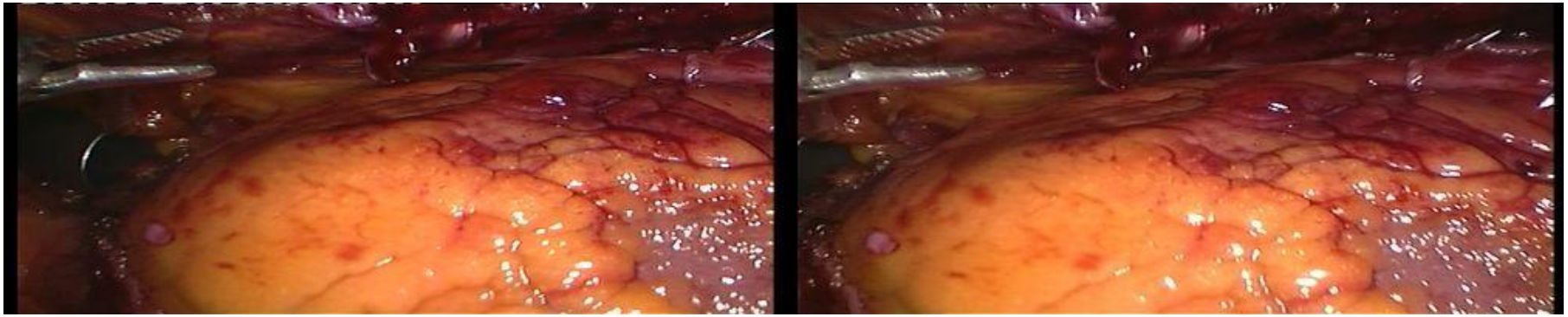
Subtasks:

- Recovery of the surface‘s 3D shape
- Tracking of non-rigid motion
- Virtual image stabilization

3D Reconstruction of the Heart Surface

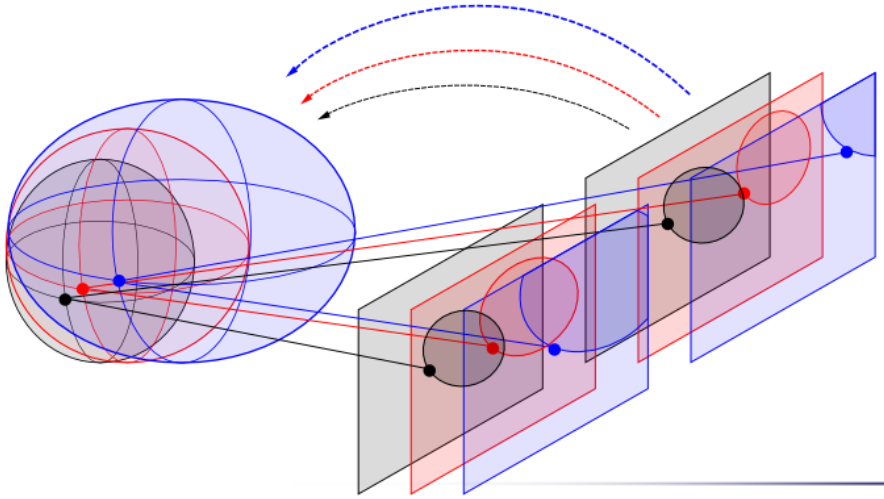
Input data:

- 2 synchronous sequences of optical images
- 50 frames per second, size of 288x720 pixels



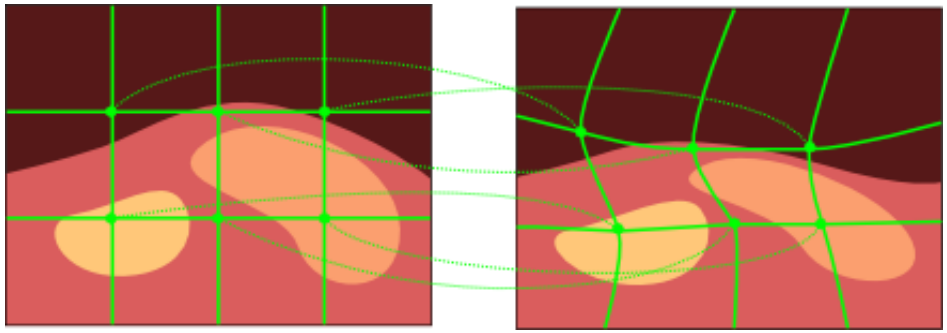
Objective:

