

Parallax-Free Long Bone X-ray Image Stitching

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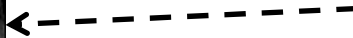
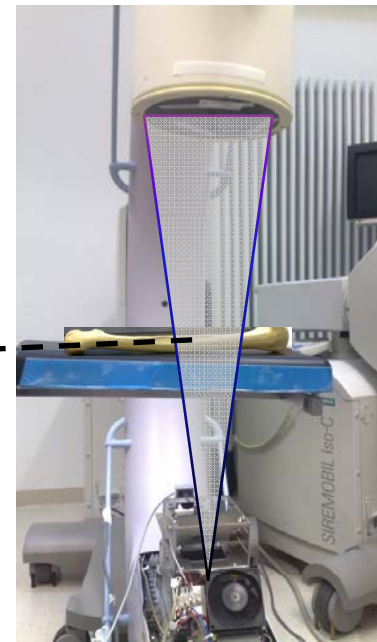
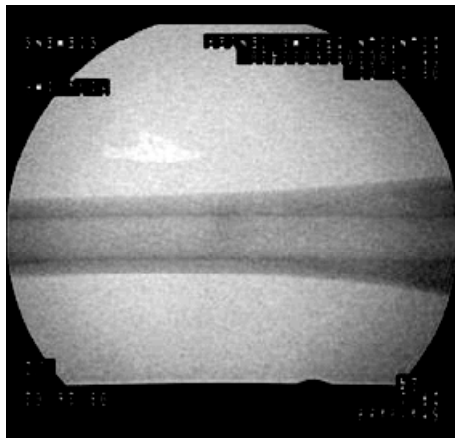
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Presented by *Lejing Wang*

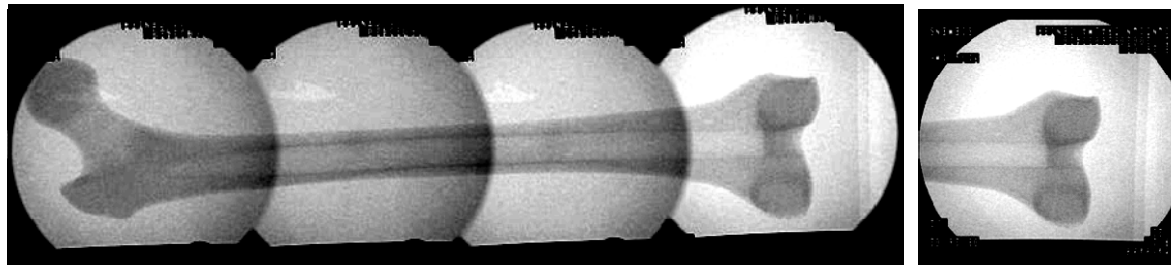
Clinical Motivation

- Orthopedic and trauma surgery relies heavily on intra-operative X-ray images to visualize bone fracture configurations and to support repositioning
- Mobile C-arm is an everyday tool for acquiring X-ray images during surgery
 - narrow imaging field of view



X-ray Image Stitching

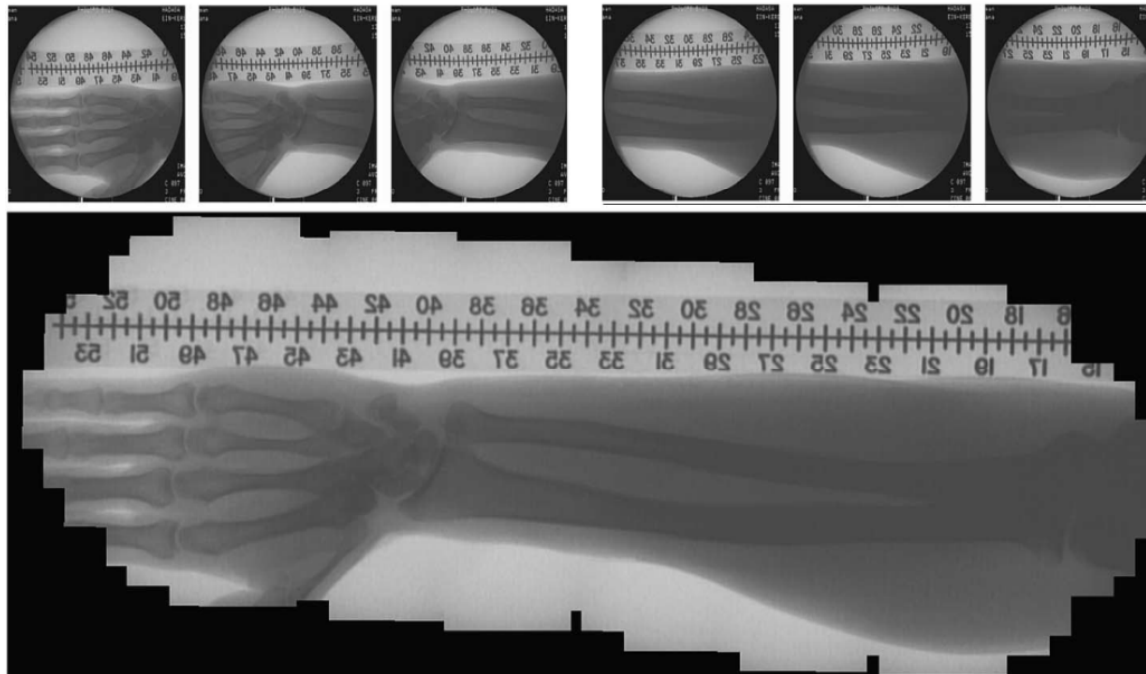
- The entire bone structure is visualized across several individual X-ray images
 - vague impression of bone configurations
 - axial malalignment in bone fracture reduction surgery reported to be 5%- 28% [1,2]



- **Panoramic X-ray image**
 - diagnosis
 - mechanical axis (alignment of fragments) control
 - metric measurements
 - documentation

