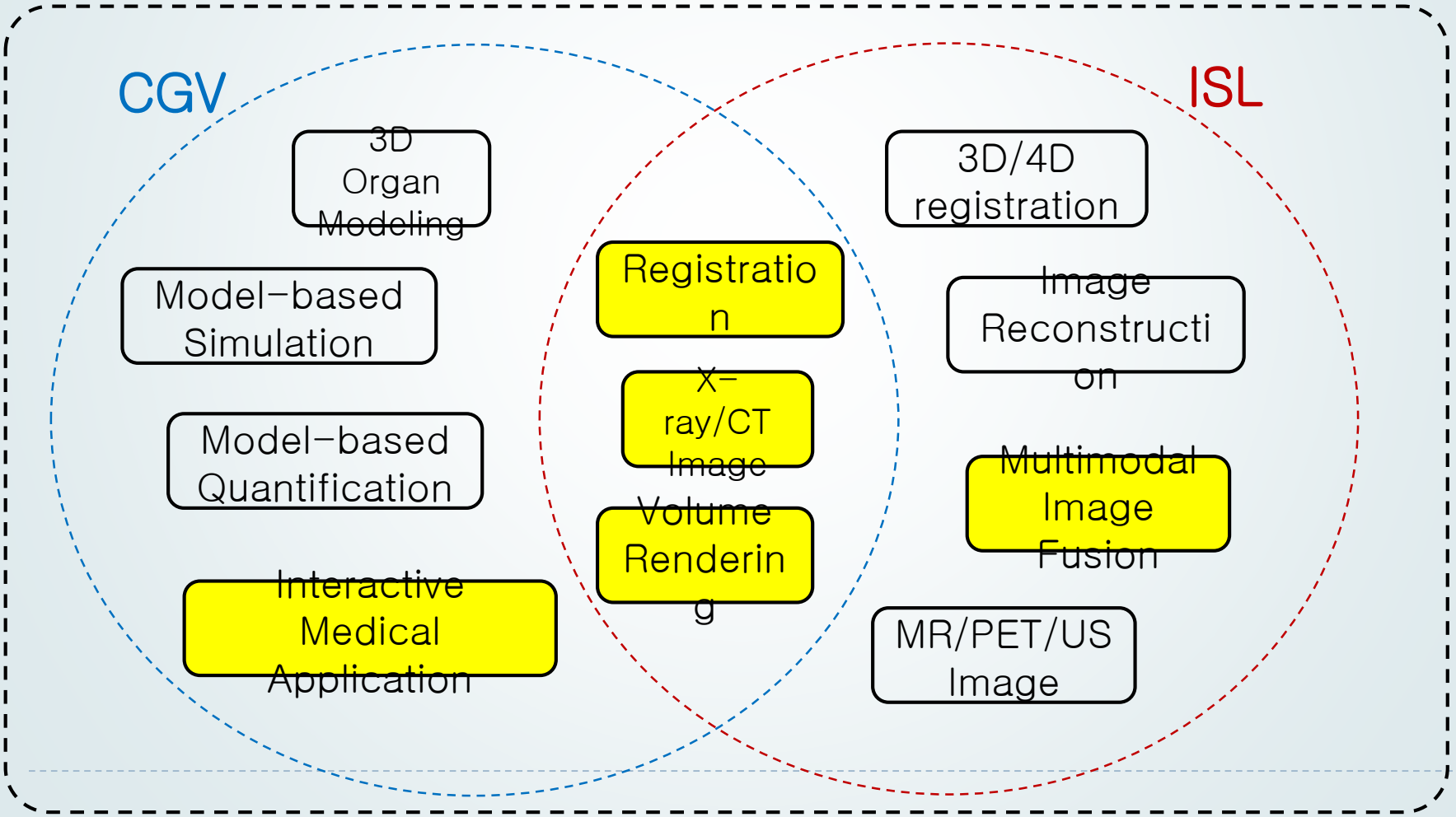
SIGMI Meeting
~Image Fusion~

Computer Graphics and Visualization Lab

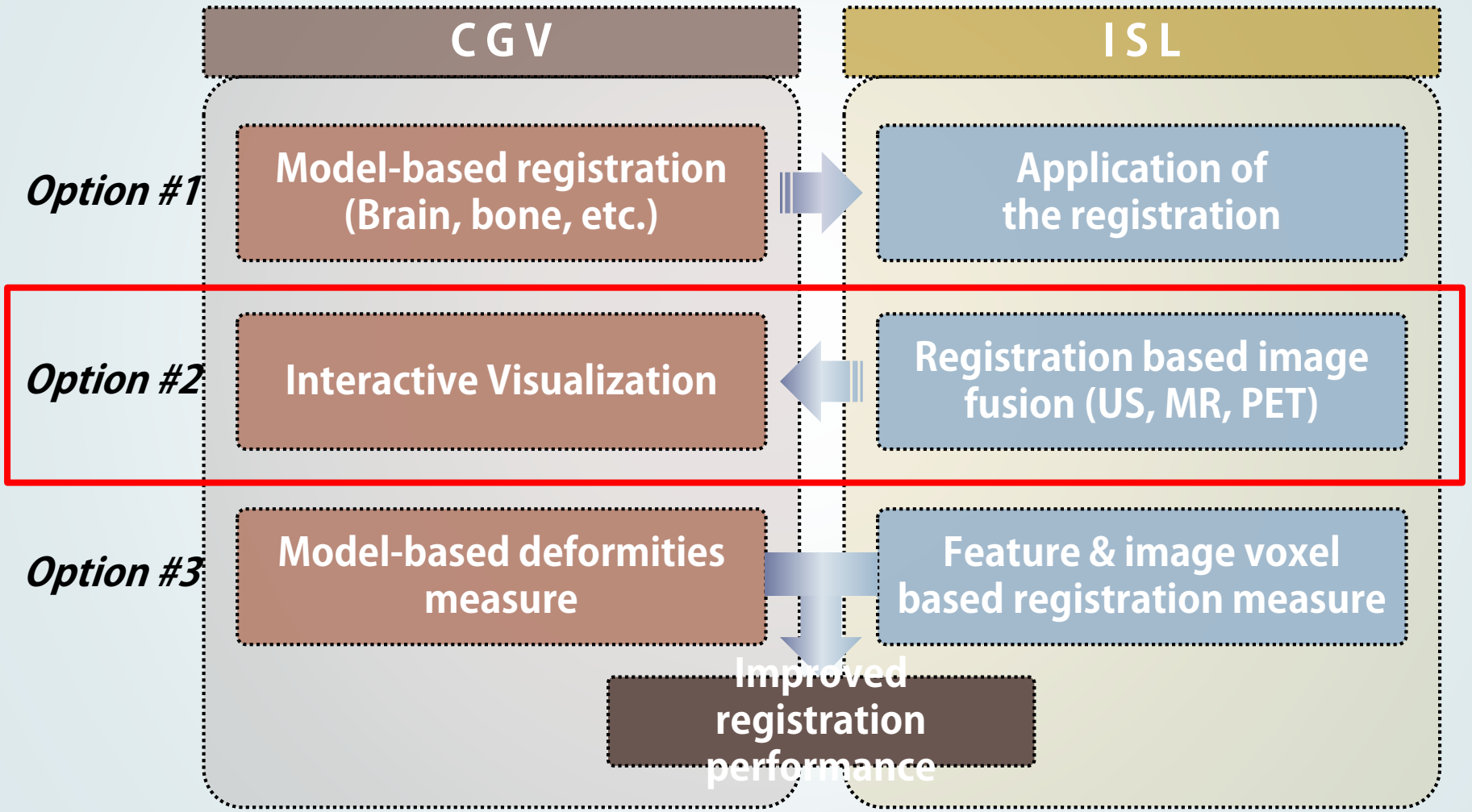
Image System Lab

Introduction

Medical Imaging and Application



Introduction



