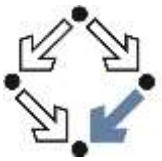


Neurosurgical Simulator for Patient-Specific Cerebral Aneurysm Clipping with Haptic Feedback

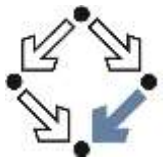
W. Fenz, J. Dirnberger, A. Olschowski, M. Gmeiner, J. Trenkler
Research Unit Medical-Informatics, RISC Software GmbH
Softwarepark 35, 4232 Hagenberg, Austria





Research Project

- Research Project „Virtual Aneurysm“
- January 2013 – July 2015
- Funded by Austrian Research Promotion Agency (FFG) in the BRIDGE Framework
- Partners:
 - RISC Software GmbH (Research Partner)
 - AESCULAP AG (Industrial Partner)
 - Landesnervenklinik Wagner Jauregg Linz (Medical Partner)
 - AKH Linz (Medical Partner)



RISC Software GmbH

Ownership

- 80% Johannes Kepler University Linz
- 20% Land OÖ (UAR GmbH)



RISC Software GmbH

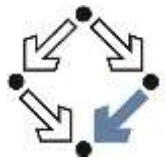
- **Software Development**
- **Applied Research (Algorithmic Mathematics)**
- Technology Transfer
- 50 Employees



RISC Institut

- **Frontier Research in Symbolic Computation**
- Head: Prof. Peter Paule
- Founder (1987): Prof. Bruno Buchberger
- 60 Members (including PhD Students)

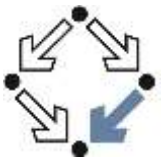




Simulation Setup

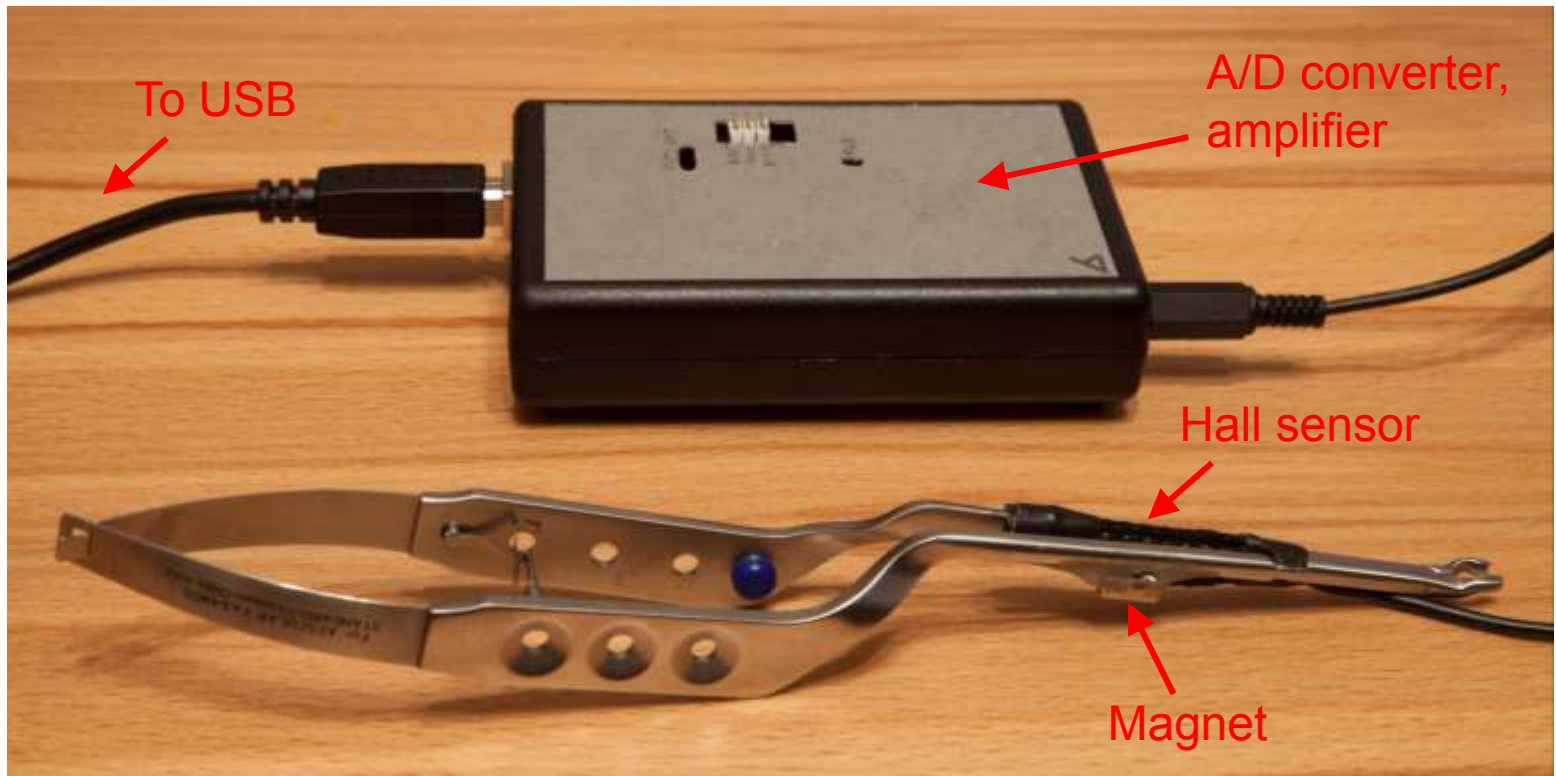
- PC + 2 Haptic Input Devices
 - Mounted Aesculap Clip Applier
 - Realtime Angle Measurement
- Standard Consumer Hardware (Low Investment)
- Optional:
 - Stereoscopic Display (3D SBS, Nvidia 3Dvision)
 - VR Head-Mounted Device (Oculus Rift)

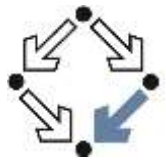




Simulation Setup

- Real forceps equipped with Hall sensor + magnet measuring the opening angle with A/D converter



