Reconstruction of 3D Neurovascular Models

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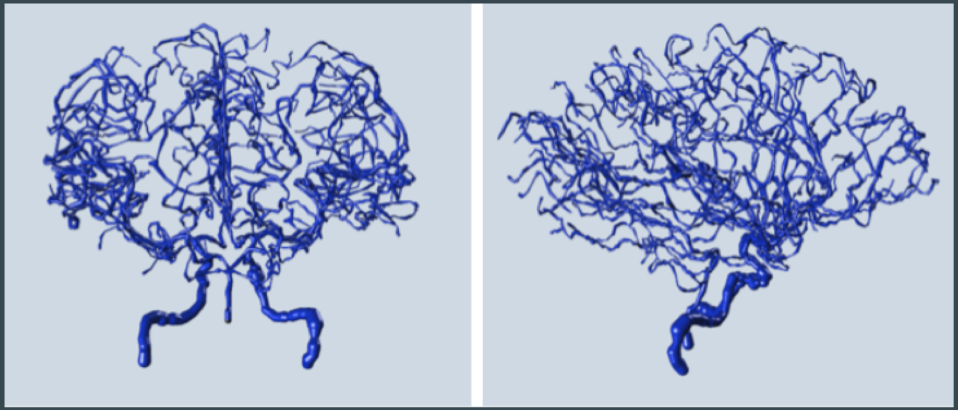
Introduction

- People always try to get a clearer view of the internal structure of the human body
- Brain vessels are more complex and difficult to reconstruct
- During surgery, X-Ray angiography is most efficient, but only 2D images
- How can we reconstruct 3D model of brain vessels with only 2D projections as input?

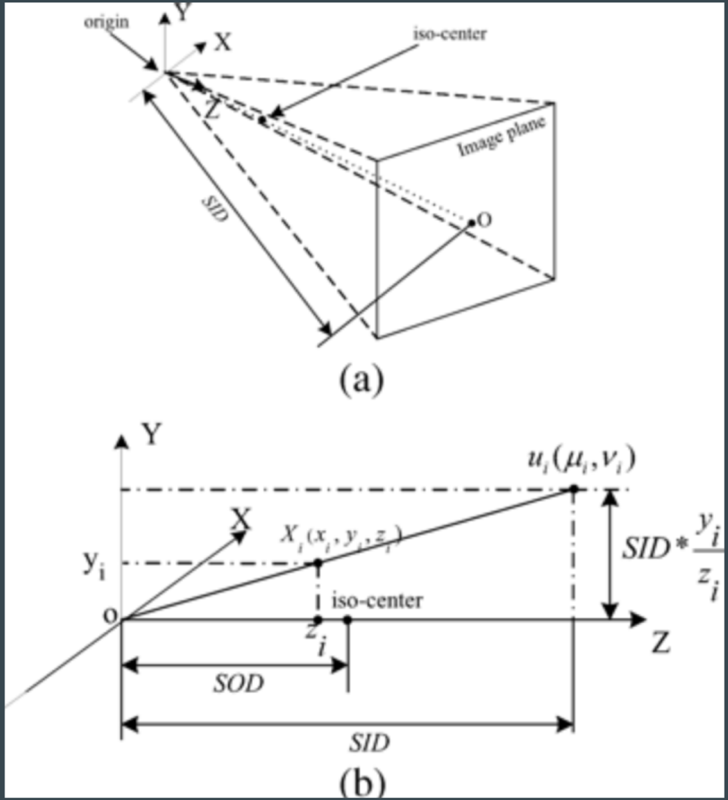
Goal

- Reconstruct 3D neurovascular model from only two input projections
- Input: two 2D projections of the model captured from different angles
- Output: 3D reconstructed model