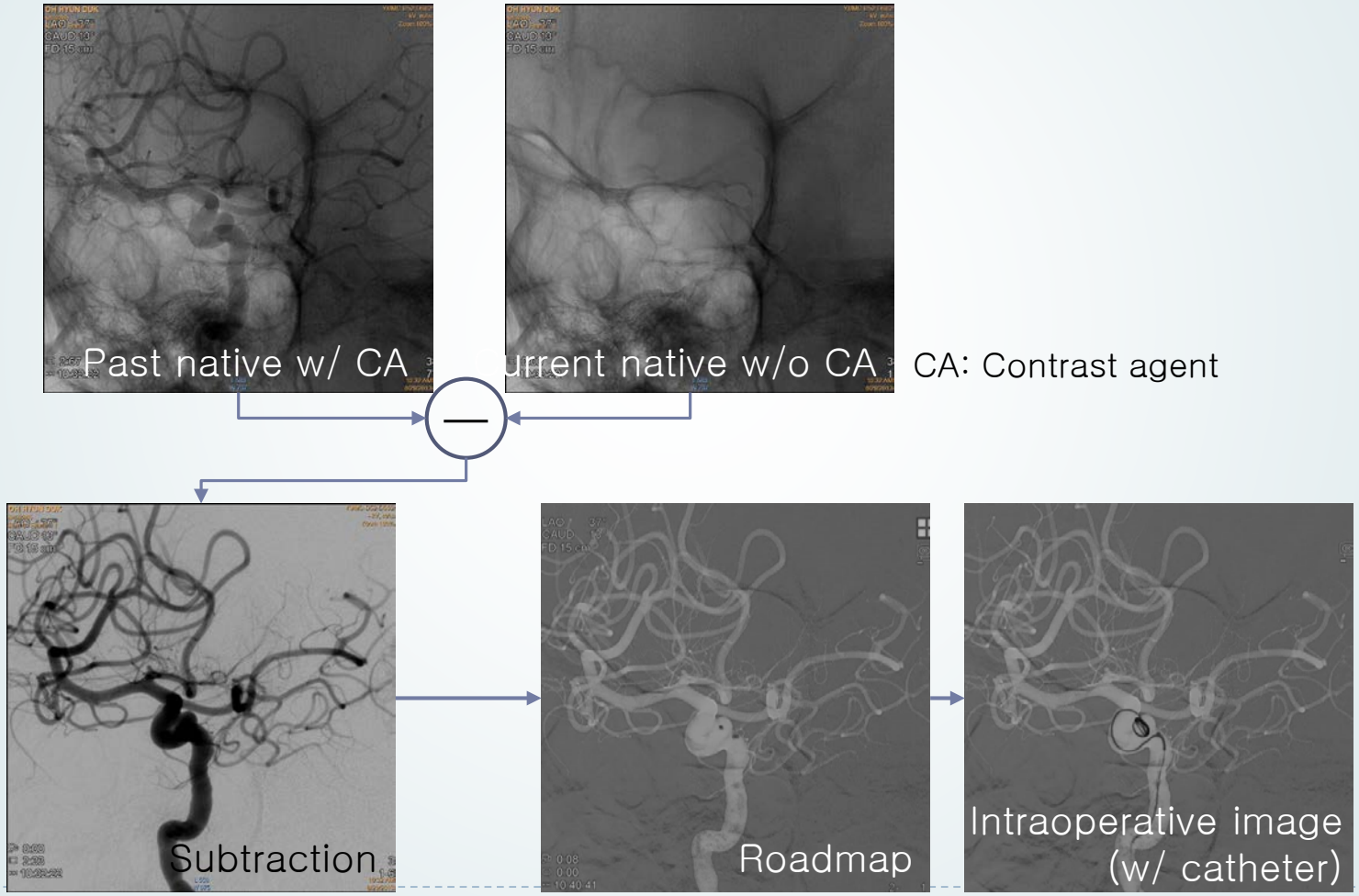
Cerebrovascular angiography

- Cerebrovascular angiography
  - A form of angiography which provides images of blood vessels in the brain for interventional procedure
- Example of cerebrovascular angiography