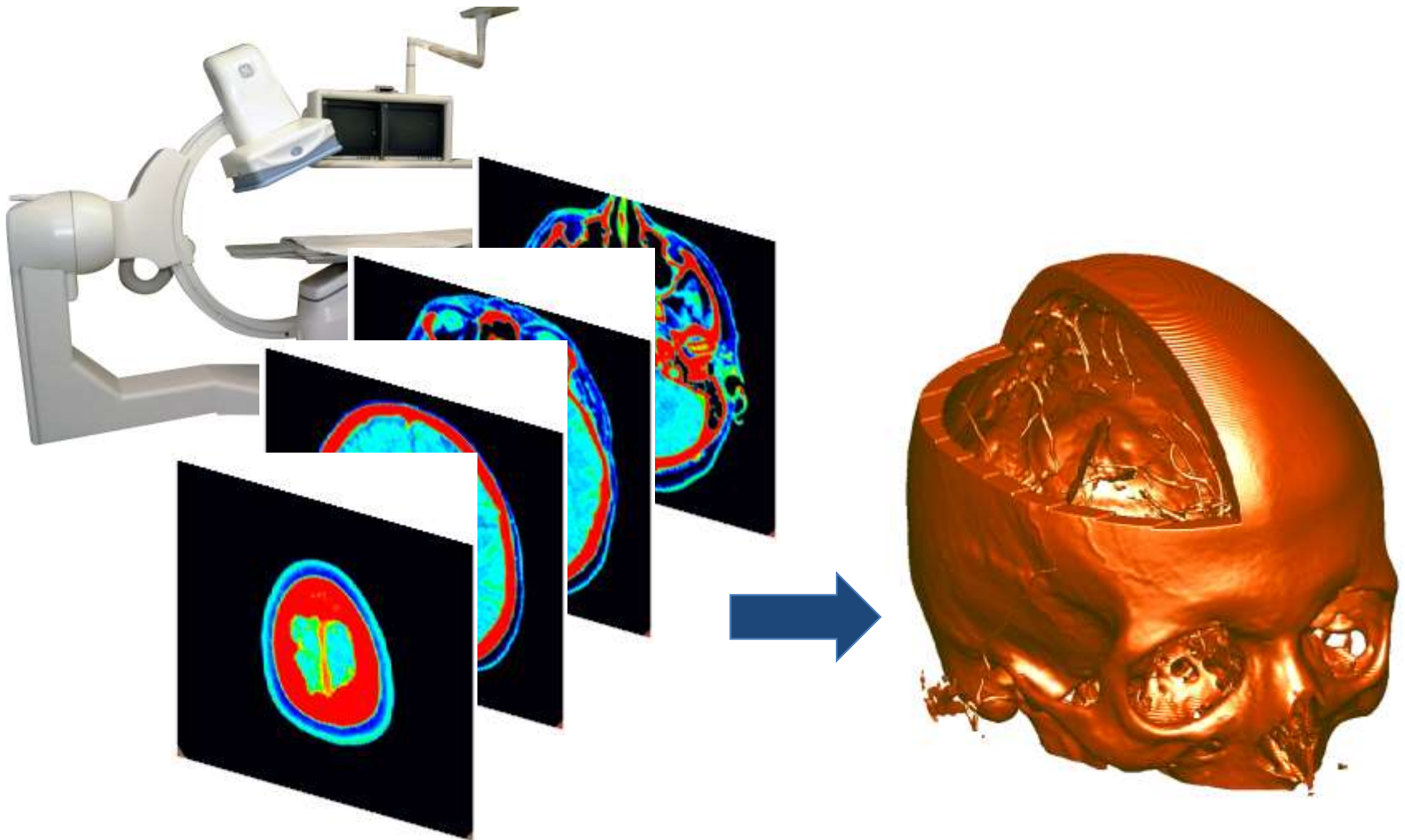


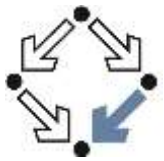
Acquisition of Patient-Specific Scenarios

3D Reconstruction of Volume Data using MEDVIS 3D

RISC Software GmbH

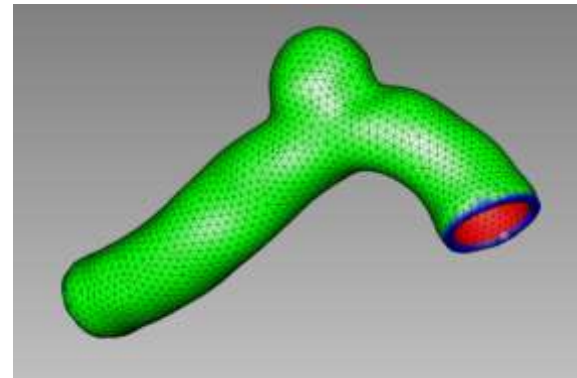
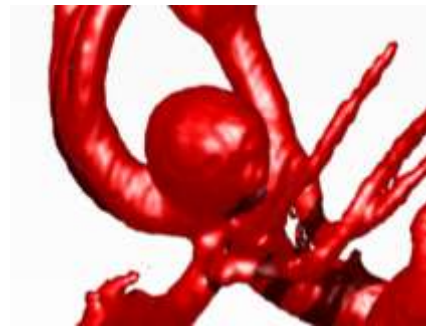
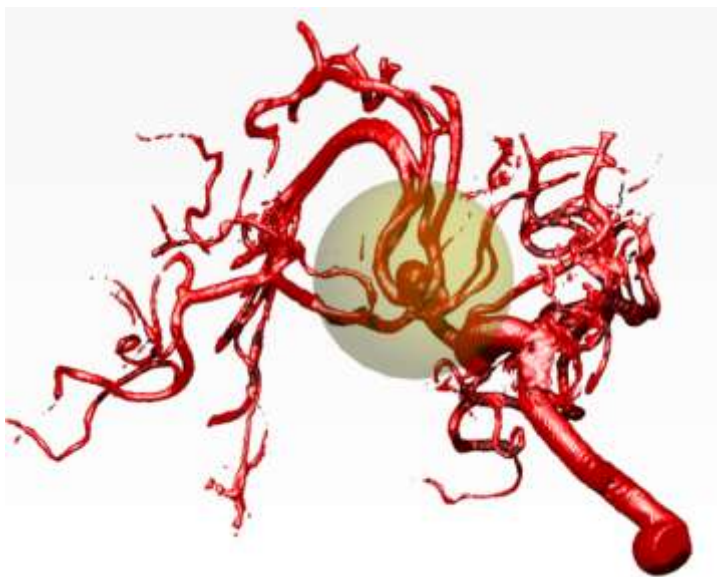
JOHANNES KEPLER
UNIVERSITY LINZ | JKU

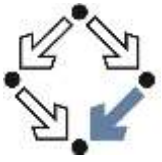




Acquisition of Patient-Specific Scenarios

Segmentation of aneurysm structure and modelling of simulation mesh using MEDVIS 3D Software (www.medvis3d.at)

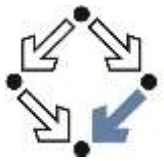




Models & Animations for Instruments + Clips

- Models courtesy of Aesculap AG





Clip Library

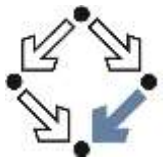
- Clips of current catalogue have been modeled manually with 3D animation software

Item No.		Main length mm	Maximum opening mm	Closing force N (1-3) (4)
FT764T		8.0	6.5	1.77 180
FT784T		10.3	7.4	1.96 200
FT823T		7.4	5.4	1.77 180
FT824T		8.4	5.8	1.77 180
FT825T		10.5	6.2	1.77 180
FT770T	 <small>height of step 2.0 mm</small>	5.0	8.0	1.96 200
FT771T	 <small>height of step 2.0 mm</small>	8.0	8.0	1.96 200
FT772T	 <small>height of step 4.0 mm</small>	5.0	8.0	1.96 200
FT748T		7.0	7.9	1.96 200
FT758T		9.0	8.7	1.96 200
FT759T		12.0	10.2	1.96 200
FT603T		6.1	6.5	1.96 200
FT613T		8.0	6.2	1.96 200