Related Work

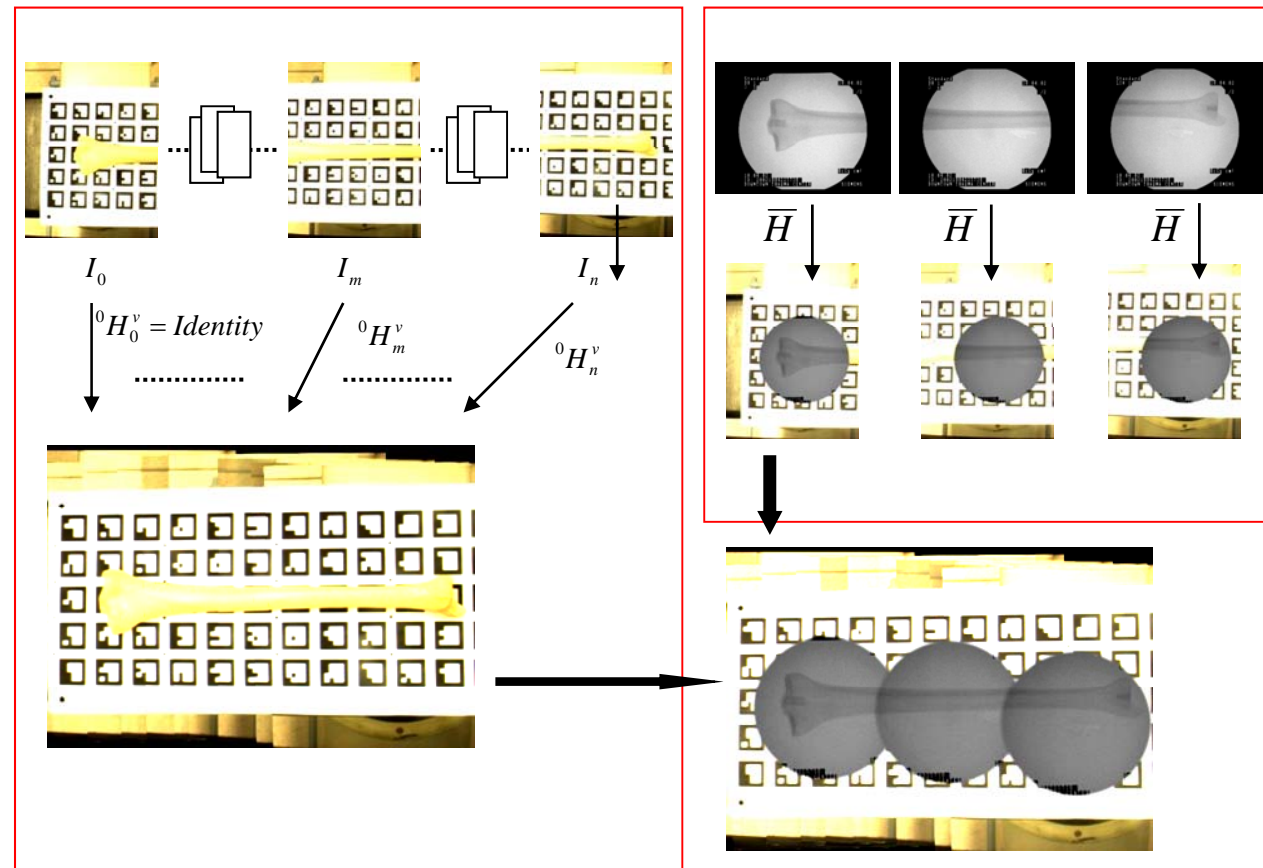
- A radiolucent X-ray ruler is placed along the bones as reference [1]



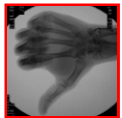
Courtesy of Yaniv & Joskowicz

Related Work

- Employ a C-arm augmented by a video camera, and a marker pattern [1]



Parallax-free X-ray Stitching



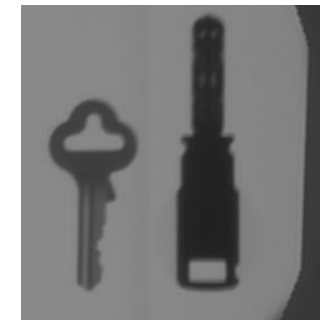
For parallax reduction, methods [1, 2] require bone structure to be

- simple planar
 - **cannot deal with fractures or patients who are unable to extend the joints**
 - **anatomical scene is rarely planar (no occlusion in X-ray images i.e. can see behind objects)**
- parallel to the plane of the ruler or marker pattern (stitching plane)
 - **not the case for soft tissue around bones**

$$H = KRK^{-1} + \frac{1}{d} Ktn^T K^{-1}$$

$= 0$
 (circled d) (circled n^T) (circled 0)

pure rotation



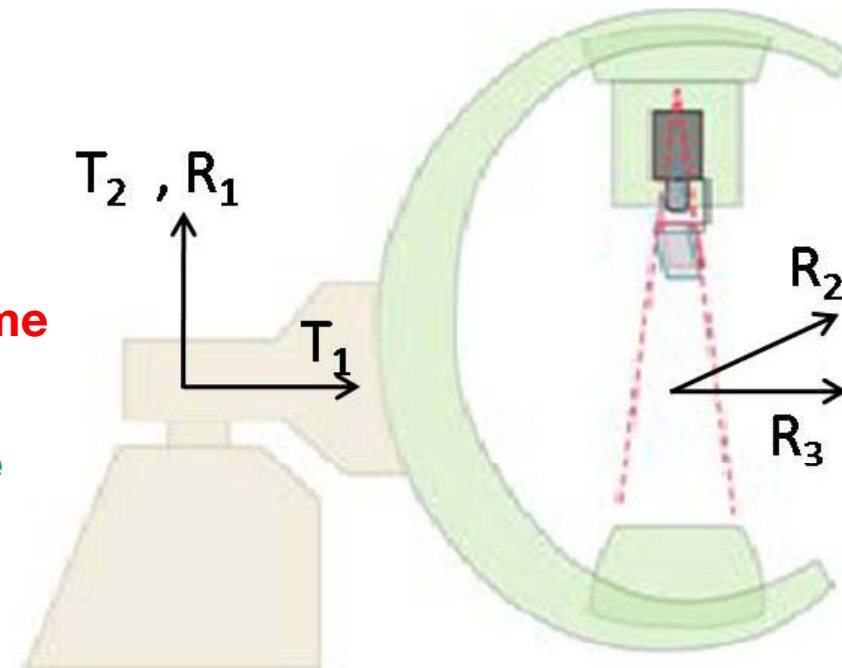
1. Yaniv and Joskowicz: Long bone panoramas from fluoroscopic X-ray images. IEEE Trans Med Imaging 2004
2. Wang et al.: Long Bone X-ray Image Stitching Using Camera Augmented Mobile C-arm. MICCAI 2008