The source of the video: www. Google. com

Cerebrovascular angiography

- Cerebrovascular angiography with a 2D roadmap



Cerebrovascular angiography

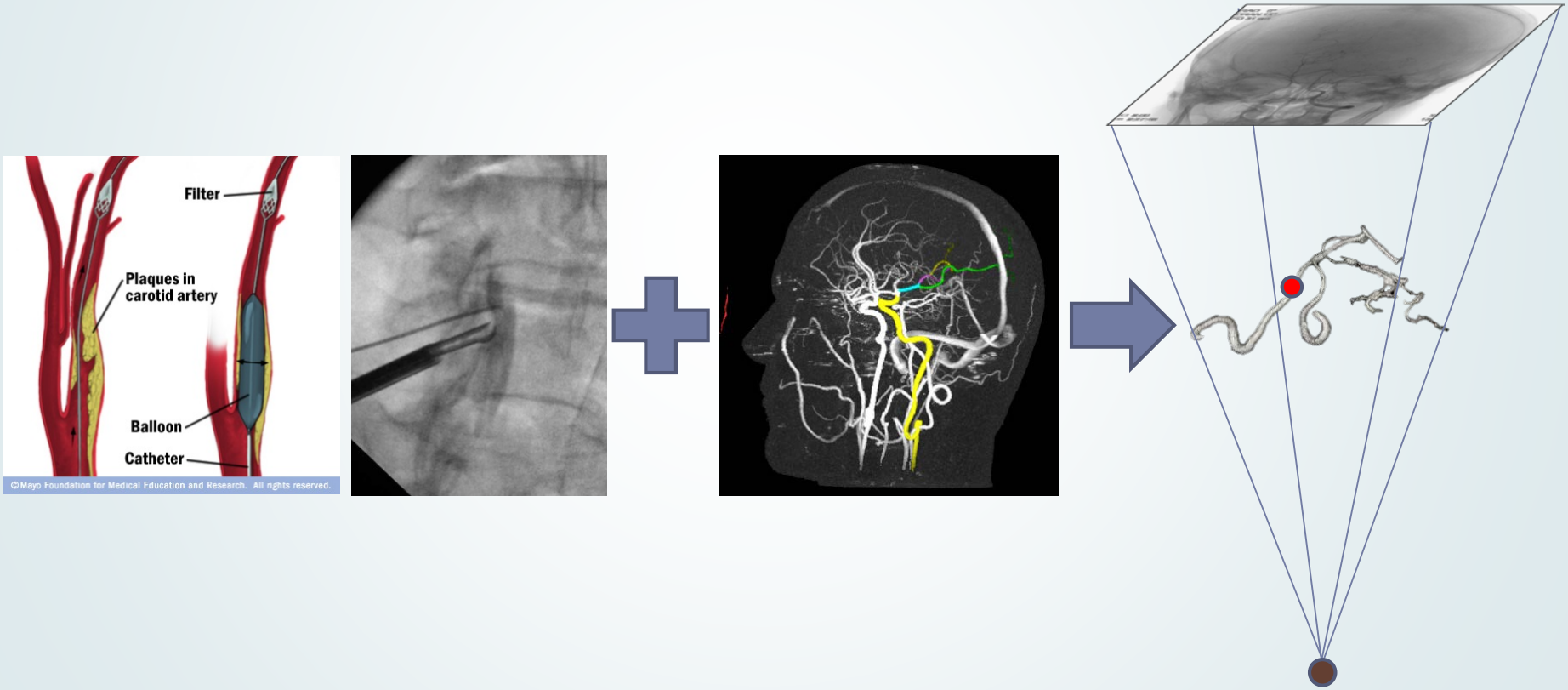
- Problem definition
  - Patient motion
    - Pre-generated roadmap may be unreliable when the target object is moving.
    - Need to re-generate the roadmap.
      - Re-inject the contrast agent.
      - Increase the procedure time (with exposure dose).
  - Catheter insertion in 3D environment
    - 2D roadmap may be hard to confirm exact location of a inserted catheter.
      - Need to current catheter location exactly in 3D environment.

Challenges

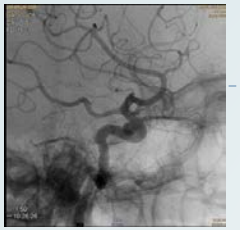
- Robust 3D roadmap generation with real-time catheter tracking for cerebrovascular angiography
  - Goal: Provide 3D roadmap for intervention based on real-time image registration and interactive visualization technique
  - Target data: Simulated X-ray, CT data from phantom
  - Synthetic data for experimental study
    - Simulate a 3D rigid phantom motion (translation and rotation)
    - Simulate catheter movement in 3D virtual environment

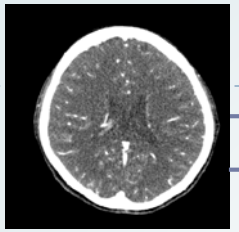
Challenges

- Robust 3D roadmap generation with real-time catheter tracking for cerebrovascular angiography



Overall flow





3D CT
w/ contrast enhanced vessels

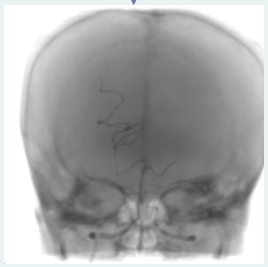
3D cerebrovascular extraction

Extracted
3D cerebrovascular

Diagnosis

Projection

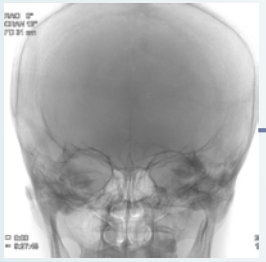
T



Projected CT

Cost measure for registration

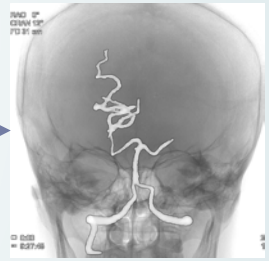
Rigid registration



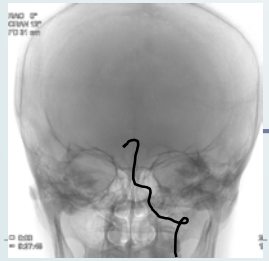
Real-time native
(with patient motion
& view change)

