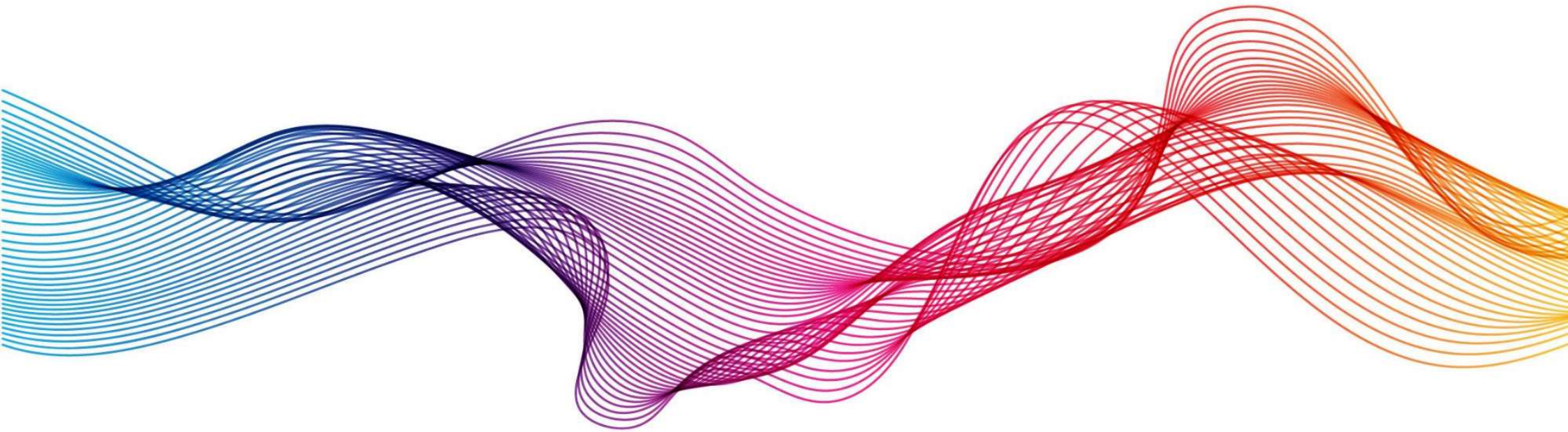




Scientific Discovery Through Visualization Support



National Research  
Infrastructure  
for Data Visualization





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# Interactive Visualization for Surgery Planning and Medical Training

Professor Ingela Nyström

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Node Coordinator of [infravis.se](http://infravis.se)

Centre for Image Analysis  
Dept. of Information Technology  
Uppsala University



*Keynote at Sunetdagarna on April 25, 2024*

## Excerpt from Ingela's CV

- SNIC-UPPMAX, Uppsala University  
Application Expert 2004-2006, Director 2006-2011
- **SUNET, Vetenskapsrådet  
Board Member 2008-2013**
- Council for Research Infrastructure, RFI, Vetenskapsrådet  
Committee Member 2014-2019, Vice-Chair 2015-2019
- Sigma2 AS (e-infrastructure for computational science in Norway)  
Board Member 2019-
- European Strategy Forum on Research Infrastructures (ESFRI)  
Member representing Sweden as expert 2020-2022
- Swedish National Infrastructure for Computing (SNIC)  
Chair 2020-2022

## Tjänster som efterfrågas

Att SUNET utöver nåttillgänglighet tillhandahåller resurser för tjänster, t.ex. virtuella mötesplatser

**Zoom!**

tillgängligheten till infrastrukturen på resande fot, i hemmen eller ute på fält. Eduroam har snabbt blivit ett mycket uppskattat hjälpmedel för distansarbete och åtkomst av elektroniska resurser från andra lärosäten. En säker autentisering liknande Eduroam skulle kunna tillgängliggöra universitetens tjänster och resurser även till forskarna via privata fasta och mobila nät. En utökning av Eduroam

**Eduroam på flygplatser med flera ställen!**

**SUNET:s strategiarbete  
forskningens behov 2011-10-16**

**Medlemmar i strategigruppen för forskningens behov**

- Göran Hilmersson, Göteborgs universitet
- Tobias C. Larsson, Blekinge tekniska högskola
- Ingela Nyström, Uppsala universitet (sammankallande)
- Stefan Petterson, Mittuniversitetet
- Göran Sandberg, Lunds universitet

Basnätet OptoSunet har en mycket hög kvalitet och kapacitet idag.