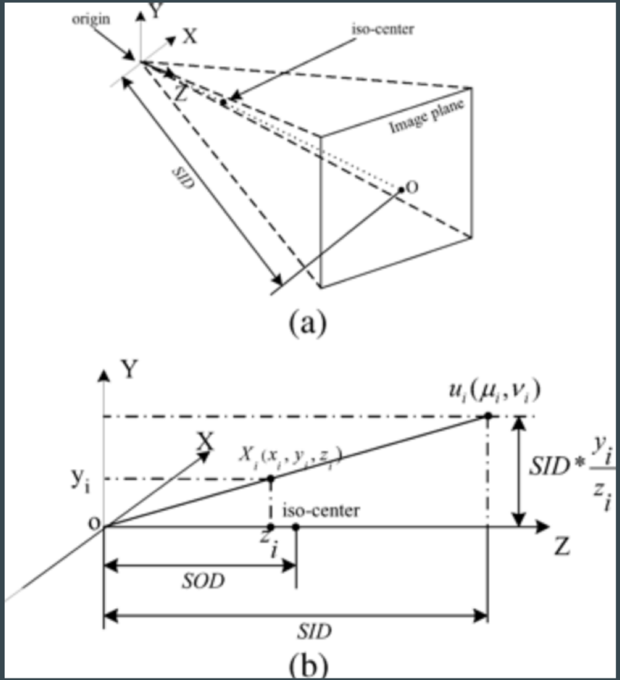
Single Plane Model

- High-energy electromagnetic radiation penetrate patient's body and an x-ray image is obtained in different shades of black and white due to the density and absorption differences
- In this model, a point in world space is projected to a two-dimension point on the image plane.



Single Plane Model

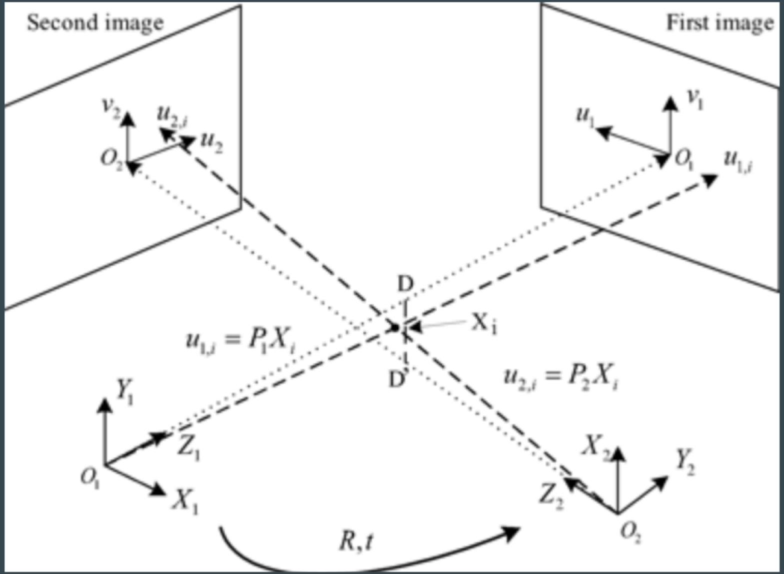
$$\begin{pmatrix} x_i \\ y_i \\ z_i \\ 1 \end{pmatrix} \mapsto \begin{pmatrix} \frac{SID}{\alpha_u} & s \cdot \frac{SID}{\alpha_v} & u_c & 0 \\ 0 & \frac{SID}{\alpha_v} & v_c & 0 \\ 0 & 0 & 1 & 0 \end{pmatrix} \begin{pmatrix} x_i \\ y_i \\ z_i \\ 1 \end{pmatrix} = PX_i \tag{2}$$



- SID: Source to image intensifier distance
- (uc, vc): Projected coordinate
- αu, αv: Image width and height pixels
- s: skew parameter

Biplane Model

- Biplane reconstruction involves a transformation of camera position which changes the projection matrix, slightly different from single plane model