T_{rigid}

3D roadmap visualization



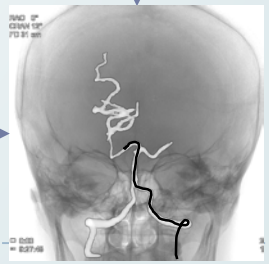
3D roadmap



Real-time native
with catheter

(3D) Catheter location estimation

3D roadmap visualization



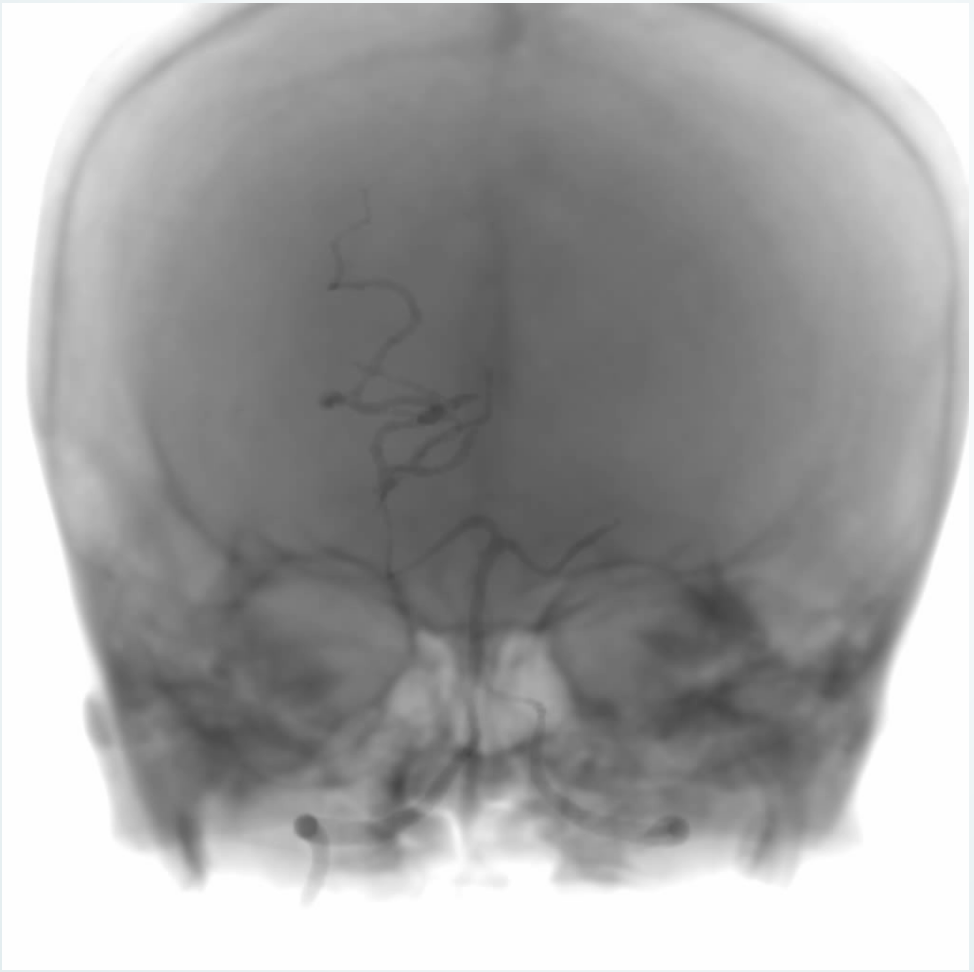
3D roadmap with catheter

Role of ISL

- Simulate a 3D phantom motion
  - Rigid motion (translation and rotation) generation similar to patient motion
- Cerebrovascular extraction from 3D CT
  - Semi-automatic segmentation method
- Registration between 2D fluoroscopy and 3D CT
  - Registration including a 3D to 2D projection process
  - Image-voxel based registration
    - Main feature: skull (low intensity and high gradient)

Role of ISL

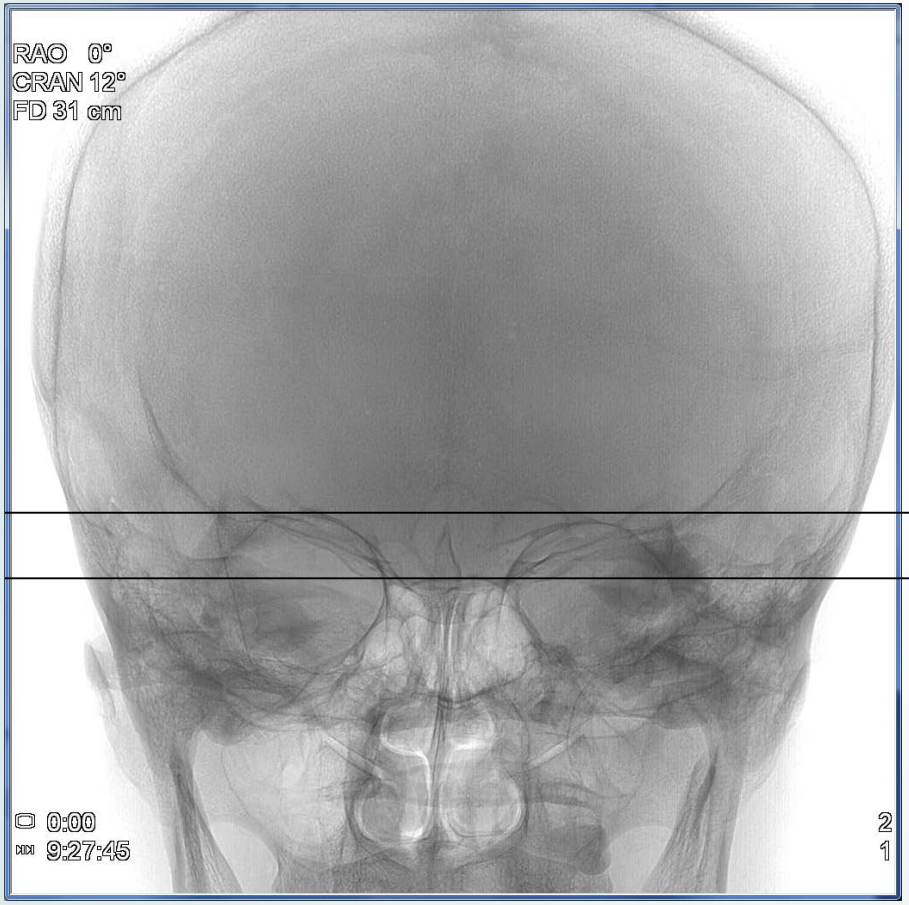
- An example of tracking to moving patient