- Reconstructing the 3D surface from sequence of image pairs
- Tracking the surface in subsequent images



Finding Image Point Correspondences: Deformable Matching

Matching task: Finding a mapping for each pixel position in the left image the corresponding position in the right image



Left image

Right image and (ideally) transformed left image

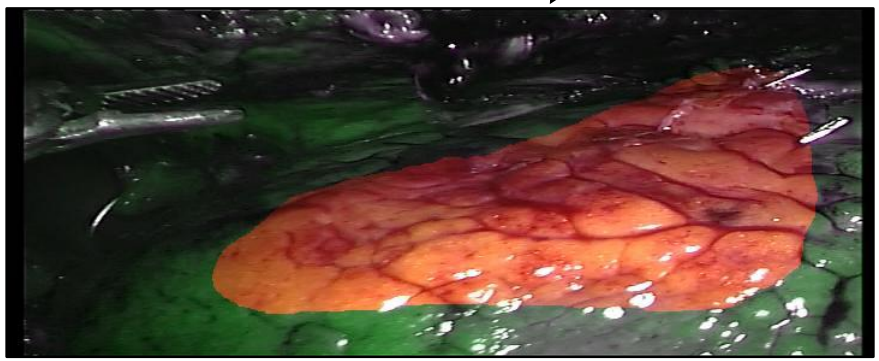
MRF-based non-rigid image matching algorithm *[Shekhovtsov et al., 2007]:*

- MRF-based model for deformable image matching applied
- Pixels are grouped in blocks
- Continuity constraints on neighboring pixel blocks → preserve 2D continuity
- Optimal deformation is maximal a posteriori probability configuration of the corresponding MRF

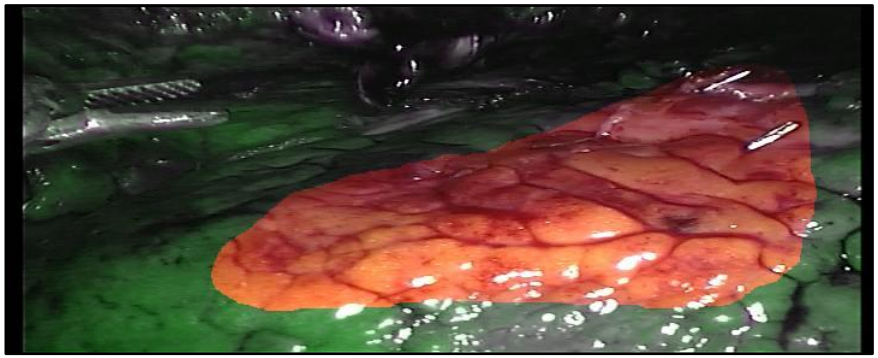
Deformable Image Matching Example

Computing the mapping from the left to the right image
(only the reddish region is considered here)