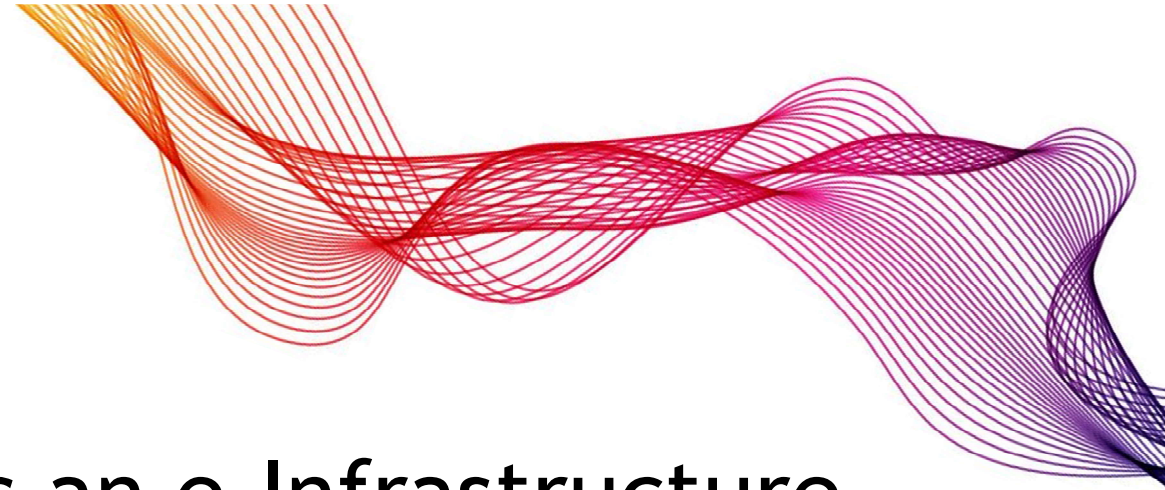


# National Research Infrastructure for Data Visualization

160 MSEK granted by RFI during 2022-2026 following positive external evaluators:  
*"The idea of a visualization competence infrastructure is novel, timely and needed.  
InfraVis is unique in the World."*



InfraVis PR video [5 minutes] [https://youtu.be/bdVpfMD5\\_lm](https://youtu.be/bdVpfMD5_lm)



# InfraVis is an e-Infrastructure

InfraVis is a research infrastructure for  
other research infrastructures  
- not for Visualization *per se*

InfraVis is a *people* infrastructure  
and not an infrastructure of  
equipment and hardware