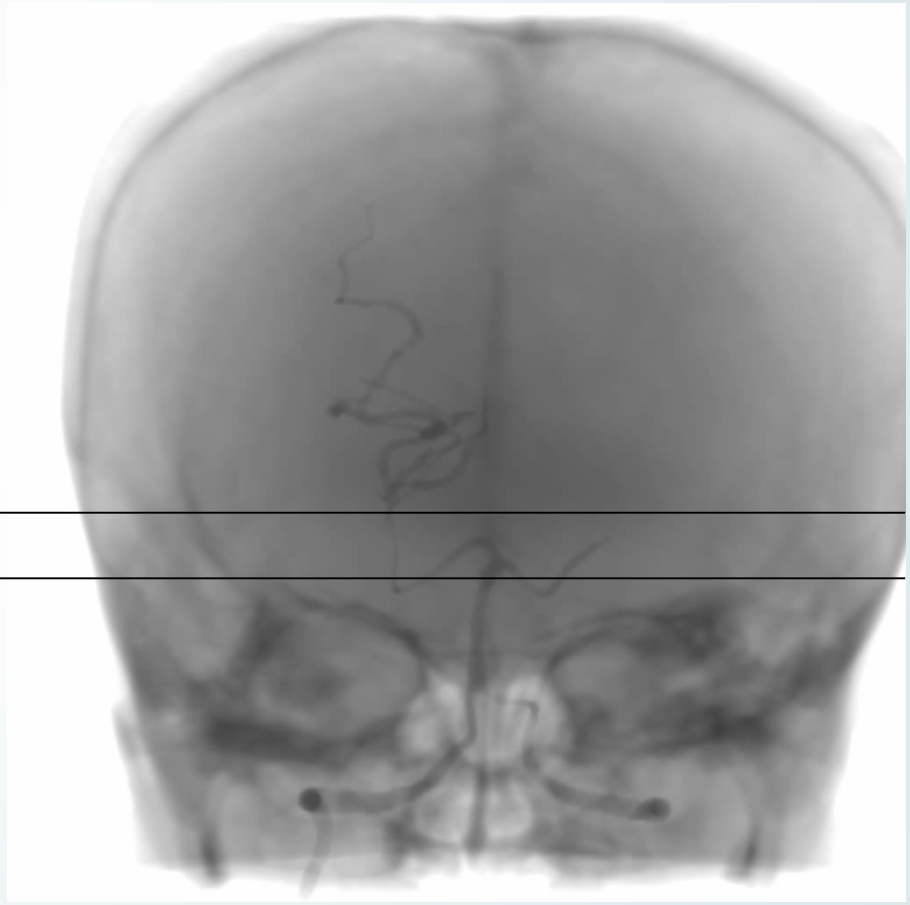
2D projected CT tracking the moving patient (panning)

Role of ISL

- Registration demonstration



Target image – 2D native



Source image – 2D projected CT

Role of ISL

- Image voxel-based registration
  - Maximize an voxel information (e.g. intensity and entropy) based similarity measure.
    - Sum of squared differences (SSD)

$$\sum_{(i,j)\in R}[A(i,j)-B(i,j)]^2$$

A: Target image

B: Source image

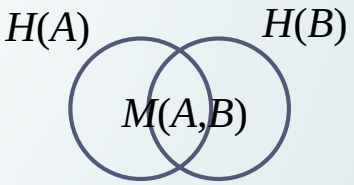
    - Normalized mutual information (NMI)
      - Measure based on the joint entropy

