JOHNS HOPKINS
WHITING SCHOOL of ENGINEERING

LABORATORY FOR Computational Sensing + Robotics

Plan in 2-D, execute in 3-D: an augmented reality solution for cup placement in total hip arthroplasty

Authors: Javad Fotouhi, Clayton P. Alexander, Mathias Unberath, Giacomo Taylor, Sing Chun Lee, Bernhard Fuerst, Alex Johnson, Greg Osgood, Russell H. Taylor, Harpal Khanuja, Mehran Armand, Nassir Navab

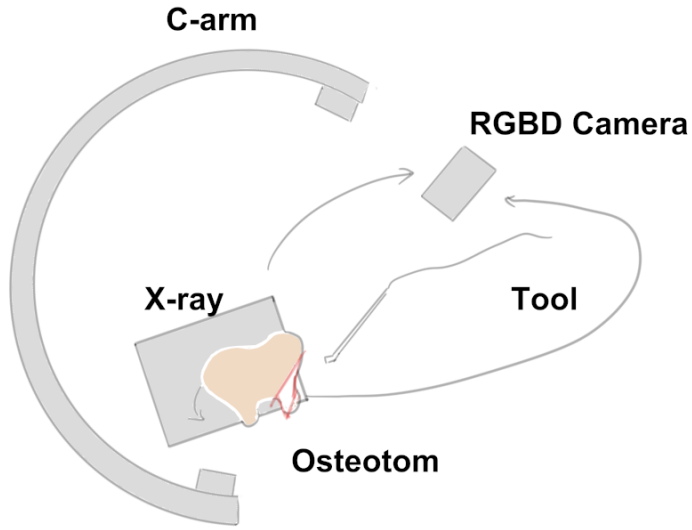
Presenter: Wenhao GU

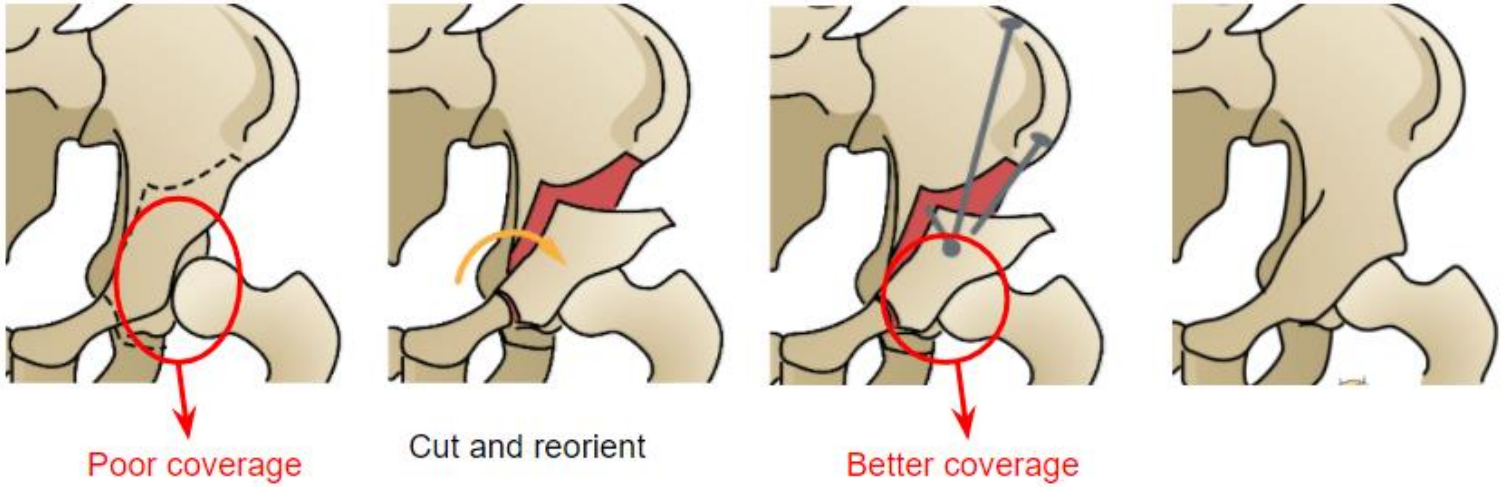
Fotouhi, J., Alexander, C. P., Unberath, M., Taylor, G., Lee, S. C., Fuerst, B., ... & Armand, M. (2018). Plan in 2-D, execute in 3-D: an augmented reality solution for cup placement in total hip arthroplasty. *Journal of Medical Imaging*, *5*(2), 021205.