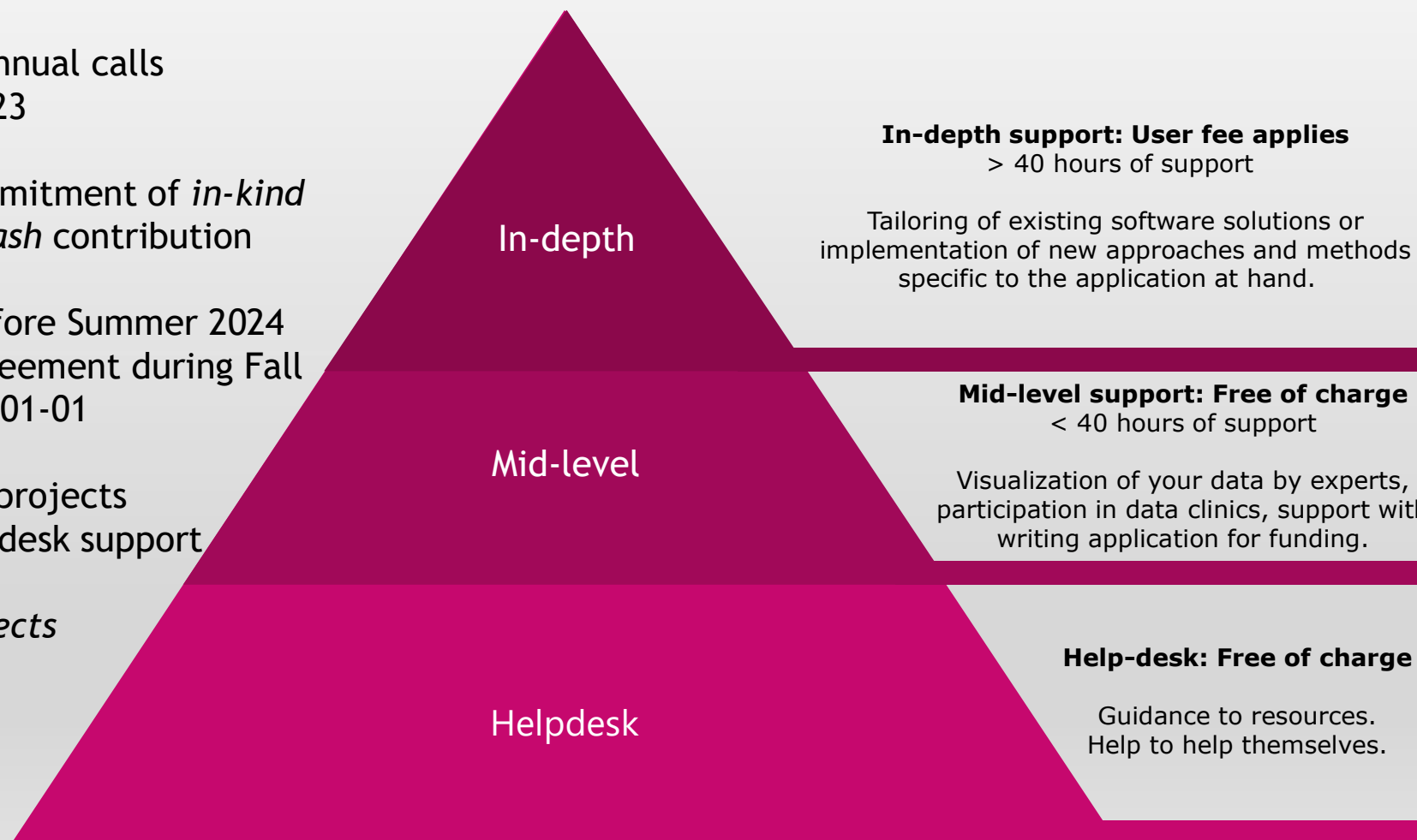
# User Support Levels

## Level-3 projects in annual calls

- 45 applications 2023
- 40 approved
- Co-funding by commitment of *in-kind* work hours or *in-cash* contribution
- New call opens before Summer 2024
- Evaluation and agreement during Fall
- Project start 2025-01-01