Item No.		Main length mm	Maximum opening mm	Closing force N (1-3) (4)
FT810T		9.0	6.5	1.96 200
FT623T		10.6	7.8	1.96 200
FT763T		11.8	8.4	1.67 170
FT819T		5.0	5.0	1.96 200
FT820T		7.0	4.5	1.96 200
FT822T		10.0	5.0	1.96 200
FT850T		6.7	5.4	1.96 200
FT851T		9.0	5.6	1.96 200
FT830T		7.0	7.2	1.96 200
FT832T		9.3	7.2	1.96 200
FT833T		11.3	8.2	1.96 200

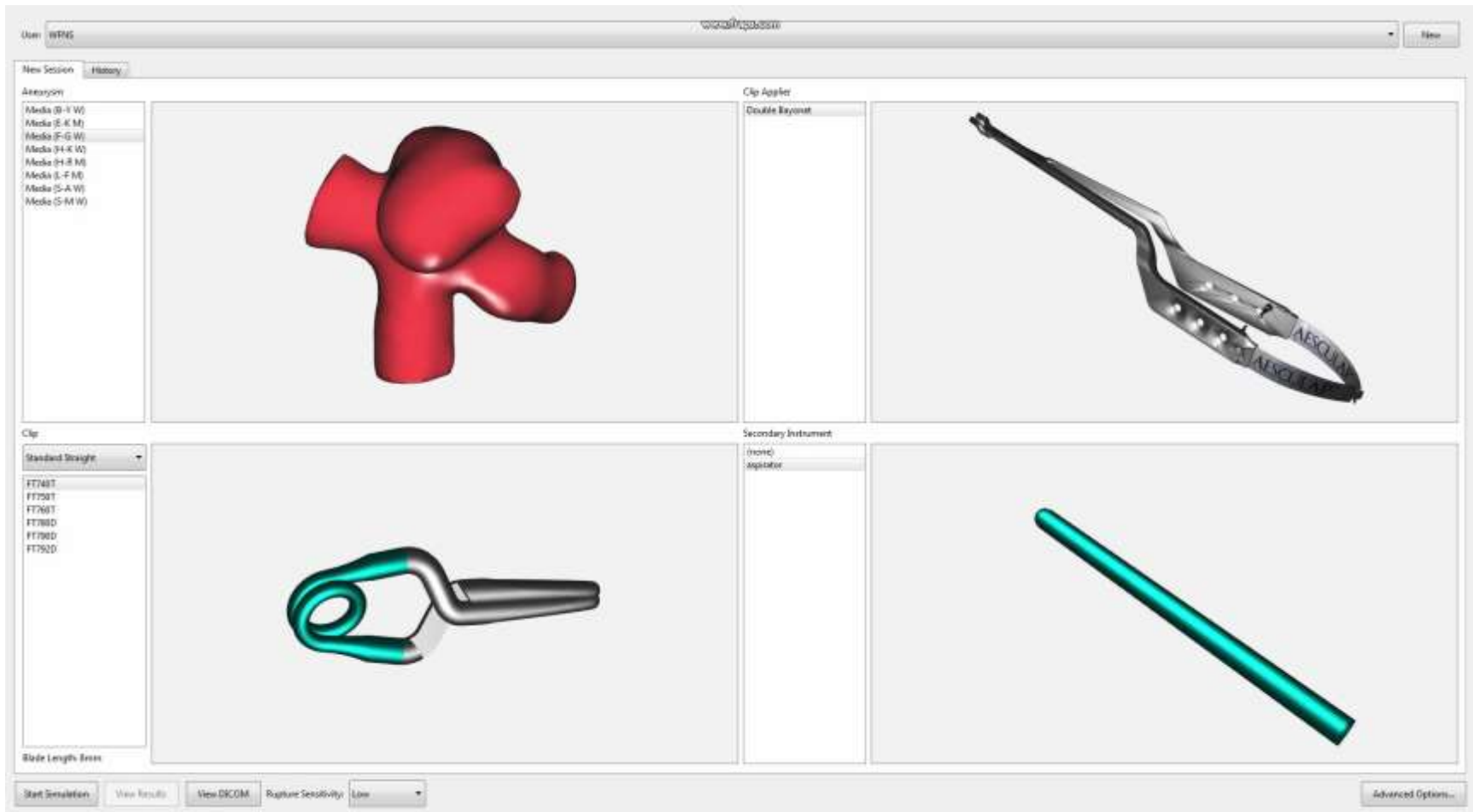
Item No.		Main length mm	Maximum opening mm	Closing force N (1-3) (4)	Diameter of fenestration 3.0 mm
FT637T		3/5.8	7.4	1.47 150	
FT638T		4/10.8	7.4	1.47 150	
FT639T		5/11.8	7.4	1.47 150	
FT640T		6/12.7	7.8	1.47 150	
FT650T		9/13.7	9.1	1.47 150	
FT642T		3/5.4	6.5	1.47 130	
FT662T		7.5/10.6	7.2	1.47 130	
FT662T		10/12.2	7.8	1.77 180	
FT644T		5/6.7	5.5	1.47 130	
FT654T		7.5/8.7	5.5	1.47 130	

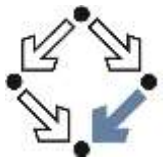
Item No.		Main length mm	Angle	Maximum opening mm	Closing force N (1-3) (4)	Diameter of fenestration 5 mm
FT652T		5.0	45°	5.5	1.47 130	
FT653T		8.0	45°	5.5	1.47 130	
FT654T		5.0	90°	5.5	1.47 130	
FT655T		8.0	90°	5.5	1.47 130	
FT656T		13.0	90°	5.5	1.37 130	
FT664T		9.0	90°	5.5	1.47 130	
FT665T		13.0	90°	5.5	1.37 130	