Mobile C-arm Movements

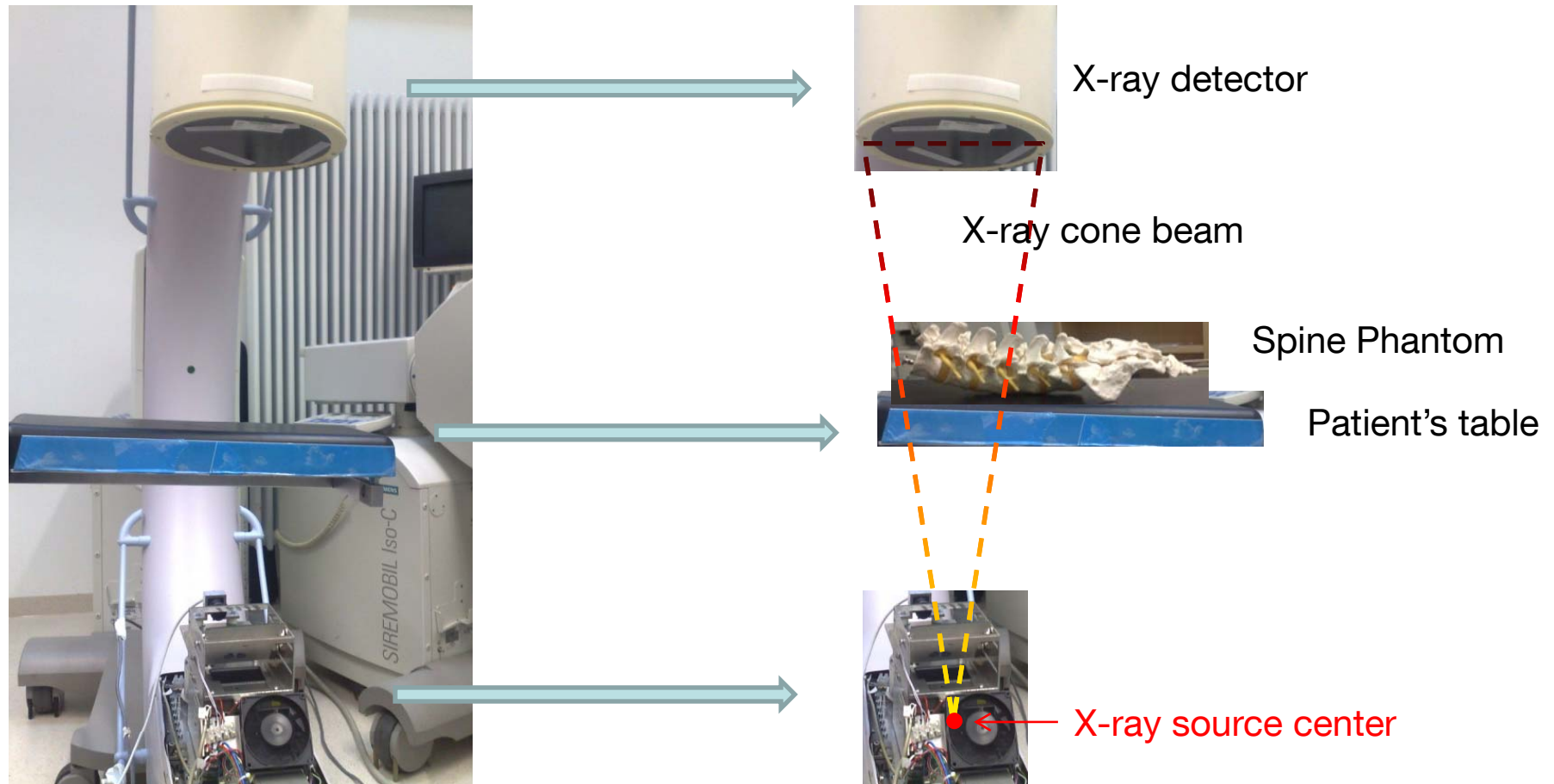
- It is difficult and sometimes impossible to make a pure rotation around the X-ray source (5DOF C-arm)