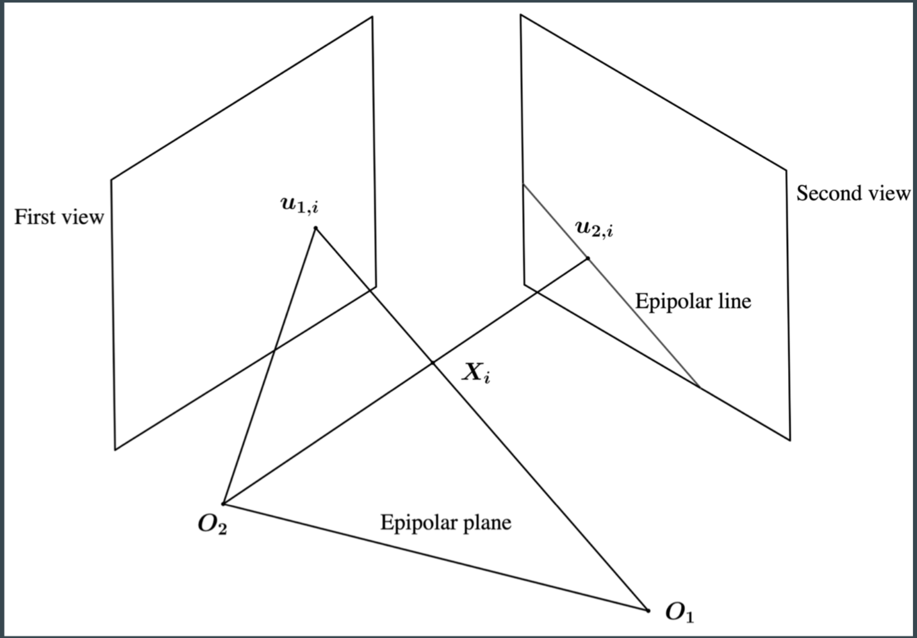
$$\begin{pmatrix} \mu_1 p_1^{3T} - p_1^{1T} \\ \nu_1 p_1^{3T} - p_1^{2T} \\ \mu_2 p_2^{3T} - p_2^{1T} \\ \nu_2 p_2^{3T} - p_2^{2T} \end{pmatrix} X = 0$$

p_i^{jT} is the jth row of the projection matrix P_i

Epipolar Constraint

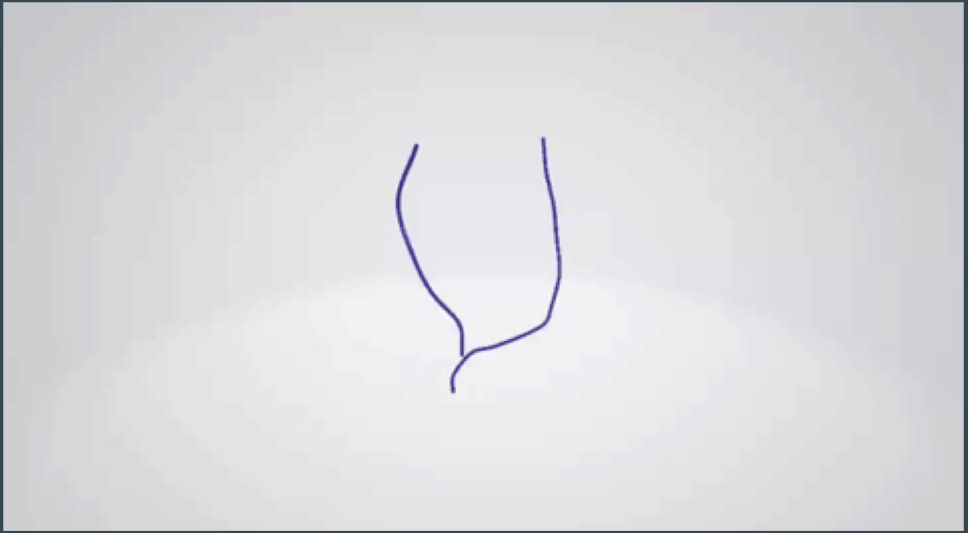
- Epipolar constraint is the restriction relationship between the epipolar plane and the epipolar line, assuming corresponding features are projections from the same three-dimension point

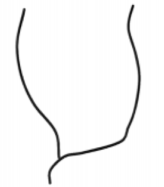
$$(\overrightarrow{O_1 u_{1,i}} \times \overrightarrow{O_1 O_2}) \cdot \overrightarrow{O_2 u_{2,i}} = 0$$