Virtual Aneurysm – Walkthrough

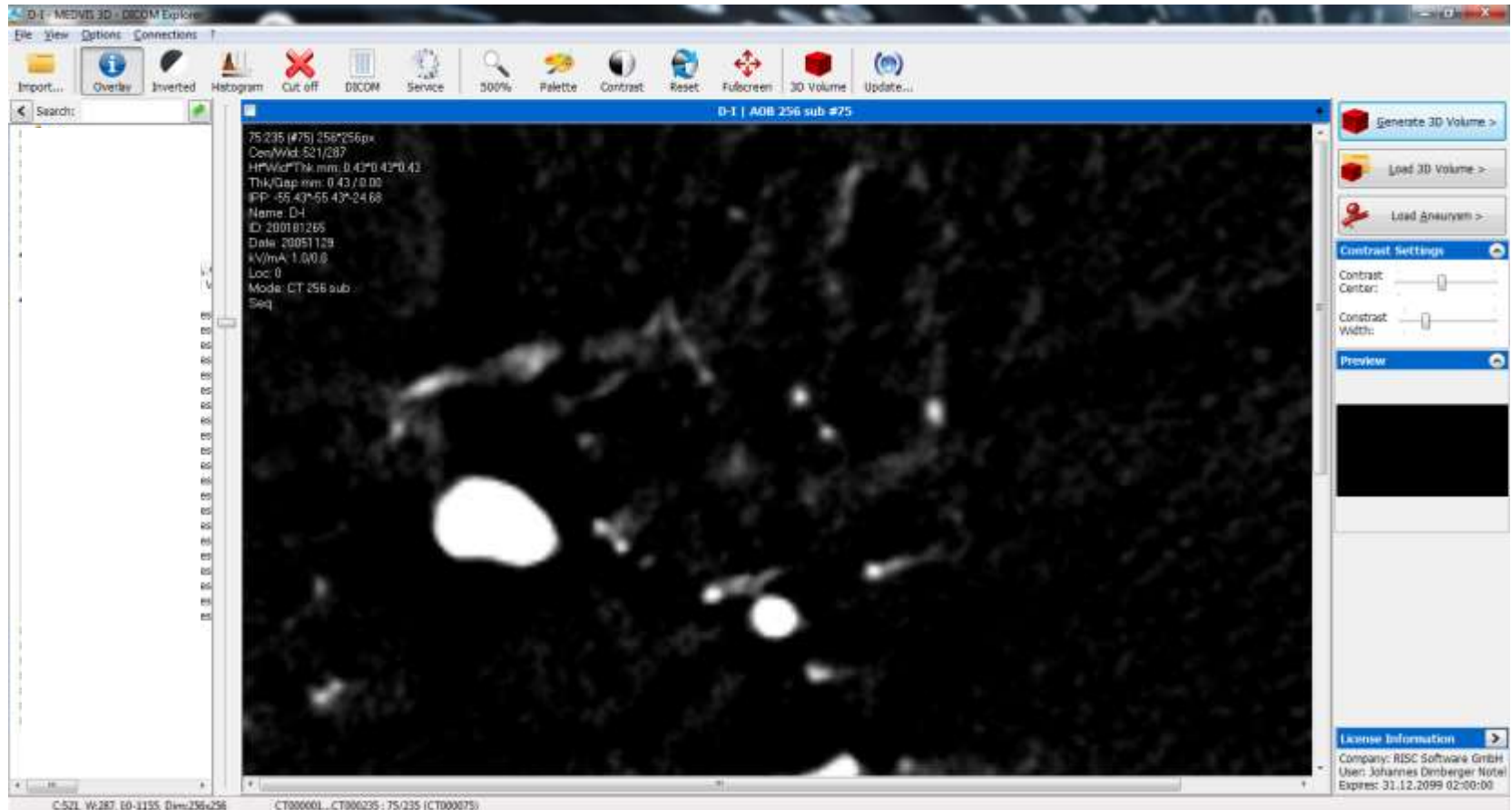
- 1. Selection of Training Scenario and Instruments