Impossible in absolute coordinate frame

Possible in relative coordinate frame

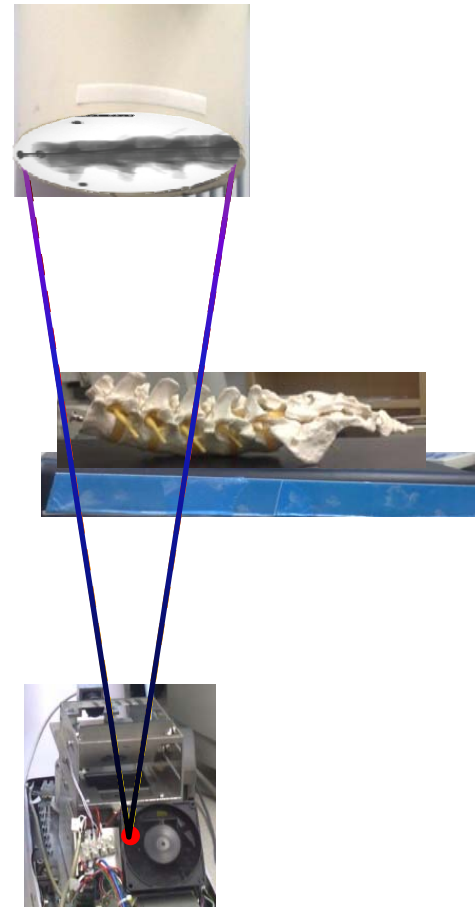


Parallax-Free Stitching

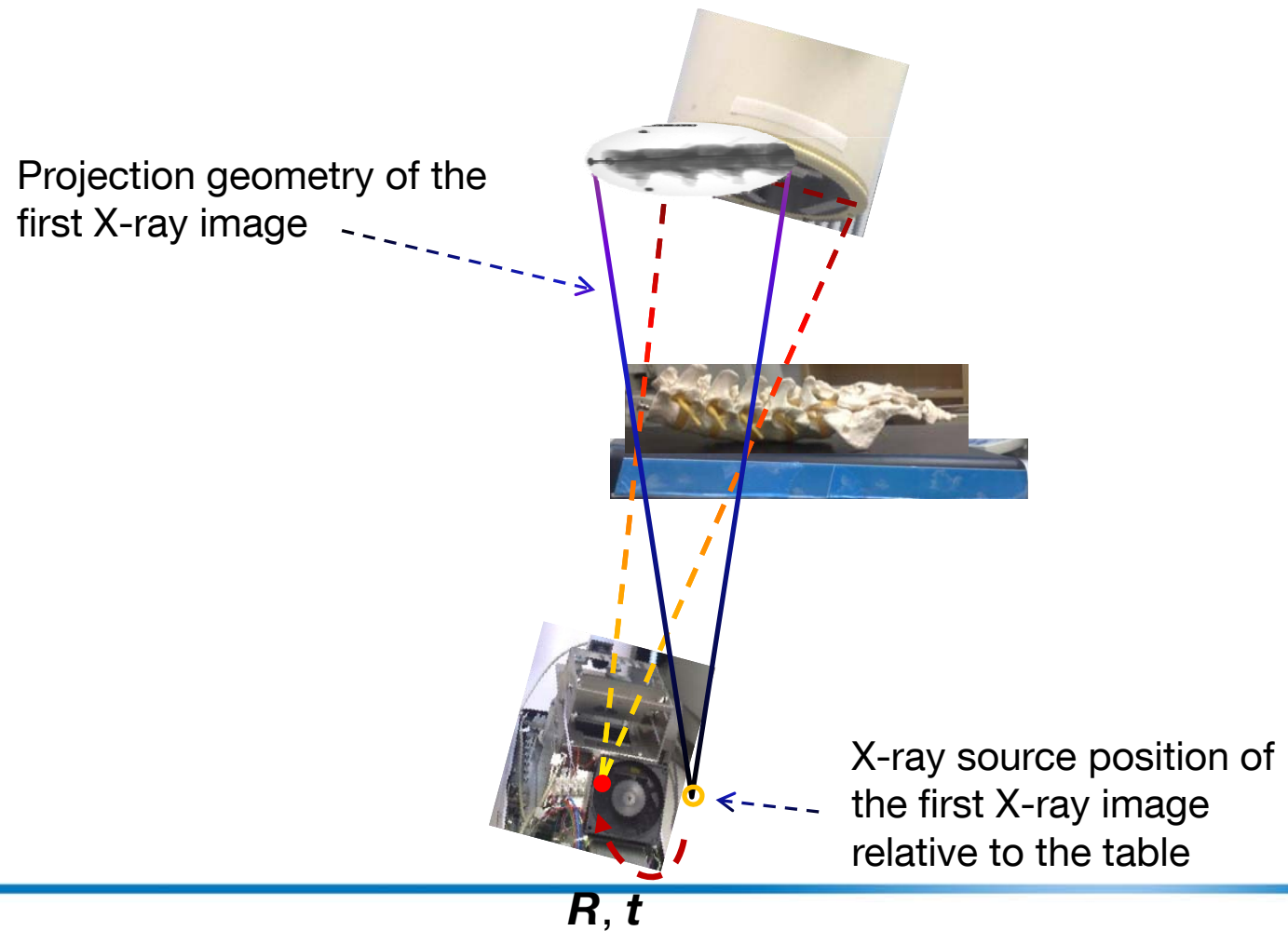


Parallax-Free Stitching

Acquire the first X-ray image!

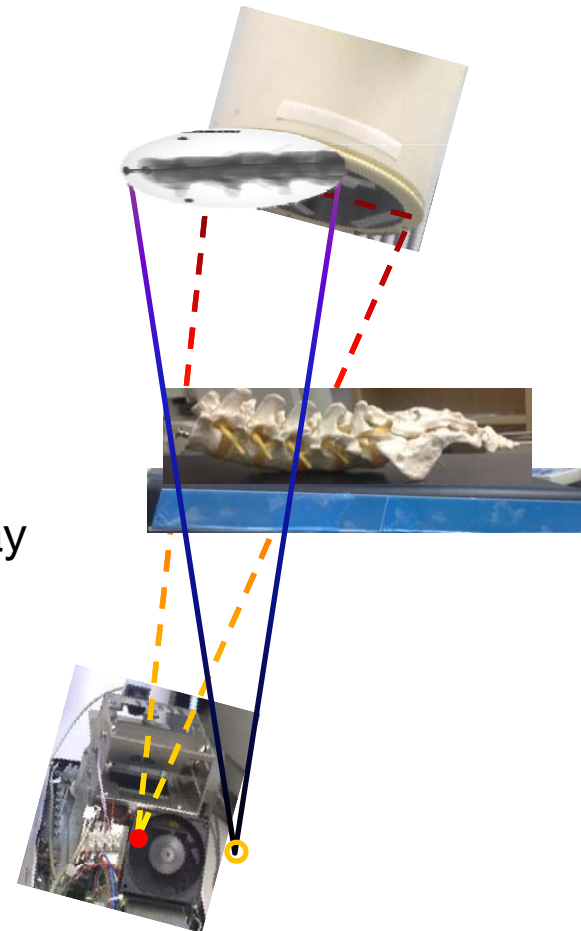


Parallax-Free Stitching



Parallax-Free Stitching

Move, **only translate**, the table to compensate for the translation of the X-ray source with respect to the table