## Level-2 and Level-1 projects continuously via Helpdesk support

Today, 79 active projects



# InfraVis Organisation

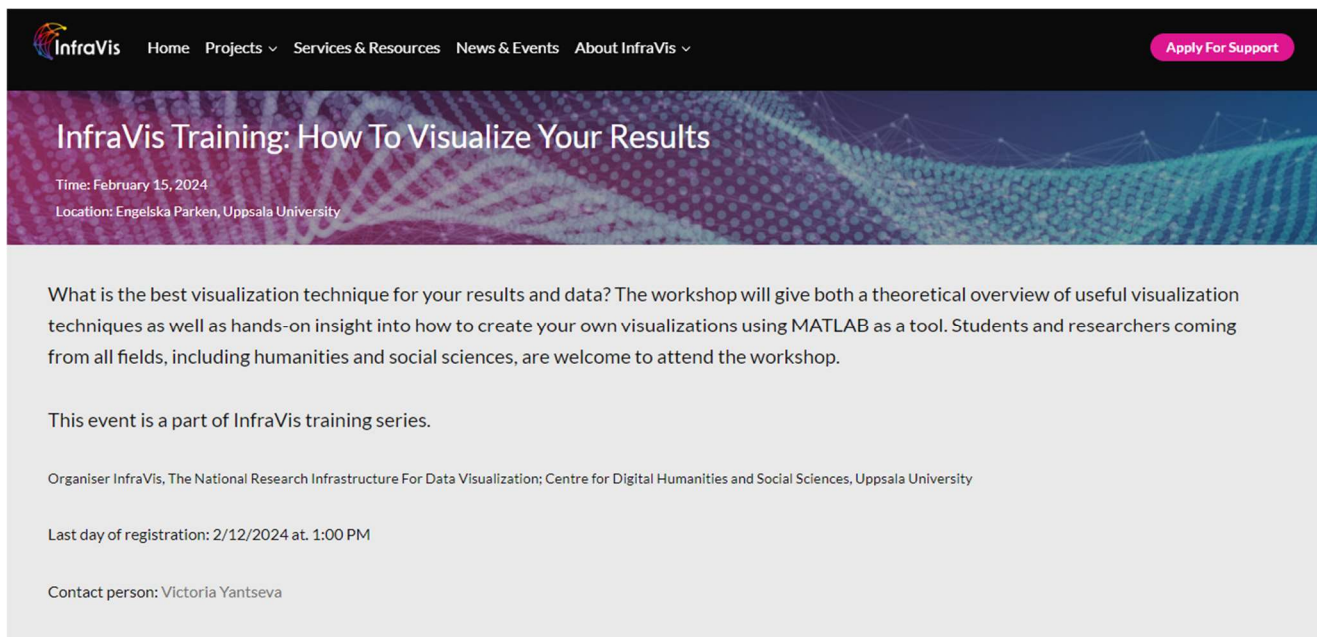
- **Leading Management Group**
  - Director Monica Billger, Chalmers
  - National Technical Managers
- **Strategic Steering Group**
  - Chair Anders Ynnerman, LiU
  - 5 board members
- **Executive Node Coordinators**
  - Ingela Nyström, UU
  - additional 7 Node Coordinators
- **Many InfraVis Application Experts and Communicators**
- More presented at <https://infravis.se/>





# Example InfraVis User Training on February 15, 2024

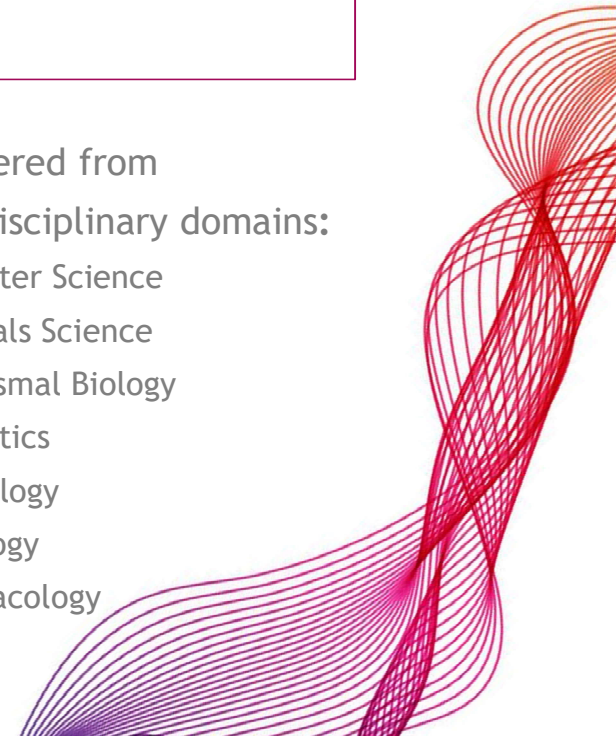
- Simple but effective graphs: *What to do and not to do*
- Visualize Machine Learning results: *How?*
- Multi-dimensional data visualization: *A great research tool!*
- Lab time + *Q&A*



The screenshot shows the website header with the InfraVis logo and navigation menu (Home, Projects, Services & Resources, News & Events, About InfraVis). A pink button for 'Apply For Support' is visible. The main heading is 'InfraVis Training: How To Visualize Your Results'. Below it, the event details are listed: 'Time: February 15, 2024' and 'Location: Engelska Parken, Uppsala University'. A paragraph describes the workshop's focus on visualization techniques and hands-on MATLAB training. Further down, it states the event is part of the training series, lists the organizer as 'InfraVis, The National Research Infrastructure For Data Visualization; Centre for Digital Humanities and Social Sciences, Uppsala University', and provides the registration deadline: 'Last day of registration: 2/12/2024 at 1:00 PM'. The contact person is identified as 'Victoria Yantseva'.