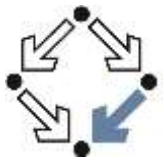




Virtual Aneurysm – Walkthrough

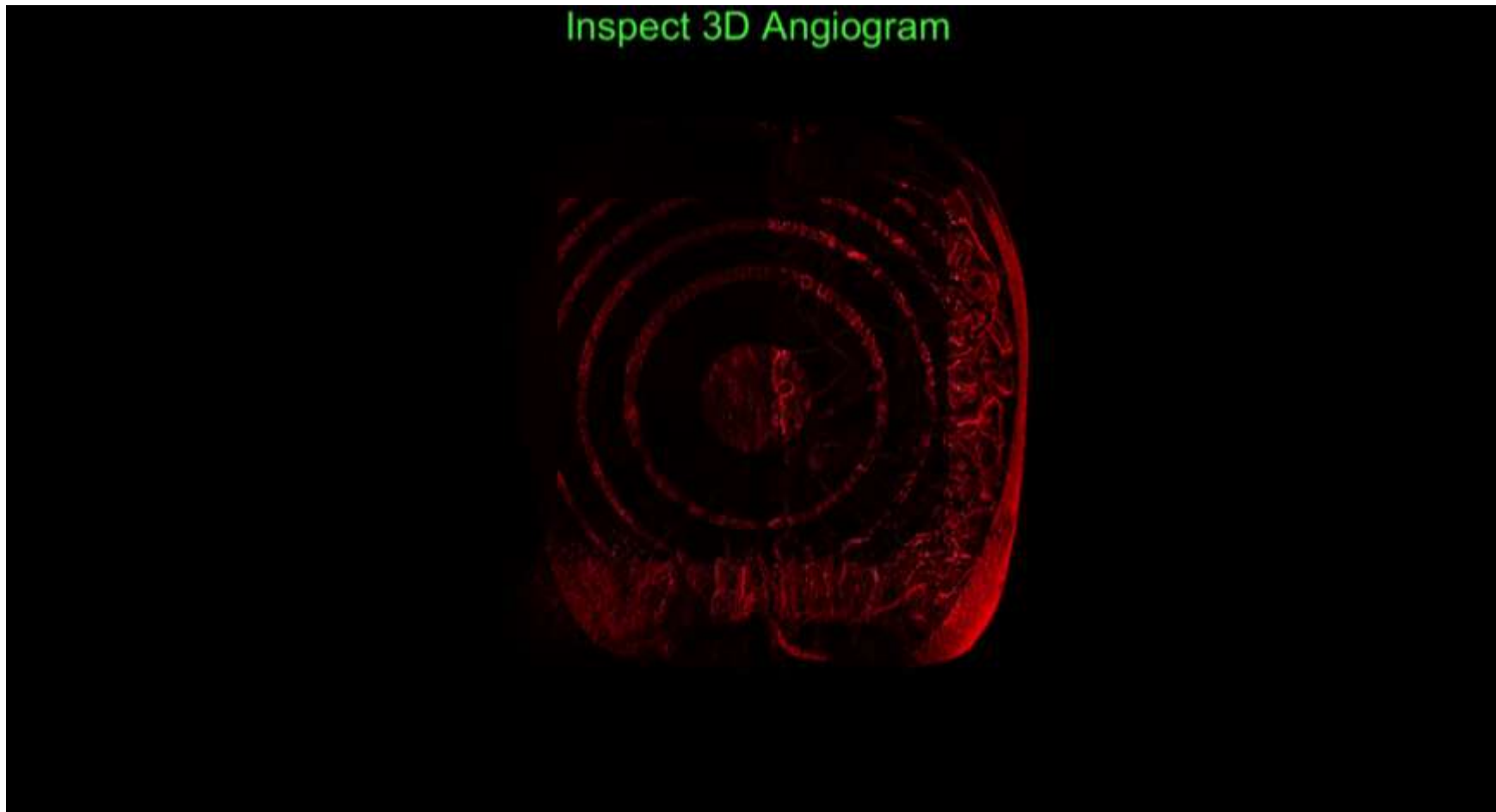
- 2. View 2D DICOM Slice Data

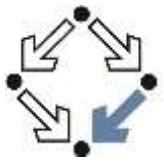




Virtual Aneurysm – Walkthrough