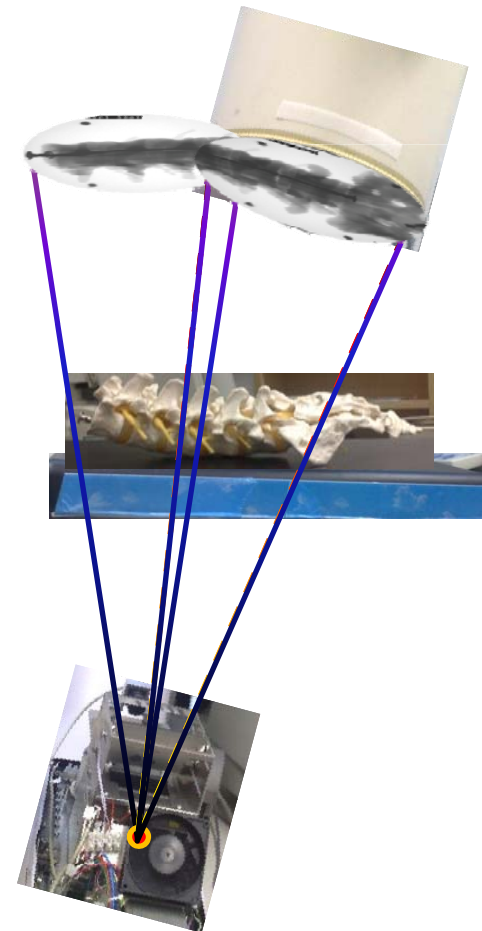


Relative pure rotation

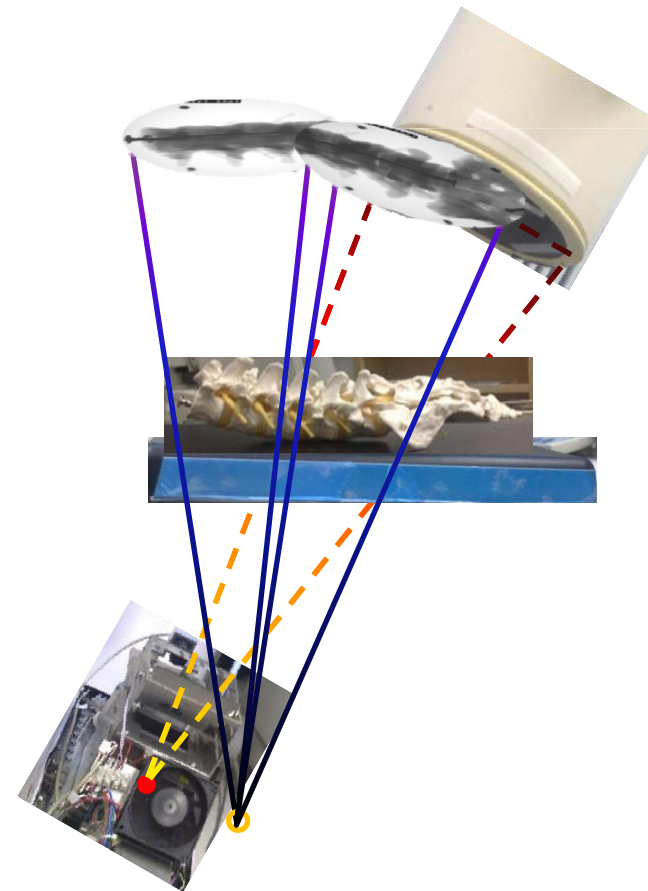
R, t

Parallax-Free Stitching

Acquire the second X-ray image!

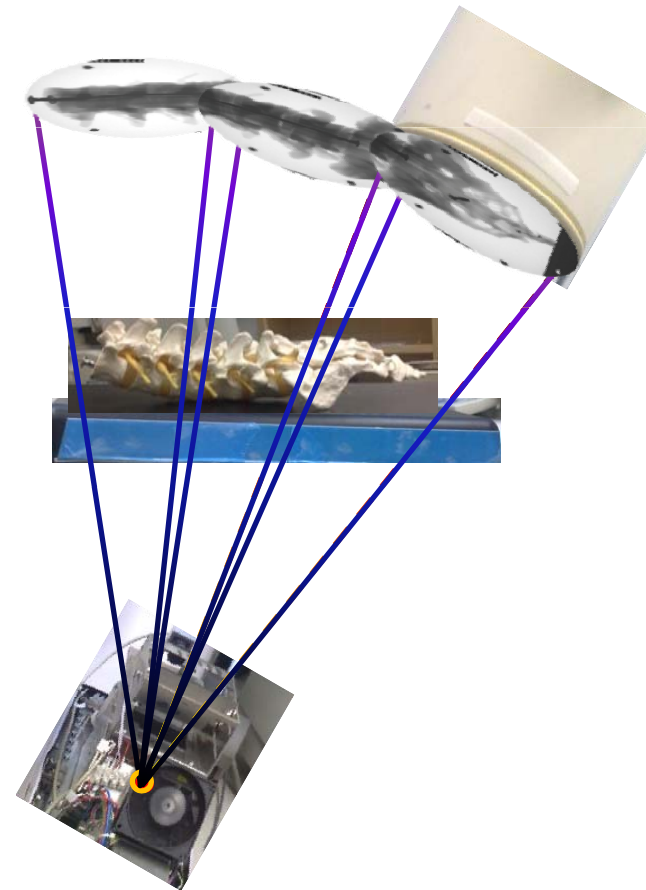


Parallax-Free Stitching



Parallax-Free Stitching

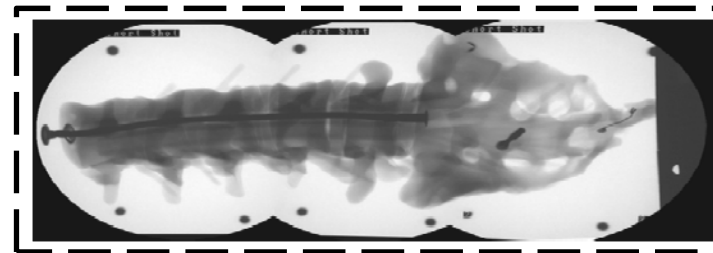
Acquire the third X-ray image!



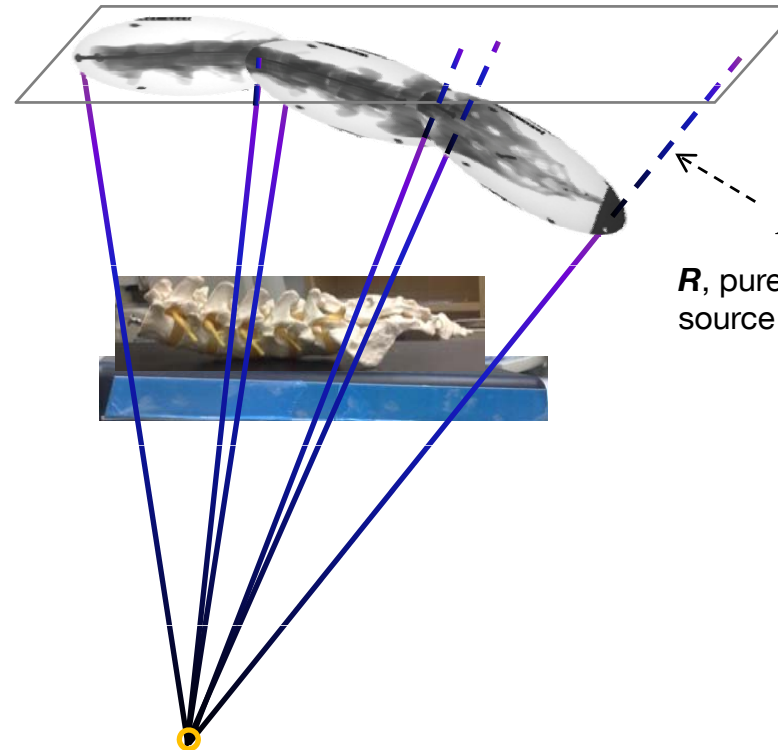
Parallax-Free Stitching

The first acquired X-ray Image is defined as reference

A true single X-ray image



Parallax-free panoramic X-ray image



$$H = KRK^{-1}$$

R, pure rotation of the X-ray source relative to the table

Parallax-Free Stitching

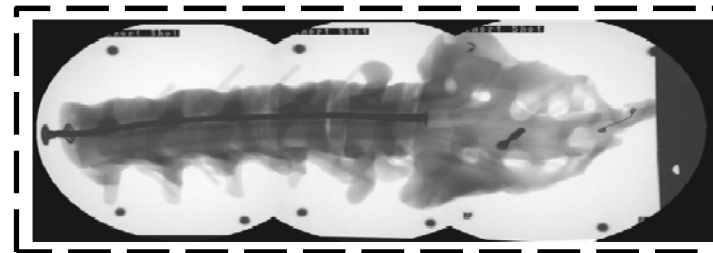
The first acquired X-ray Image is defined as reference