$$Y(A,B)=\frac{H(A)+H(B)}{H(A,B)}$$

$H(A)$, $H(B)$: Marginal entropy

$H(A,B)$: Joint entropy

$M(A,B)$: Mutual information



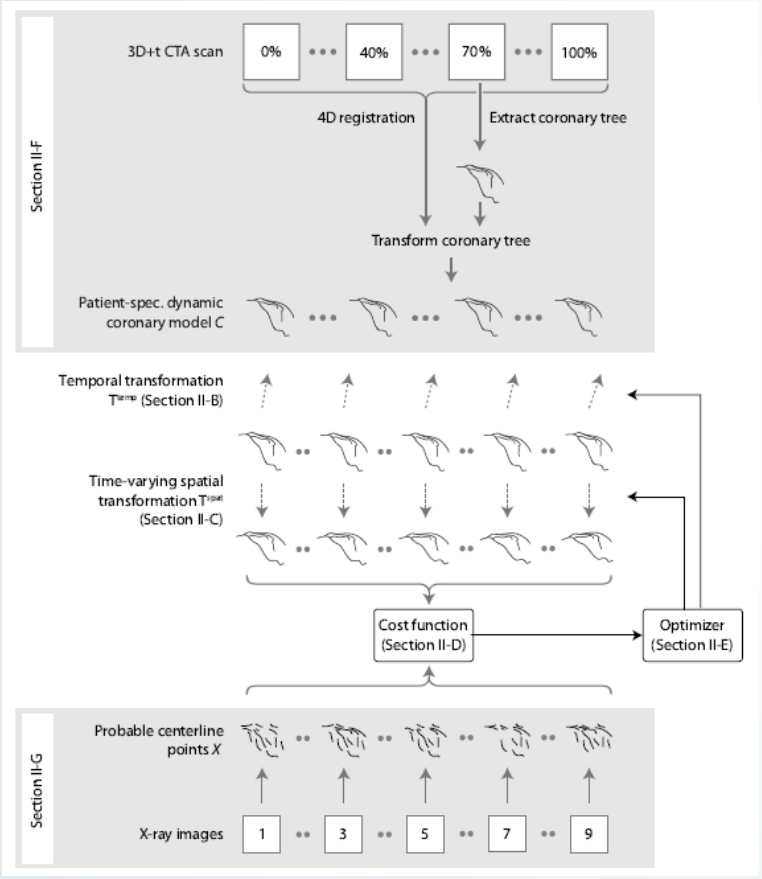
$$M(A,B)=H(A)+H(B)-H(A,B)$$

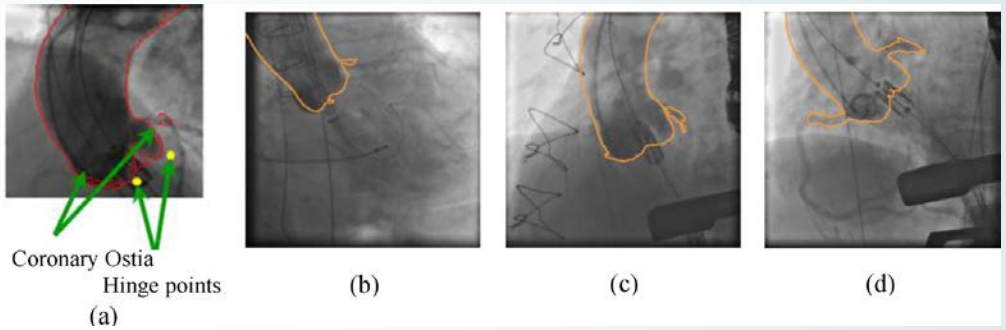
Y. S. Kim, J. H. Lee, and J. B. Ra, Pattern Recognition, vol. 41, issue 11, pp. 3356-3365, Nov. 2008.

J. H. Lee, Y. S. Kim, D. Lee, D. -G. Kang, and J. B. Ra, IEEE Signal Processing Letters, vol. 17, no. 4, pp. 347-350, Apr. 2010.

Role of ISL

- Related works





Coert T. Metz et al. , IEEE Transaction on Medical Imaging, vol. 32, issue 5, pp. 919-931, Feb. 2013.

Rui Liao et al. , Computerized Medical Imaging and Graphics, vol. 37, issue 2, pp. 150-161, Mar. 2013.

Jian Wang et al. , in IEEE NSS/MIC, Seoul, Korea, Nov. 2013.

Hua-mei et al. , IEEE Transaction on Medical Imaging, vol. 22, issue 9, pp. 1111-1119, Sep. 2003.

Jurgen Weese et al. , IEEE Transaction on information Technology in Biomedicine, vol. 1, issue 4, pp. 284-293, Dec. 1997.

Role of CGV

- Simulated catheter motion
  - Trajectory generation
  - → 3D position approximation

- Interactive visualization
  - Catheter visualization based on 3D roadmap model
  - Visual guidance related to catheter movement
  - Context-based view generation

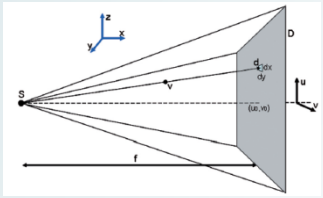
Catheter tracking techniques

- Catheter tracking
  - 3D roadmap
    - Generated from 3D rotational angiograp
  - Real-time registration
    - Between 2D fluoroscopy and 3D roadm
    - Static 3D roadmap

→ Overlay 3D road map to 2D fluoroscopy containing catheter motion

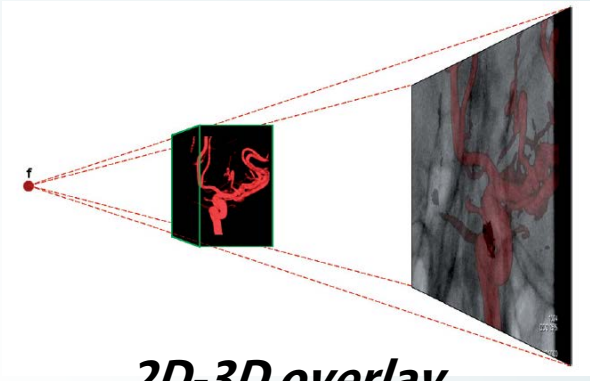
Multimodal angiographic assessment of cerebral arteriovenous malformations: a pilot study Neuroimaging, Jun 2015
3D roadmap in neuro-angiography: technique and clinical interest Neuroradiology, Oct 2005
Philips Healthcare - Imagens 3D RoadMap com (2009)