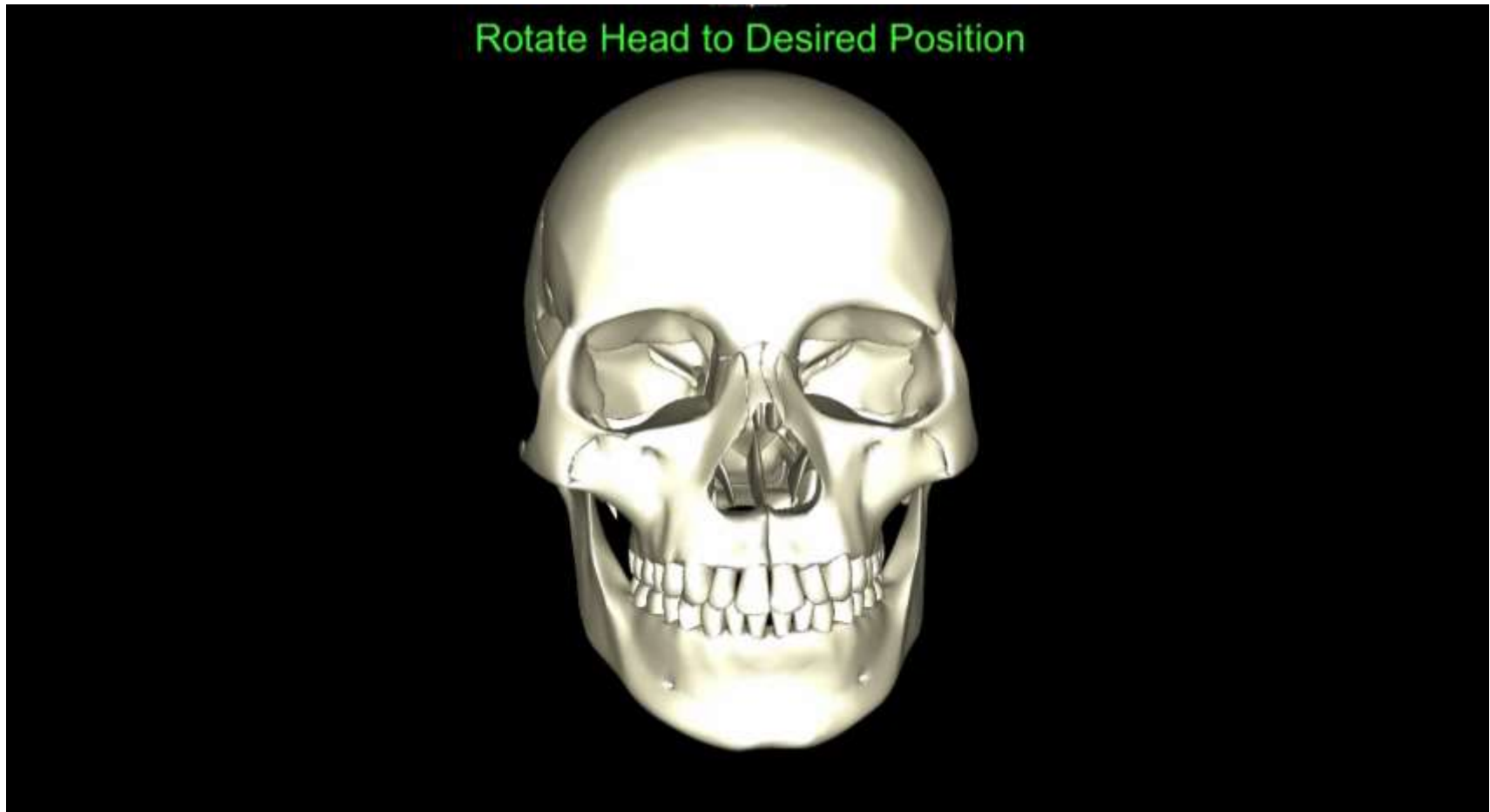
- 3. View 3D Angiogram

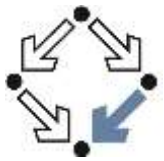




Virtual Aneurysm – Walkthrough

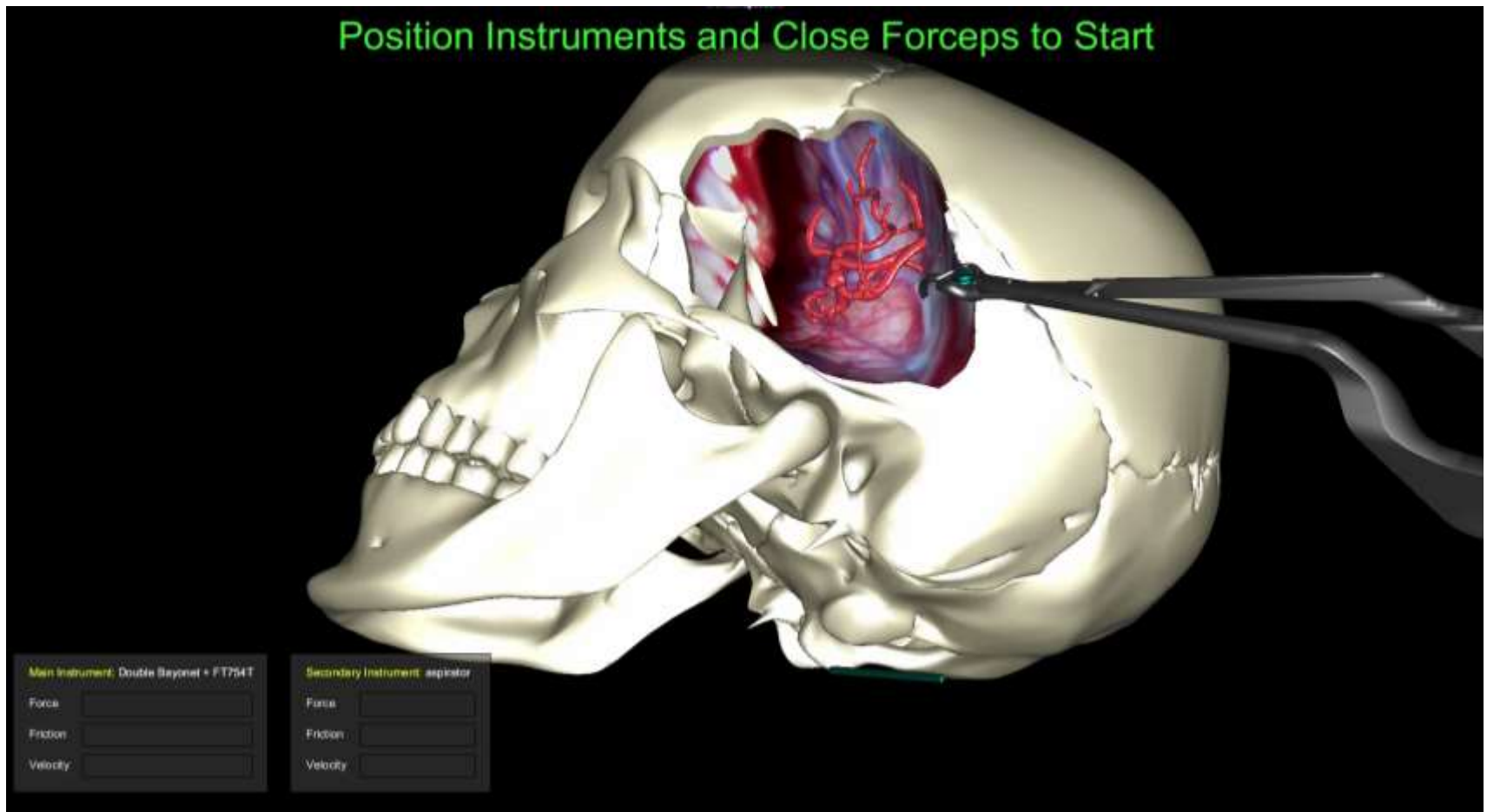
- 4. Find Optimal Head Position and Perform Craniotomy