A true single X-ray image

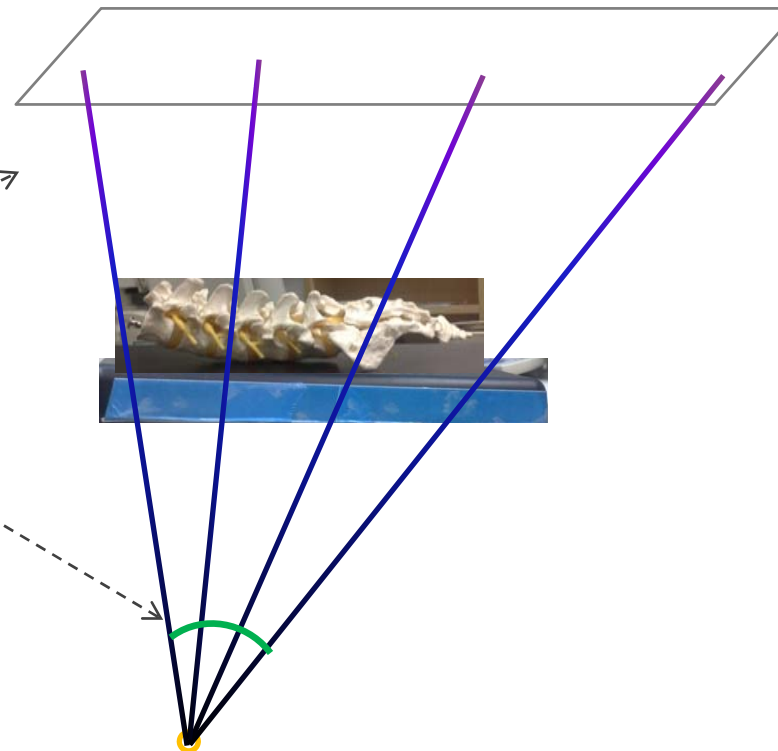
From a C-arm having an exceptional wide imaging field of view

- *Bigger X-ray detector*
- *Bigger viewing angle*

Preserves linear perspective projection



Parallax-free panoramic X-ray image



Challenge : How to translate the table to achieve a relative pure rotation ?

Table Translation based on C-arm Pose Estimation

- C-arm pose estimation employs a **Camera Augmented Mobile C-arm (CAMC)** system [1,2] and a **visual marker pattern**

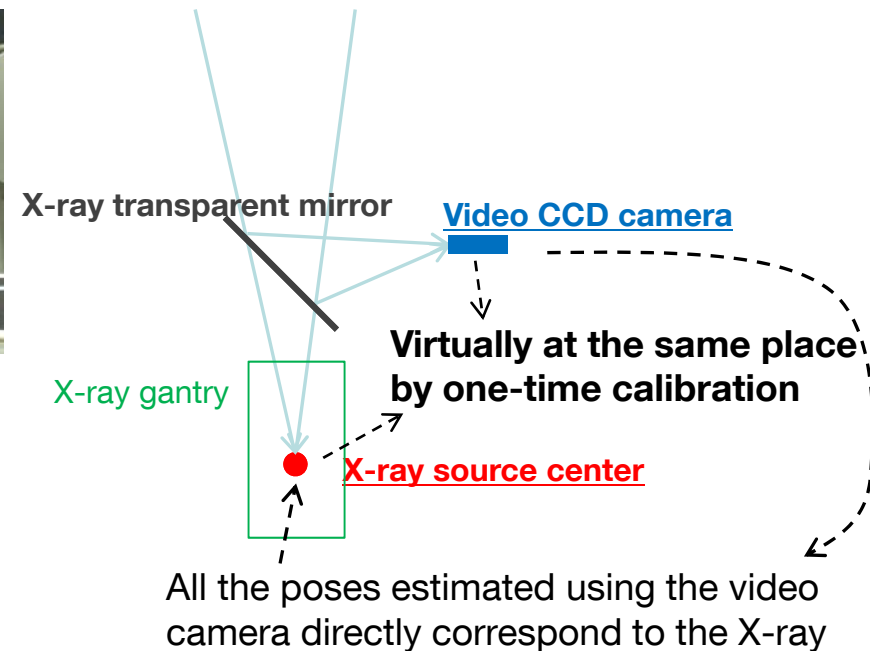
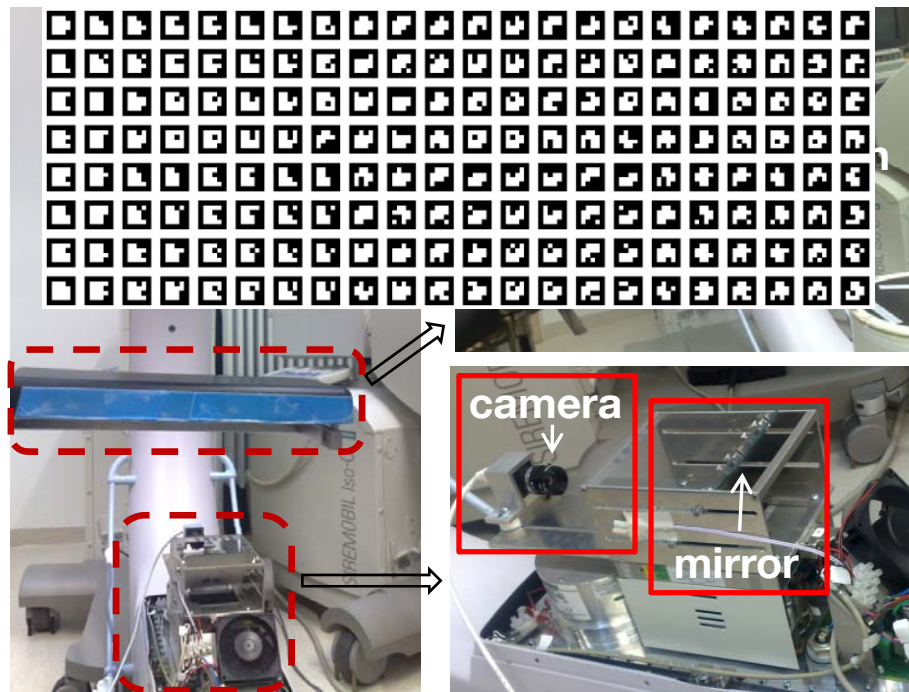
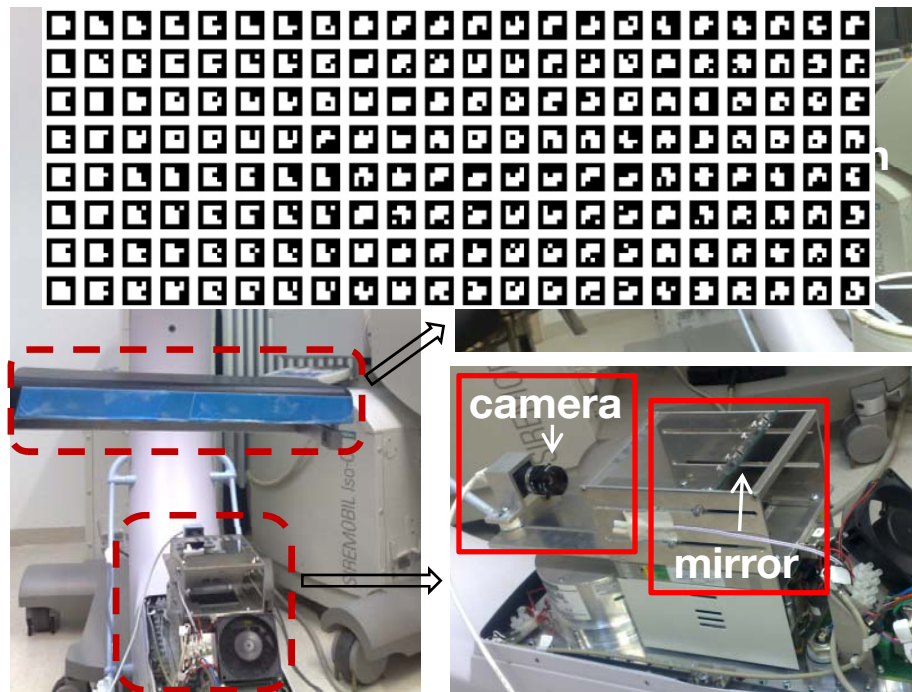