Result on Simple Model

Original model and Input images



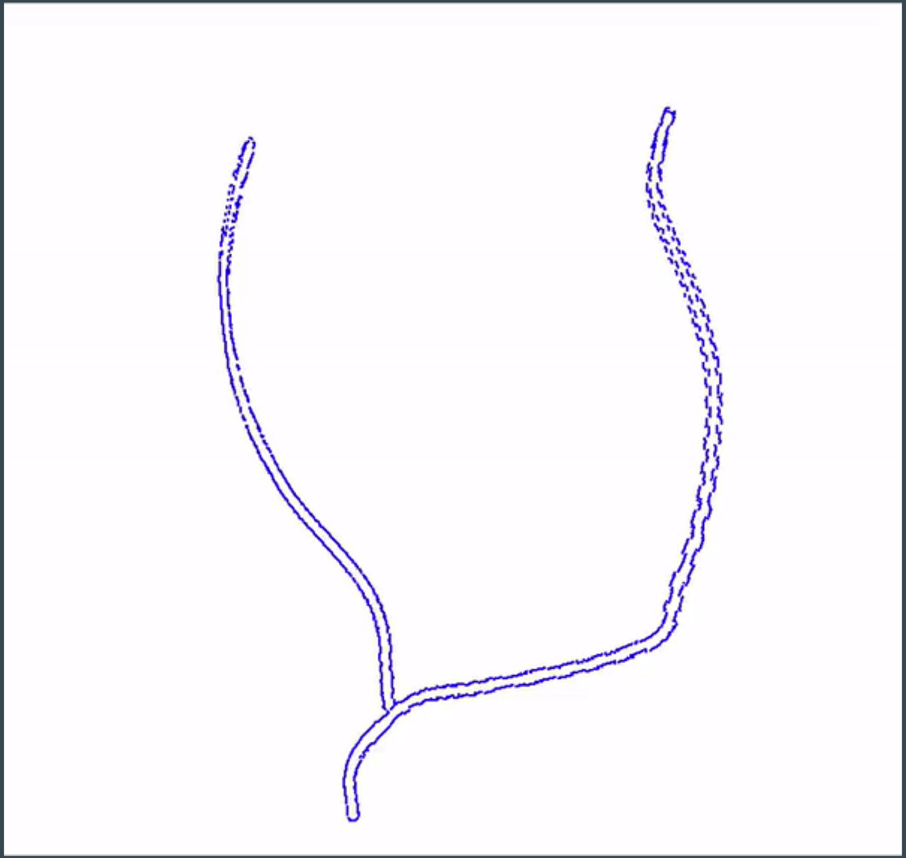


(a) Input1

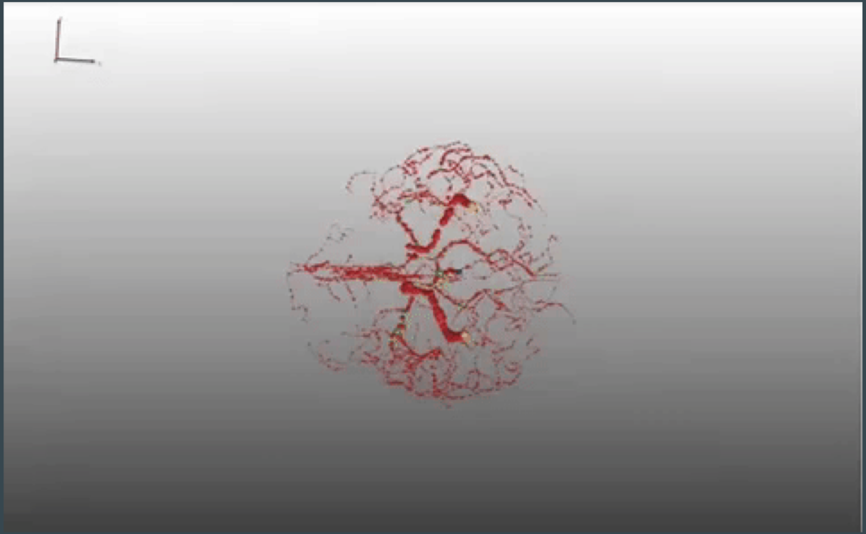
(b) Input 2

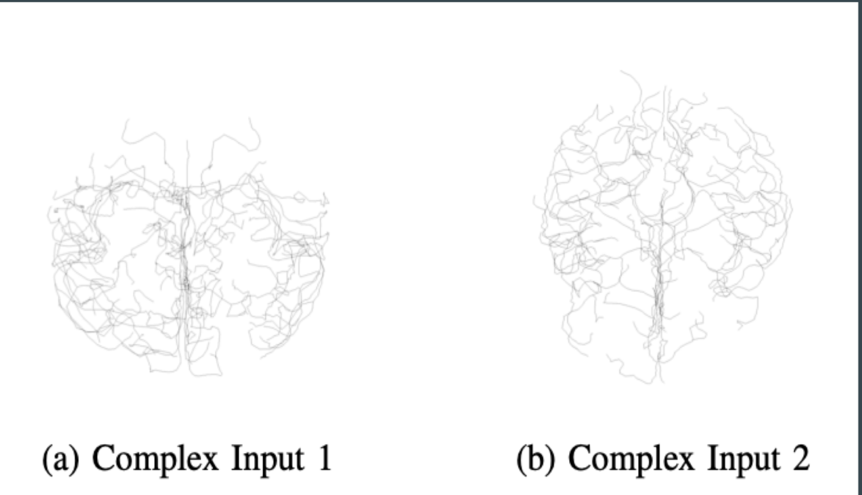
Result on Simple Model

Reconstructed model



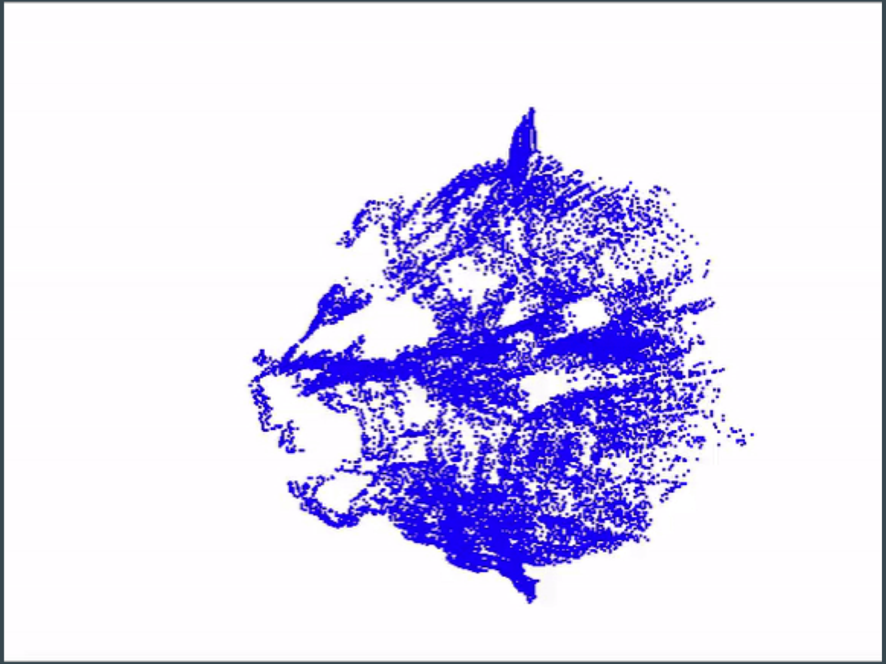
Result on Complex Model





Result on Complex Model

Reconstructed model



Discussion

- Problems of this method
  - Only two input images
  - Cannot eliminate many noises, not enough input to verify
  - Manually calibrate input images’ parameters instead of using DICOM files
  - Inevitable errors from semi-automatic calibration
- Future Work
  - Can apply post-processing techniques to enhance results/remove noises
  - Optimization algorithms such as Levenberg-Marquardt Algorithm
  - Frangi filter

Conclusion

- Reconstructs 3D model from two view planes
- Utilizes stereo image reconstruction techniques(Biplane model + Epipolar constraint)
- Results can still be improved by post-processing techniques
- Promising performance

References

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Thank you !