Review of Project

Objective:

Track the osteotom tool with respect to the pelvis in PAO using RGBD and X-ray images





(Image taken from https://hipdysplasia.org/adult-hip-dysplasia/adult-treatments/hip-preservation-surgery-for-adult-hip-dysplasia/)

Paper selection

- Javad Fotouhi, Clayton P. Alexander, Mathias Unberath, Giacomo Taylor, Sing Chun Lee, Bernhard Fuerst, Alex Johnson, Greg M. Osgood, Russell H. Taylor, Harpal Khanuja, Mehran Armand, Nassir Navab, "Plan in 2-D, execute in 3-D: an augmented reality solution for cup placement in total hip arthroplasty," Journal of Medical Imaging 5(2), 021205.

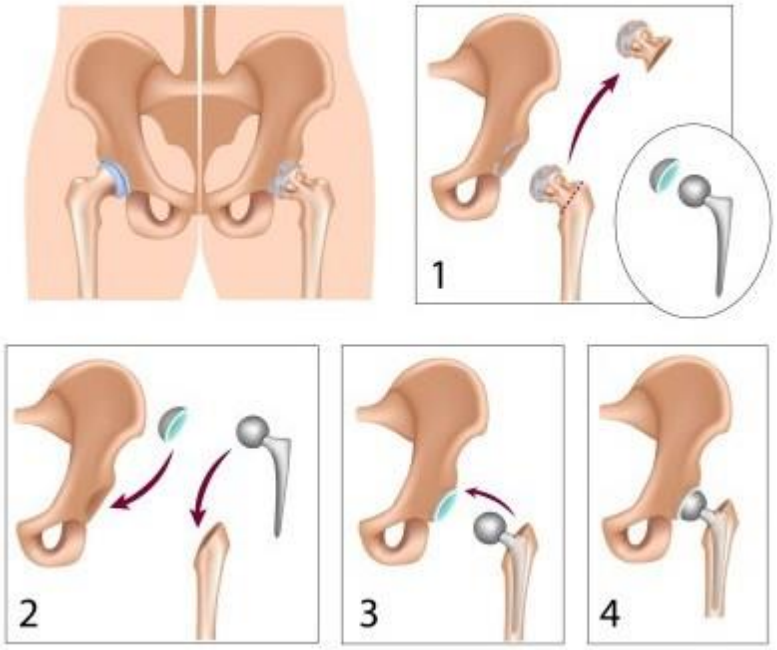
<u>Reasons:</u>

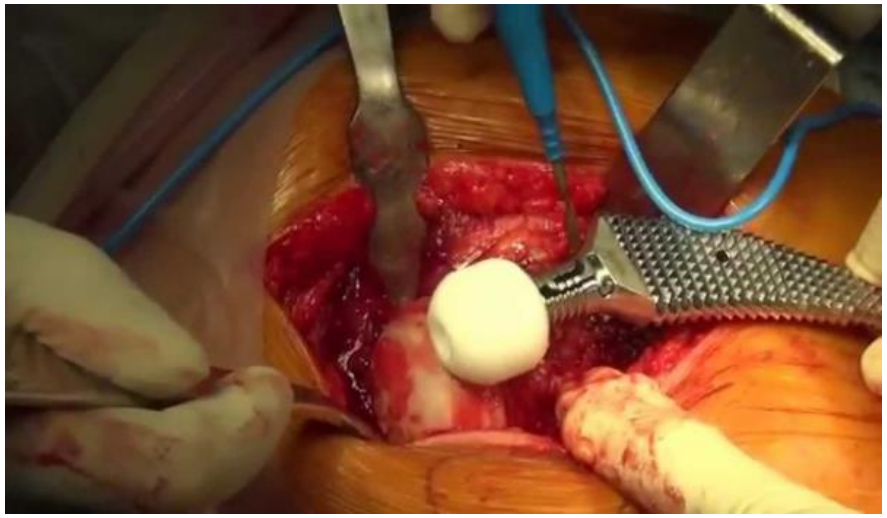
- Shows the overall picture of how the camera-augmented C-Arm (CAMC) system works
- Similar to our project (RGBD and X-ray data is also used)