Table Translation based on C-arm Pose Estimation

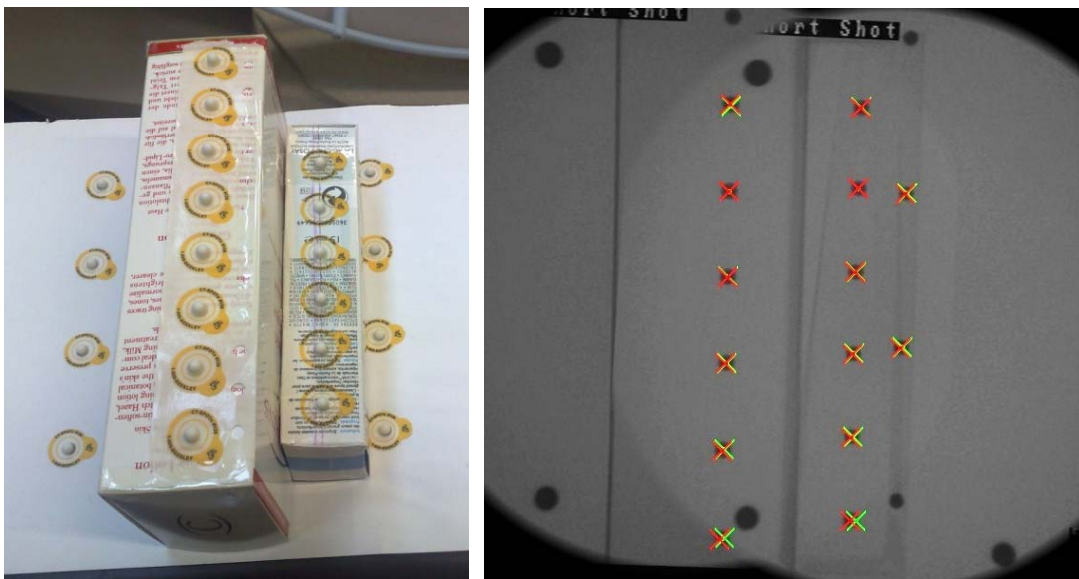
- C-arm pose estimation employs a **Camera Augmented Mobile C-arm (CAMC)** system [1,2] and a **visual marker pattern**



- **Invisible** to the whole surgery
 - smooth integration into the surgical procedure
- Continuous C-arm pose estimation **without radiation**
 - feedback for supporting the translation of the table

Experiments & Results

- **Quantify** the accuracy by computing the distance between marker pairs inside the overlapping area of two stitched X-ray images.



Left: Spherical X-ray markers on three different planes

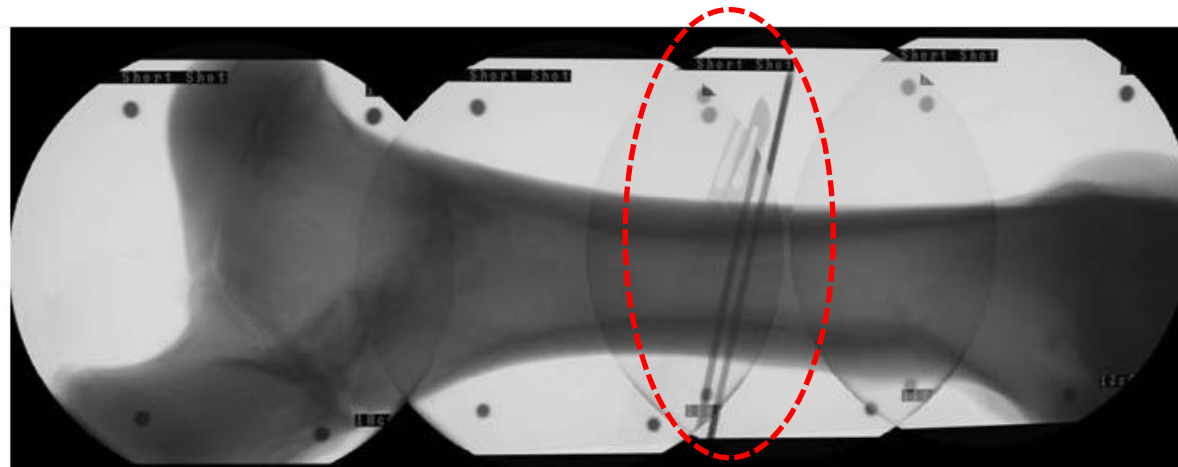
Right: Extracted centers of X-ray markers marked by red and green crosses in the two stitched X-ray images