Catheter tracking techniques



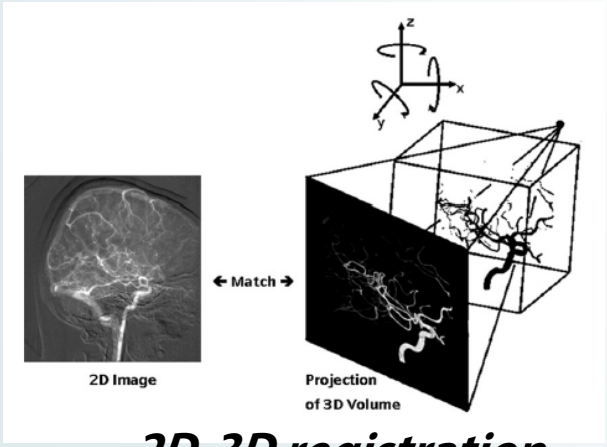
Pinhole camera model of C-arm

Projection geometry



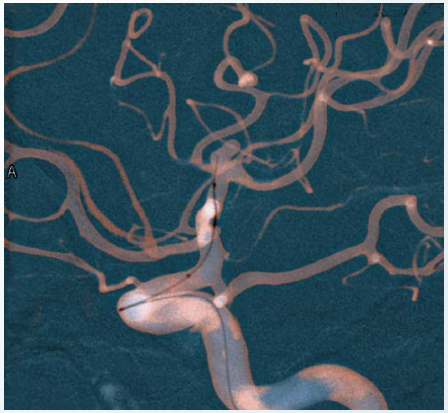
2D-3D overlay

Visualization



2D-3D registration

Registration result



3D roadmap result

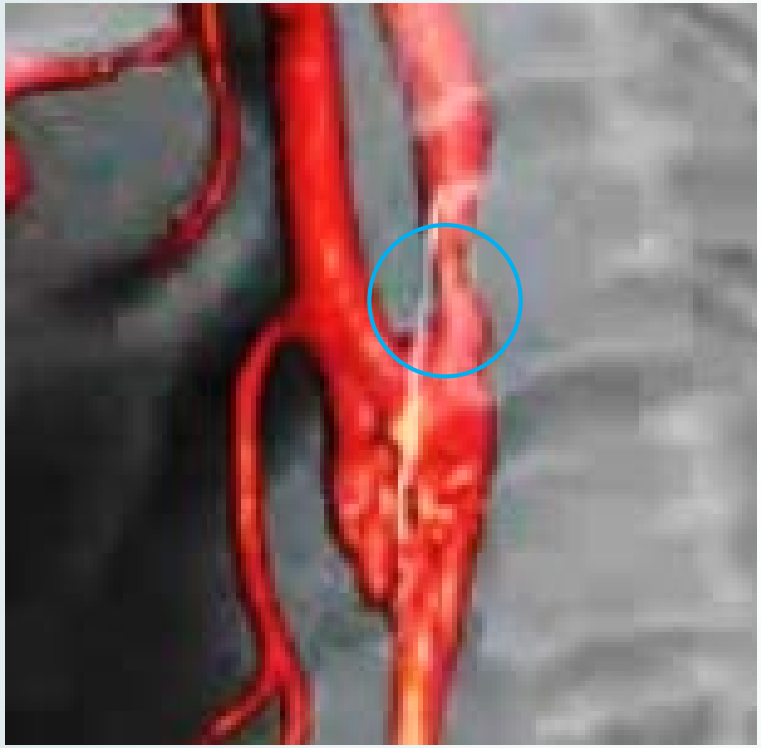
Toward True 3D Visualization of Active Catheters Using Compressed Sensing
Magnetic resonance in medicine, Jun 2009

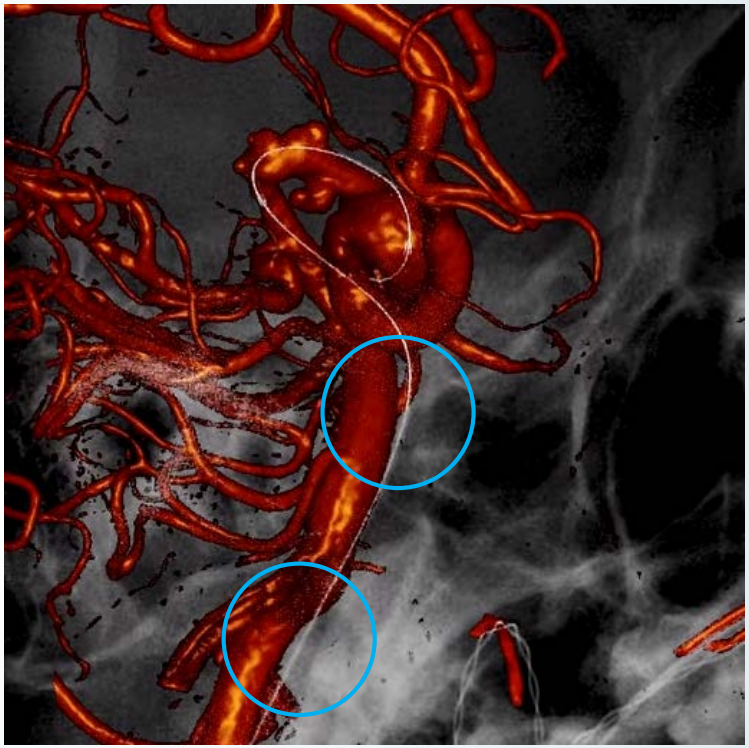
Issues in catheter tracking

- Objective
  - Provide robust visual information (roadmap) during the catheter operation
- Placement issue
  - Calculate true 3D position of catheter based on 2D position on fluoroscopy
- Visualization issue
  - Provide real-time visualization due to changes in fluoroscopy
  - Provide visual guidance during the catheter insertion process