Background

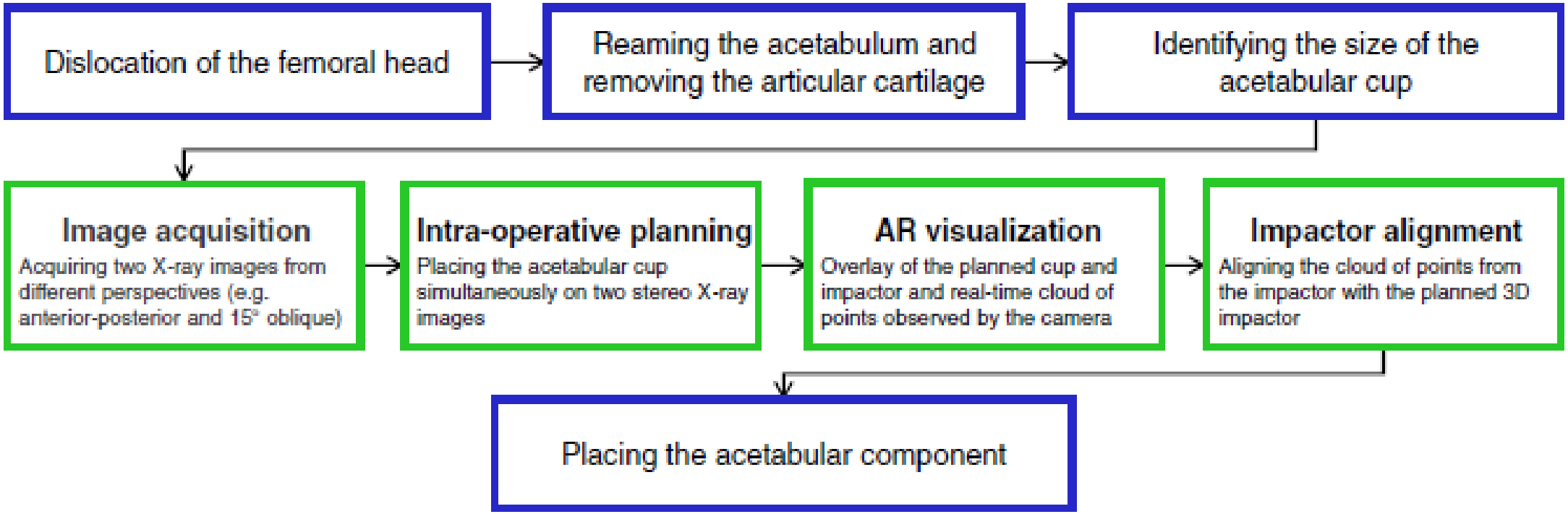
<u>Total hip arthroplasty (THA)</u>

- Replace the damaged bone with prosthetic component.
- Proper implant placement is critical but challenging
- Use intraoperative fluoroscopy to guide the surgeon