	#1	#2	Overall
Mean (pixels)	1.68	1.84	1.76
STD (pixels)	1.30	1.17	1.36
# X-ray markers	14	13	27

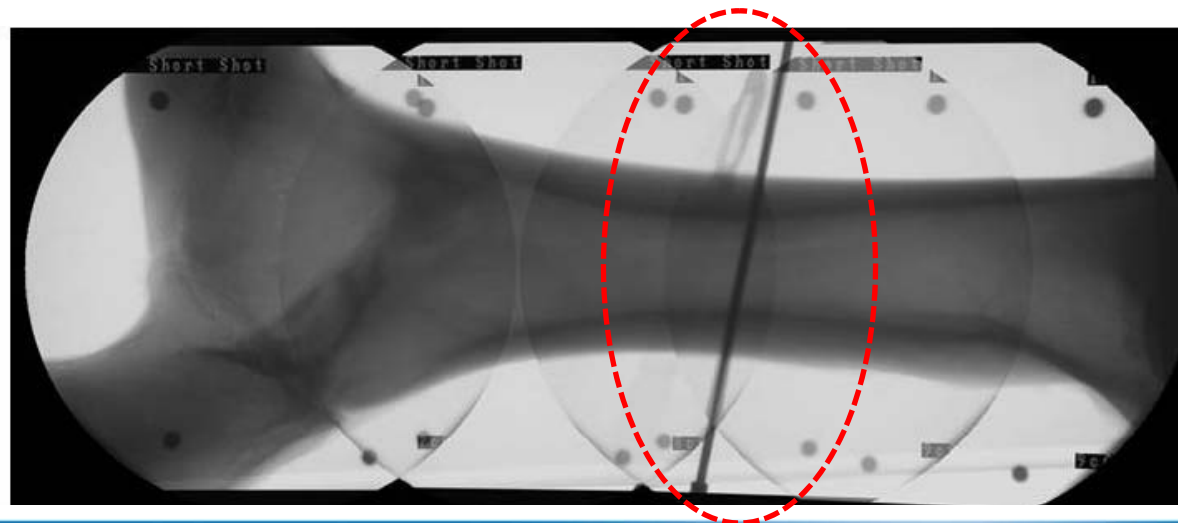
Experiments & Results



non parallax-free stitching



parallax-free stitching



Discussion & Conclusion



A true parallax-free panoramic X-ray image based on relative rotation

- suitable for any part of body X-ray imaging, e.g. pelvis or whole-spine imaging

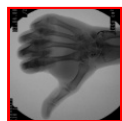


Minimized radiation (no overlapping X-ray regions required)



Smooth integration to the whole surgery

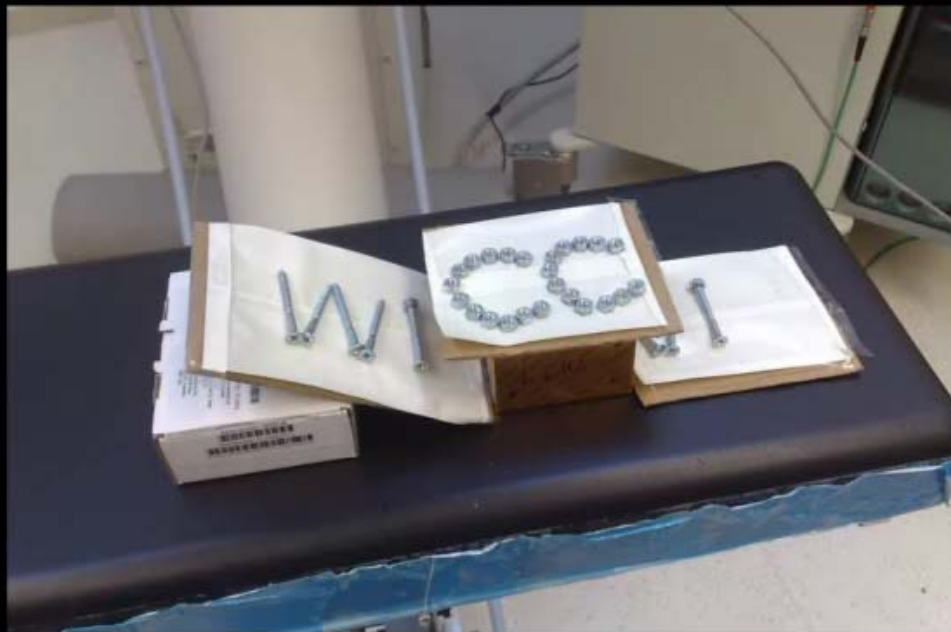
- C-arm systems with known relative pose information
 - external tracking
 - Robotic C-arm, e.g. Artis zeego Multi-axis system from Siemens



Control of the entire environment (C-arm, table, patient)

- limited space between C-arm and patient -> **collision**

Video for MICCAI

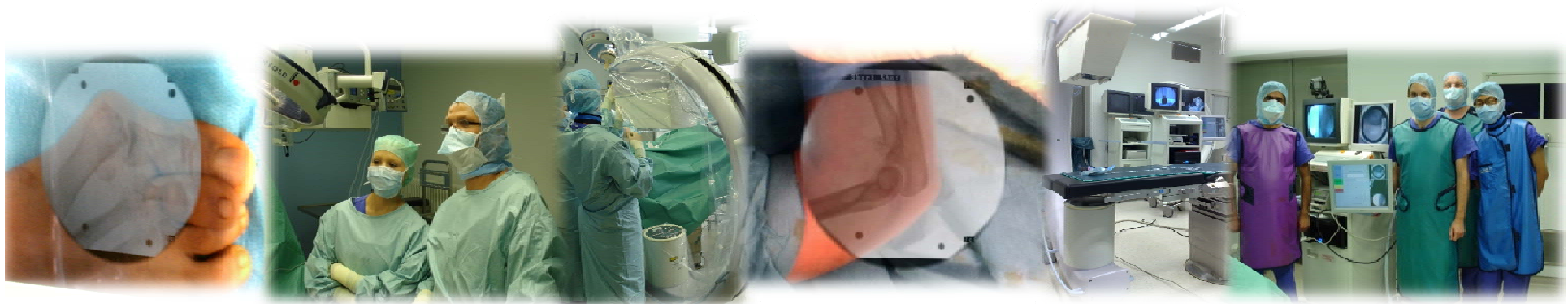


Metal screws on different planes

Acknowledgement

- Thanks to Trauma Surgery Department, Klinikum Innenstadt, LMU Munich
- Our colleagues at NARVIS lab

Thank you for your attention



- CAMC system has been developed with partial support from Siemens Healthcare
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