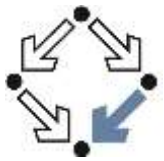




Virtual Aneurysm – Walkthrough

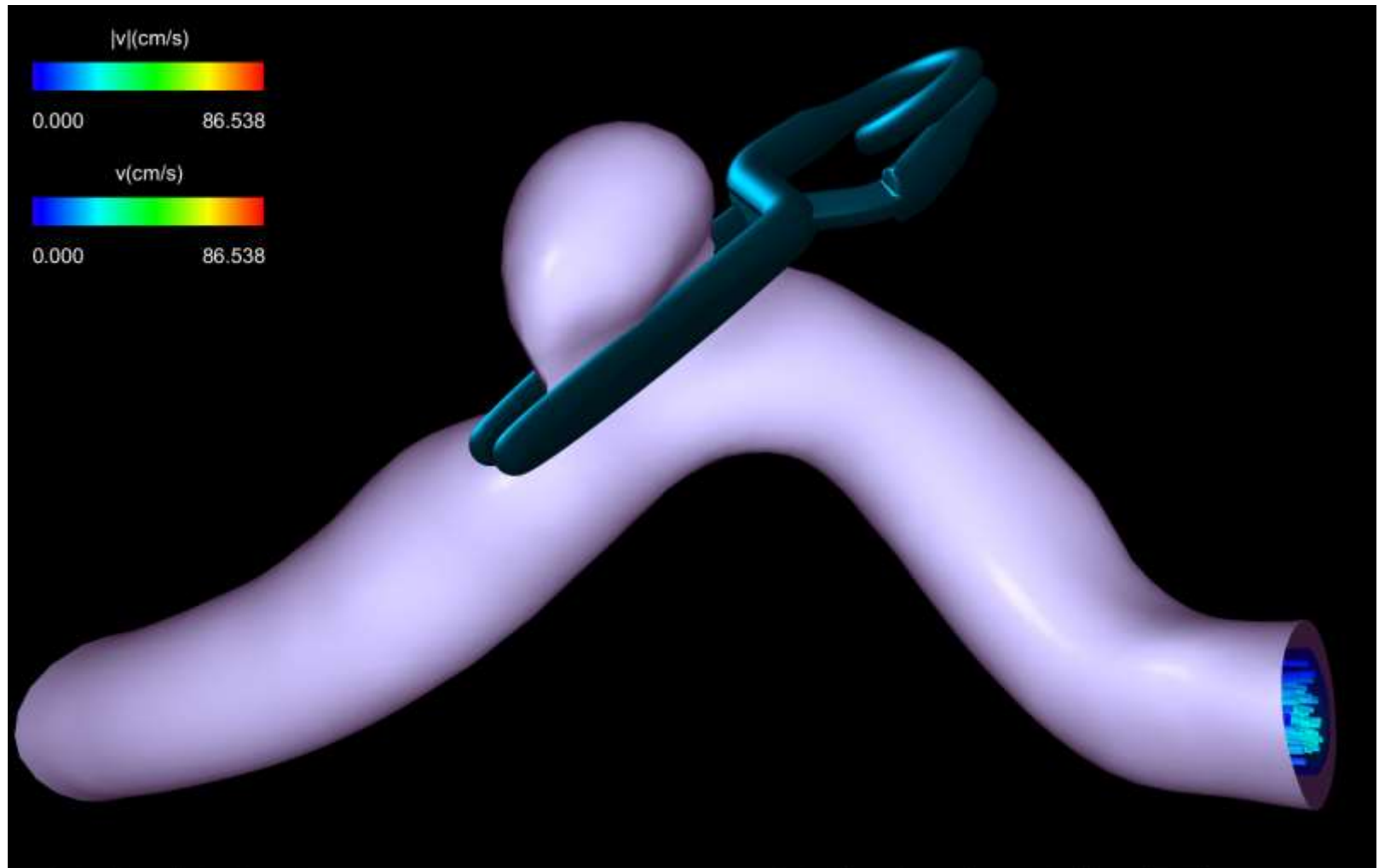
- 5. Place Clip(s) on Aneurysm

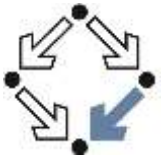




Virtual Aneurysm – Walkthrough

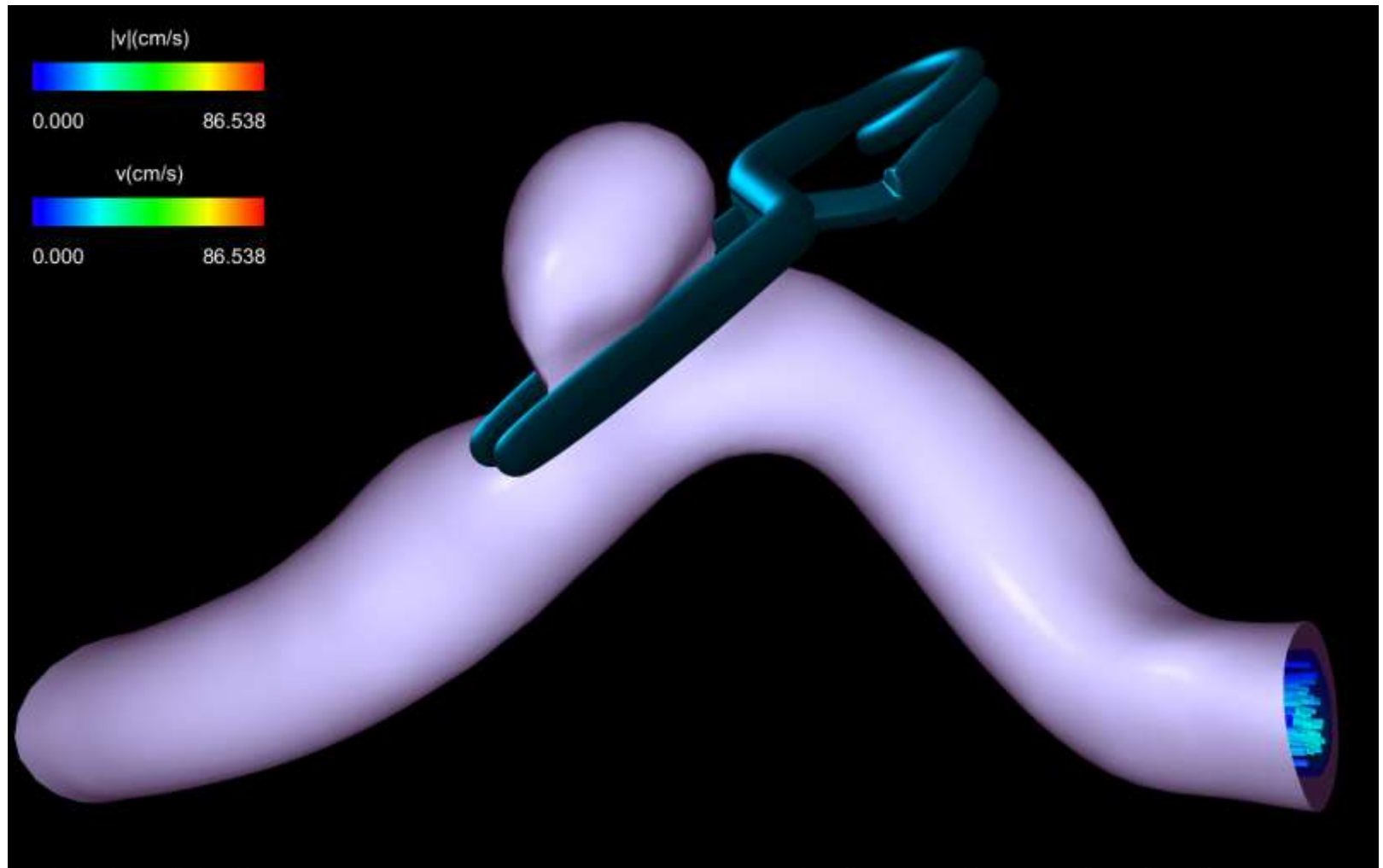
- 7. Review Results

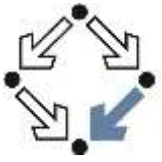




Blood Flow Simulation

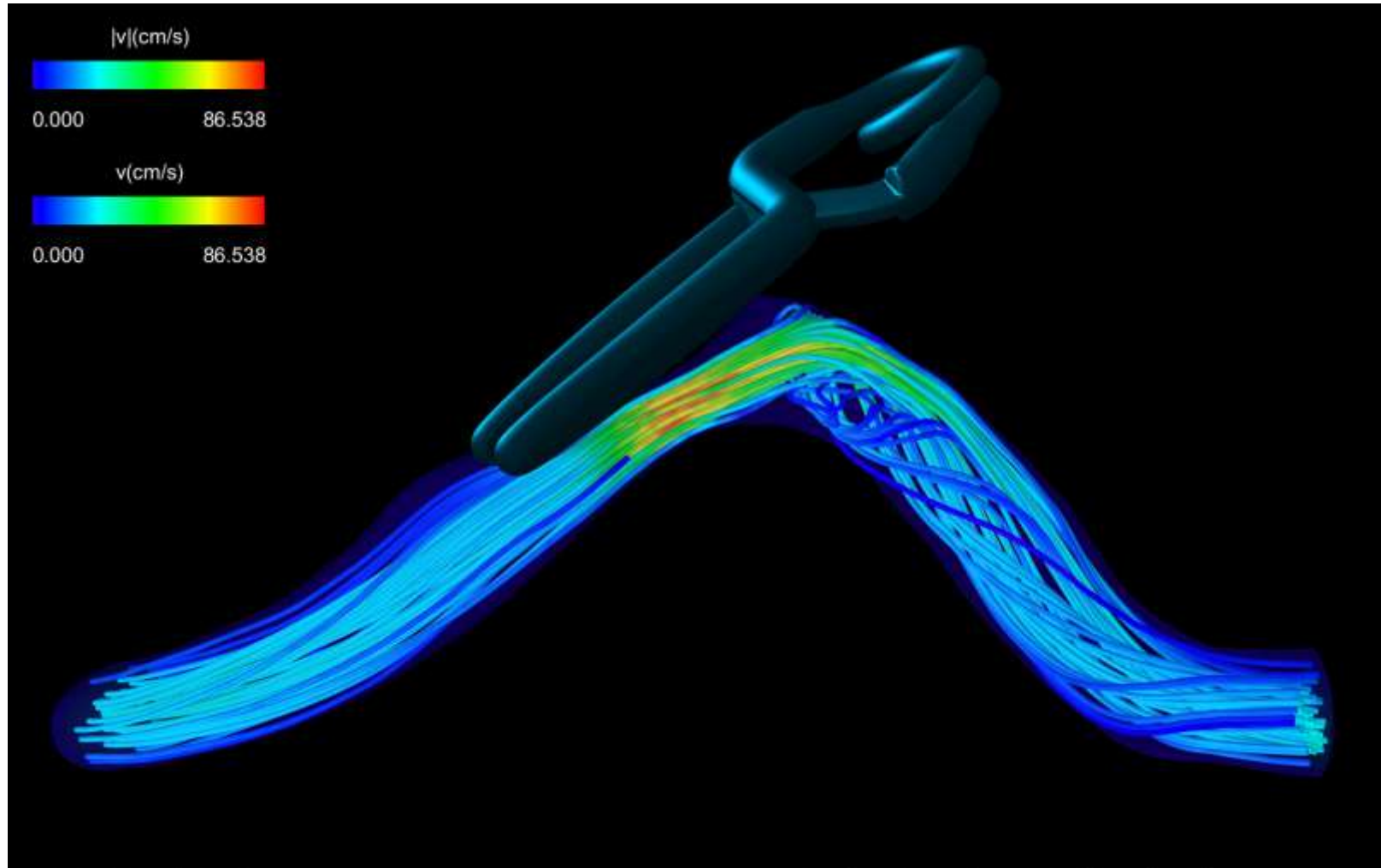
- 7. Review Results and Simulate Resulting Blood Flow