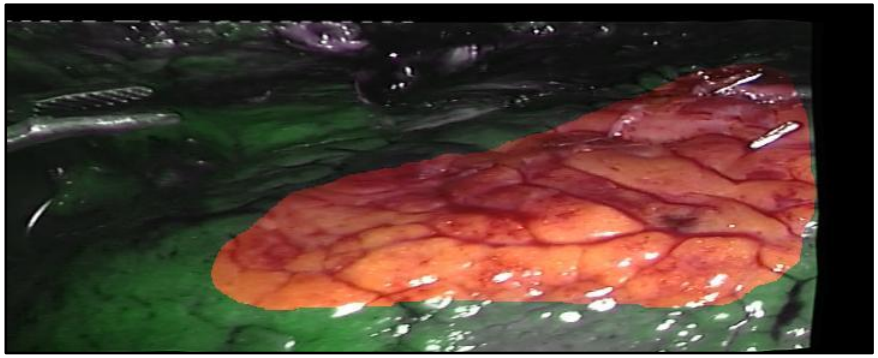
Left input image



Right input image

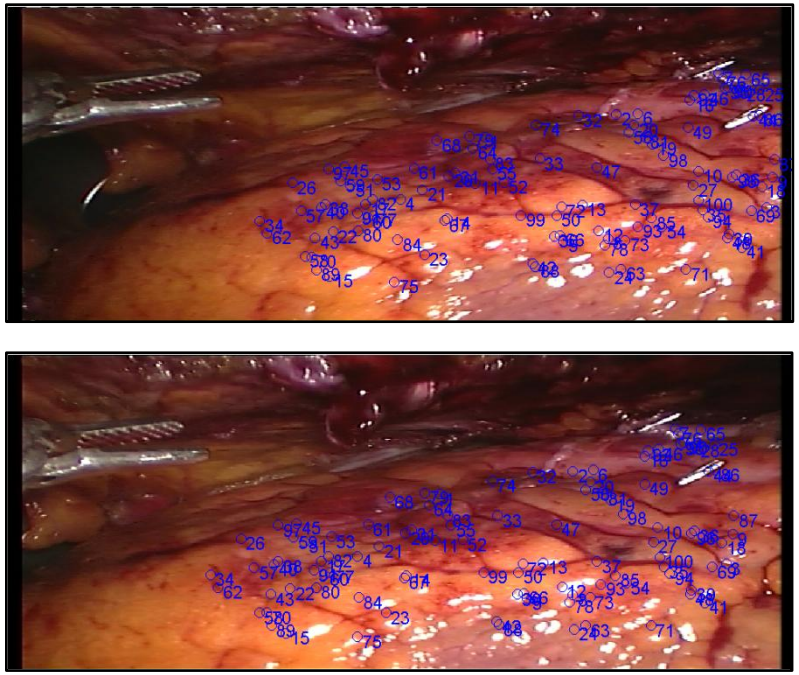


Back-transformed result:
Pixels from the left image are mapped to
the corresponding ones in the right image

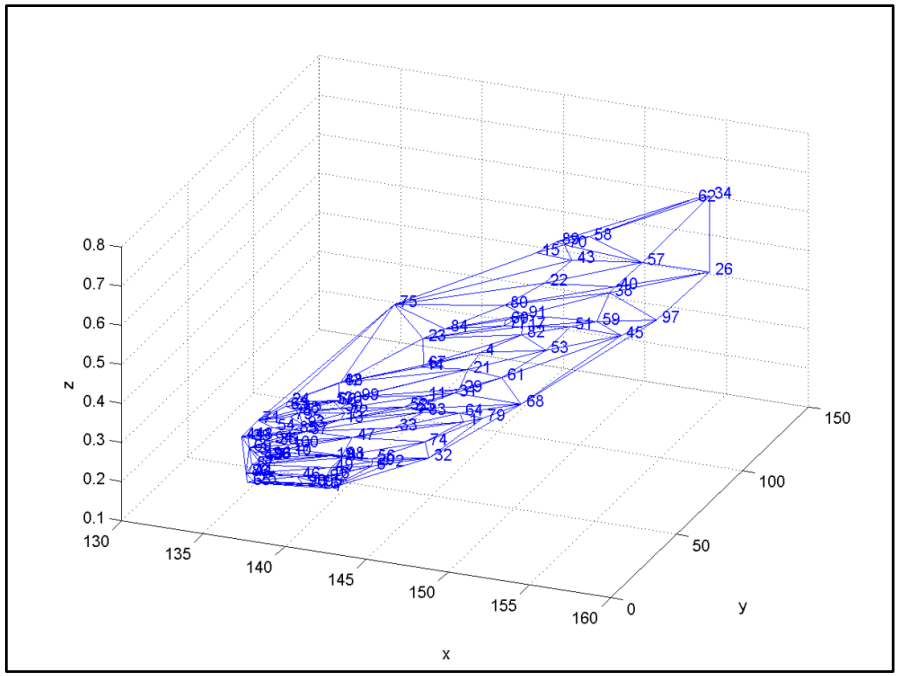


Reconstruction Example

Left and right image with a subset of corresponding image points marked:



Subset of reconstructed world points w.r.t. the left camera frame:



Distorted reconstructed surface because of small errors in matching
→ Upgrading the reconstruction using constraints ...*ongoing work*

Thank you for your attention.