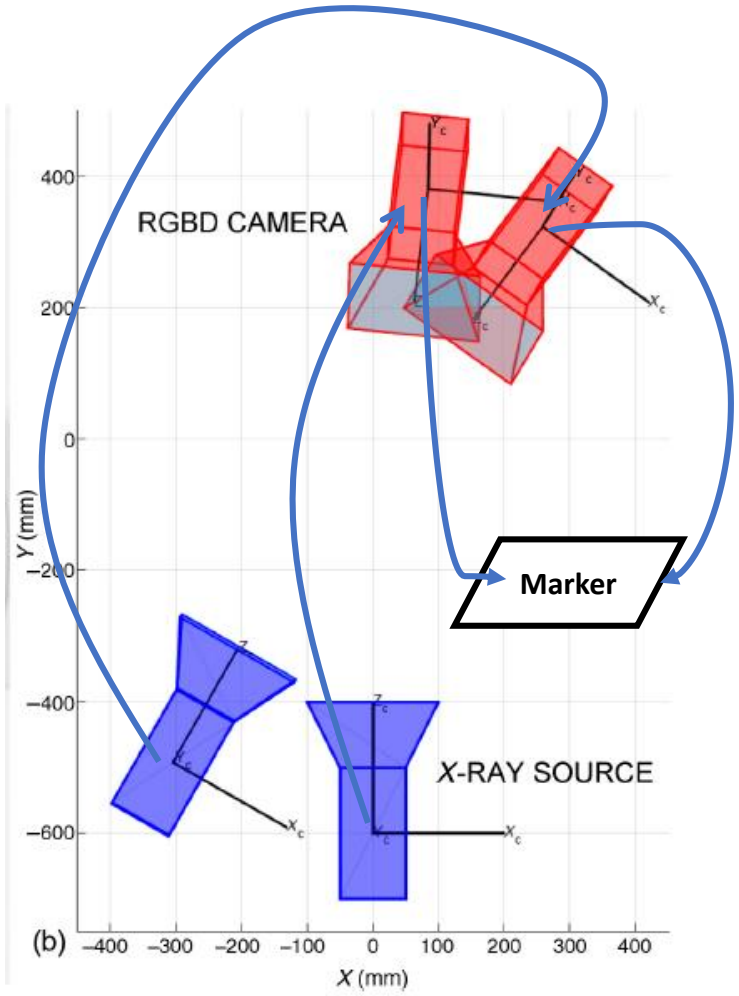




Method

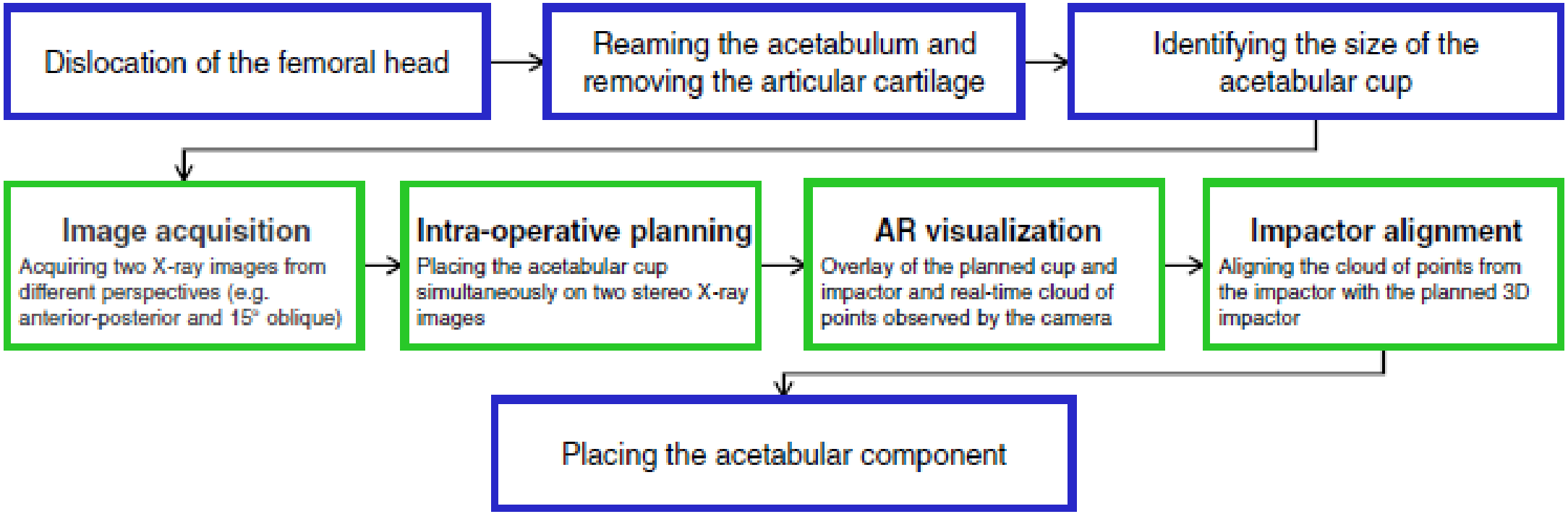

Dislocation of the femoral head
Reaming the acetabulum and removing the articular cartilage
Identifying the size of the acetabular cup
Image acquisition
Acquiring two X-ray images from different perspectives (e.g. anterior-posterior and 15° oblique)
Intra-operative planning
Placing the acetabular cup simultaneously on two stereo X-ray images
AR visualization
Overlay of the planned cup and impactor and real-time cloud of points observed by the camera
Impactor alignment
Aligning the cloud of points from the impactor with the planned 3D impactor
Placing the acetabular component

Method



$$ {}^{X'}\mathbf{T}_{X} = {}^{RGBD'}\mathbf{T}_{X'}^{-1\,M}\mathbf{T}_{RGBD'}^{-1}\,{}^{M}\mathbf{T}_{RGBD}\,{}^{RGBD}\mathbf{T}_{X} $$