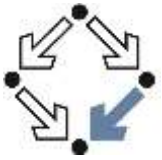




Blood Flow Simulation

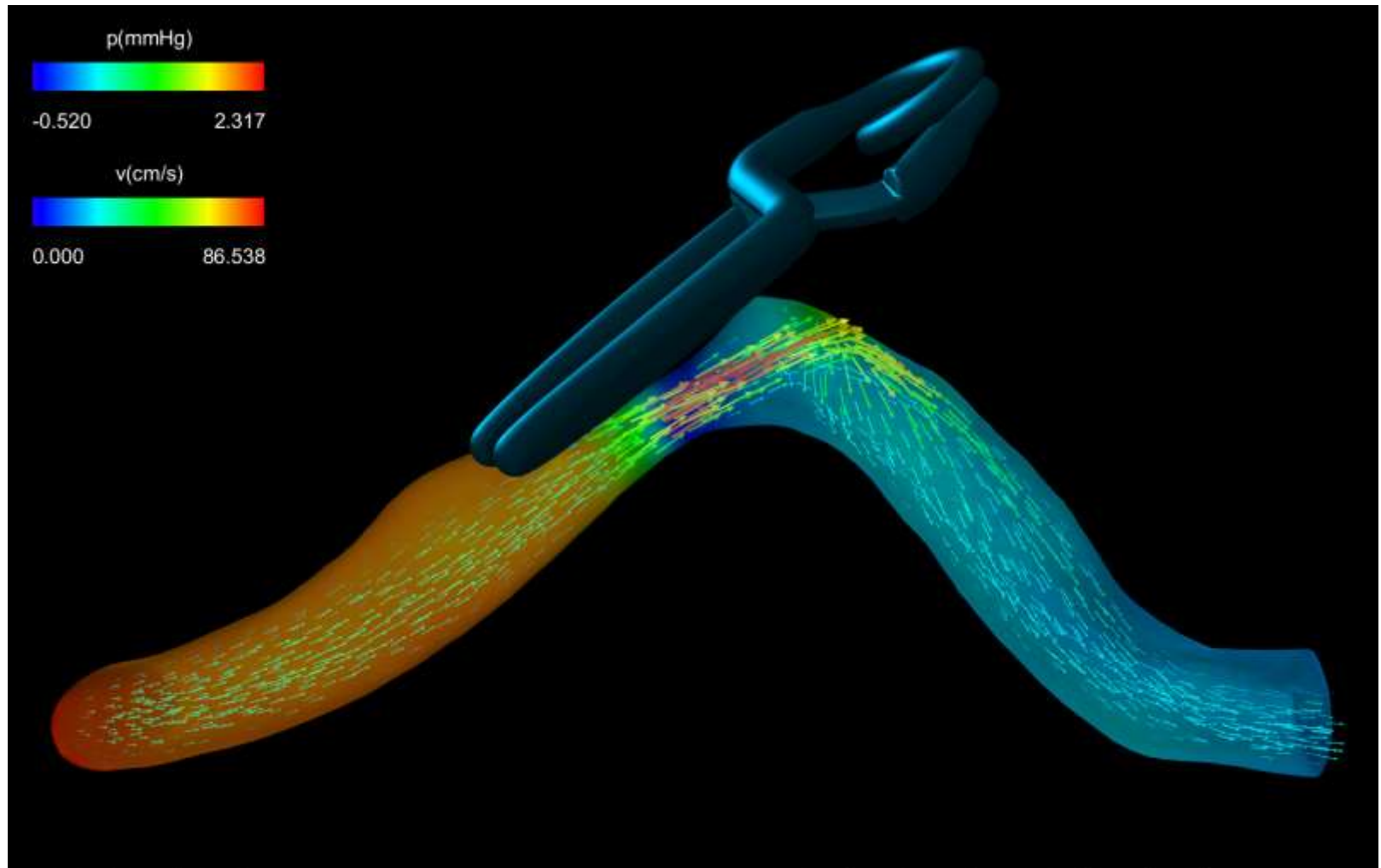
- 7. Review Results (Streamlines)

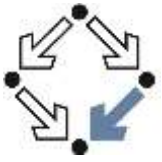




Blood Flow Simulation

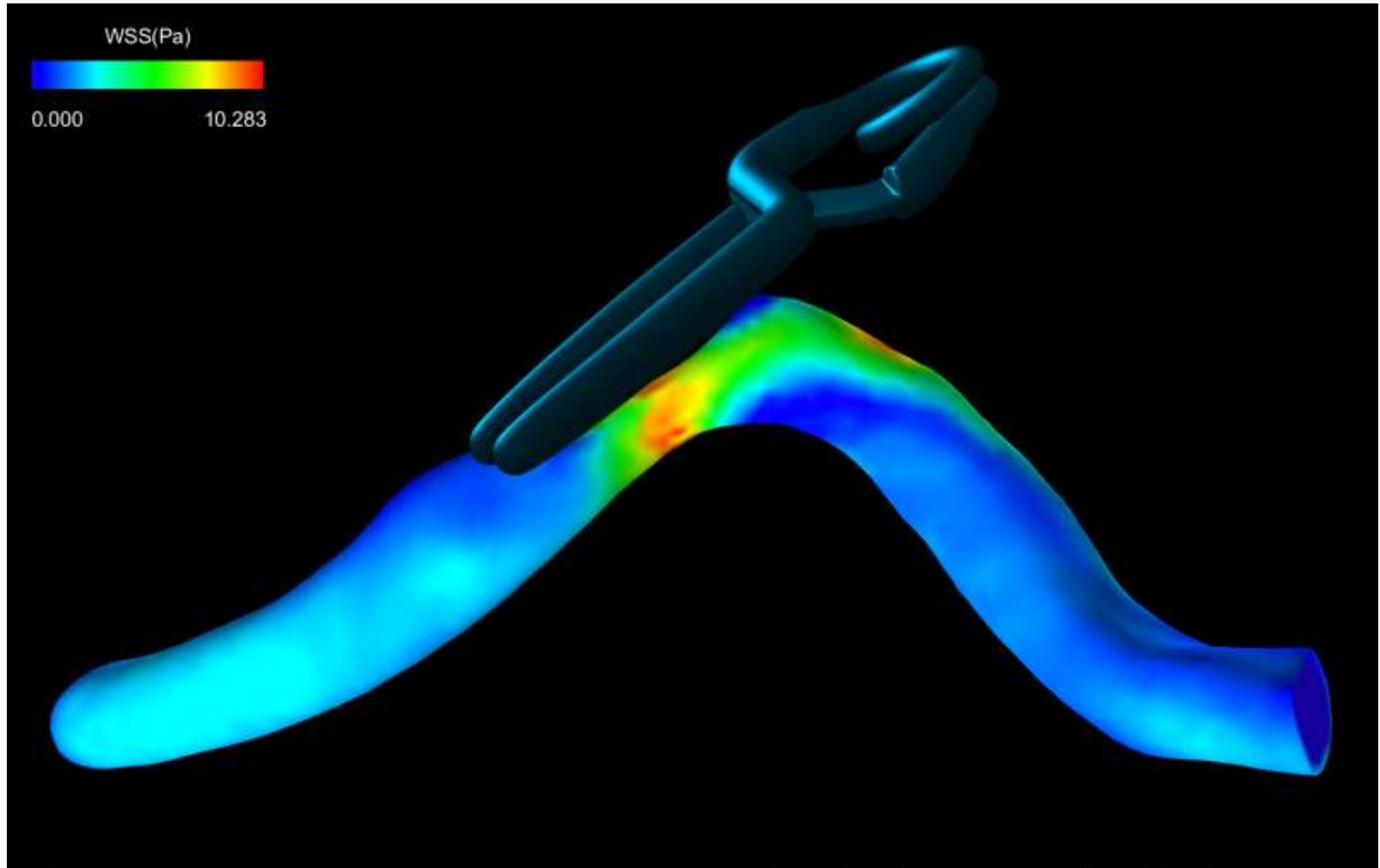
- 7. Review Results (Blood Velocity)

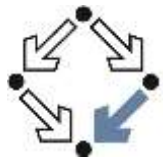




Blood Flow Simulation

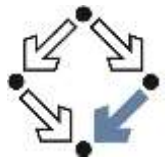
- 7. Review Results (Wall Shear Stress)





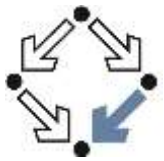
Result Assessment

- Trainee gets penalties for
 - Number of clip repositionings
 - Aneurysm rupture
 - Induced Artery Stenosis
 - Residual Aneurysm Surface
 - Penalty for long durations
- Score is generated automatically after reviewing results and computing blood flow simulation
- All results are stored in a database for review



Summary

- Simulator for Complete Work Flow of Clipping
- Haptic Interaction with Vessels
- Different Training Scenarios
- Different Levels of Experience
- Standard Consumer Hardware
- Affordable Price



Live Demonstration

Visit us at **B. Braun Aesculap Booth (opp. Tiziano 3)**
and try yourself!

We would like to thank
the FFG for funding and
B. Braun for supporting us

Thank you!



Austria - Sweden

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