Issues in catheter tracking

- Placement issue





Catheter getting out of provided 3D roadmap

- *Caused by registration*
- *Caused by solid model*

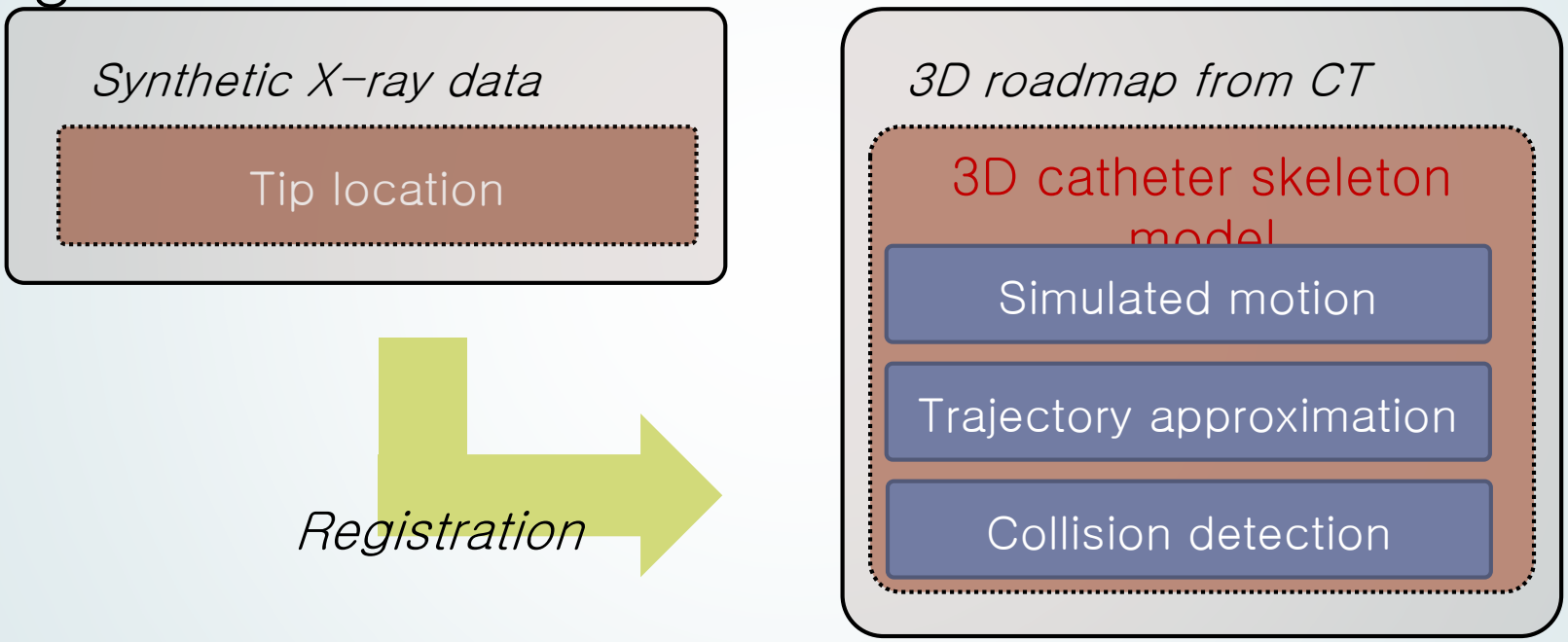
Issues in catheter tracking

- Visualization issue

Manual view modification due to occlusion problem

3D catheter visualization model

- Tip-information based 3D catheter motion generation



Provide virtual motion of catheter based on 3D roadmap and 2D posi

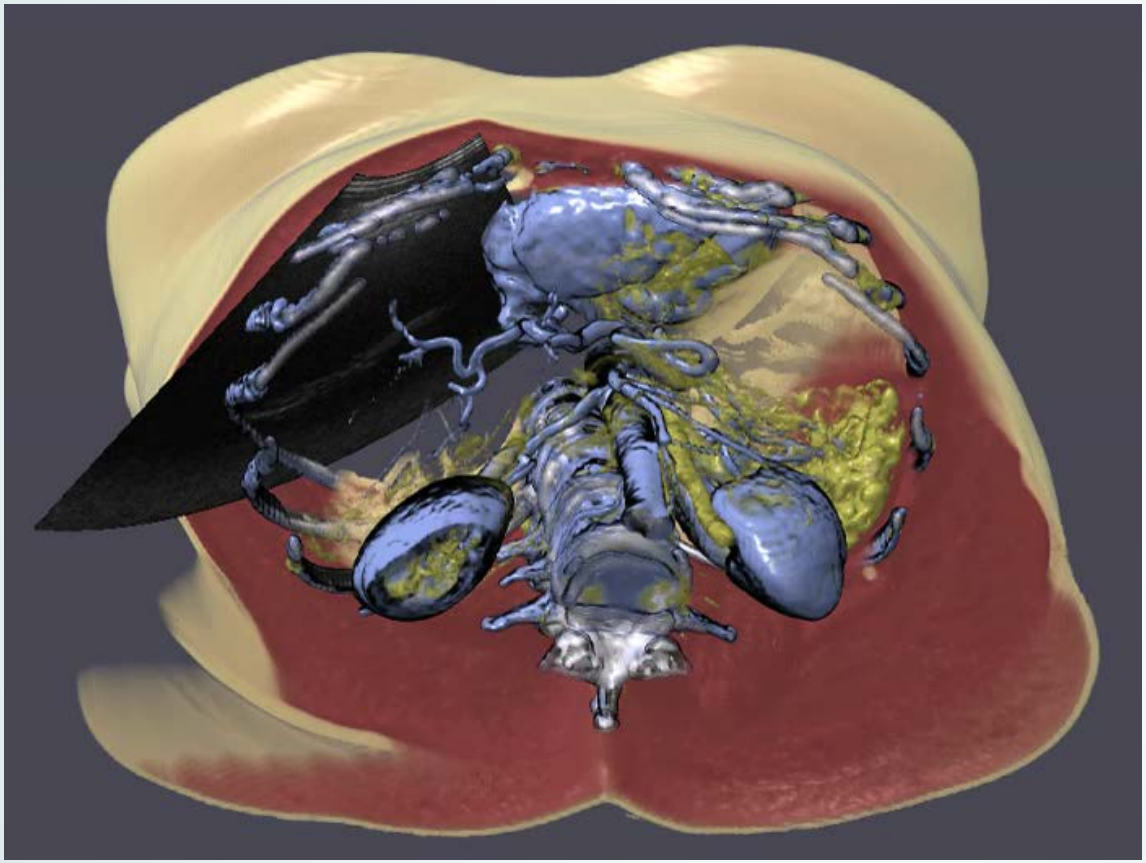
Comprehensive visualization

- Comprehensive medical visualization
  - Dense clinical data + real-time imaging
  - Utilize two or more types of medical data together

- Objectives
  - Provide **sufficient spatial perception** of the anatomy of interest
  - Maintain information from rich pre-operative scan
  - Provide additional information from the real-time image displayed embedded within the volume

Comprehensive visualization

- Related work



Feature Emphasis and Contextual Cutaways for Multimodal Medical Visualization
Eurographics / IEEE VGTC Symposium on Visualization 2007, May 2007

4D US
+
3D CT

Provide automatic ROI based on location of US image in unified virtual environment

Visualization in catheter tracking

- Context-based view generation
  - Based on situation during the simulated catheter motion
  - Avoid overlapped view
  - → To provide clear representation of the roadmap structure

- Informative visualization
  - Emphasize significant region/direction to provide visual guidance according to the catheter motion

Thank you ☺