Method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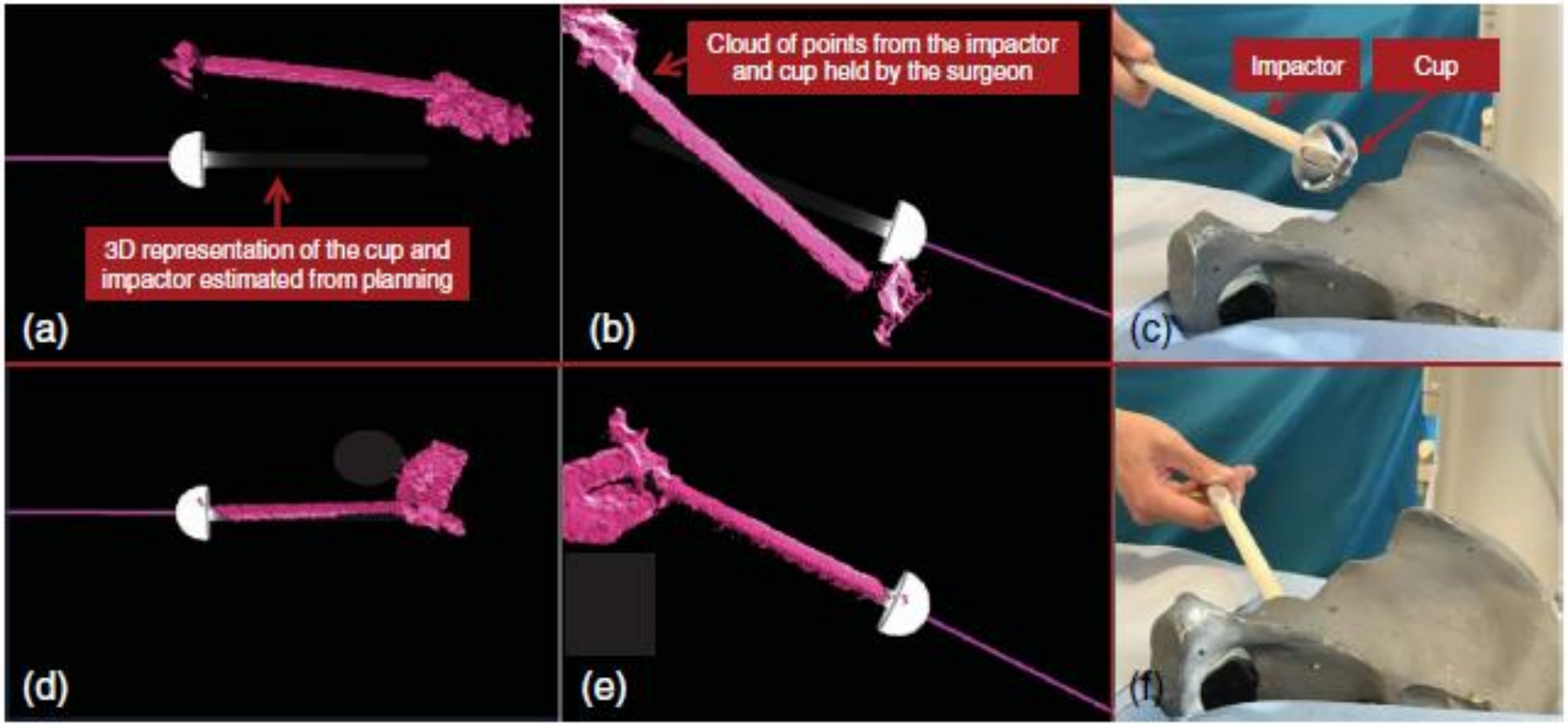
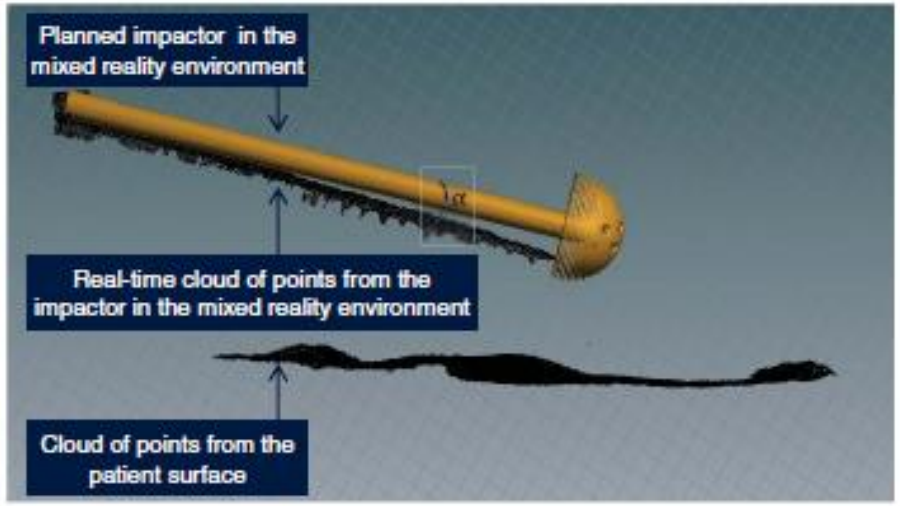

3D representation of the cup and impactor estimated from planning
(a)
Cloud of points from the impactor and cup held by the surgeon
(b)
Impactor
Cup
(c)
(d)
(e)
(f)

Results

- 10 different poses and 4 virtual perspectives of the surgical site for each pose
  - Translational error: 1.98 mm
  - Orientation error: 1.22 deg



→ Smaller than the navigation-based system (by Sato et al.)
  - Translational error: 2.98 mm
  - Orientation error: 4.25 deg

Assessment

- Pros:
  - Shows how the camera-augmented C-arm (CAMC) is used in a procedure
  - Reduced error compared with previous works
- Cons:
  - A visual marker needs be placed on the surgical site
  - Patient assumed to be static
  - Do not involve tracking of the cup