23 registered from several disciplinary domains:

- Computer Science
- Materials Science
- Organismal Biology
- Linguistics
- Archaeology
- Radiology
- Pharmacology
- ...



# Keep in touch with InfraVis

## Receive support

Apply for user support on [infravis.se](http://infravis.se) or talk to a node coordinator

## Subscribe: Events and News

InfraVis National  
Newsletter

Social media



InfraVis Sweden



[infravis\\_sweden](https://twitter.com/infravis_sweden)

**More information**

[infravis.se](http://infravis.se)

# Select Supported Projects



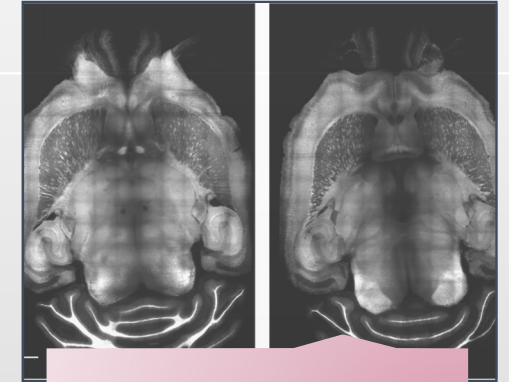
In-situ visualization support for AMR meshes in Nek5000



Immersive visualization of climate change



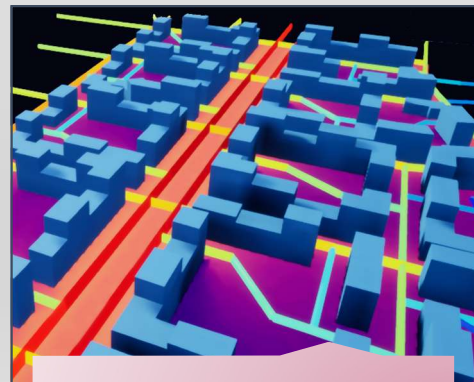
Host Virtual Reality applications on the cloud



Visualization of healthy and epileptic brain profiles



Visualization of online activism factors



Pedestrian noise exposure visualization



Visualization of patients' digital twins for a healthy life



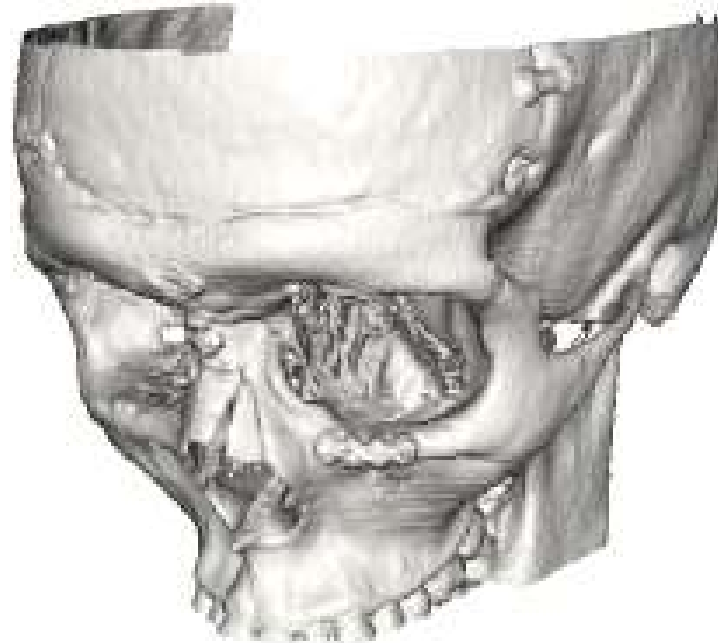
Addressing climate crisis through paleobiologic data visualization



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## Example project: Cranio-maxillofacial surgery planning

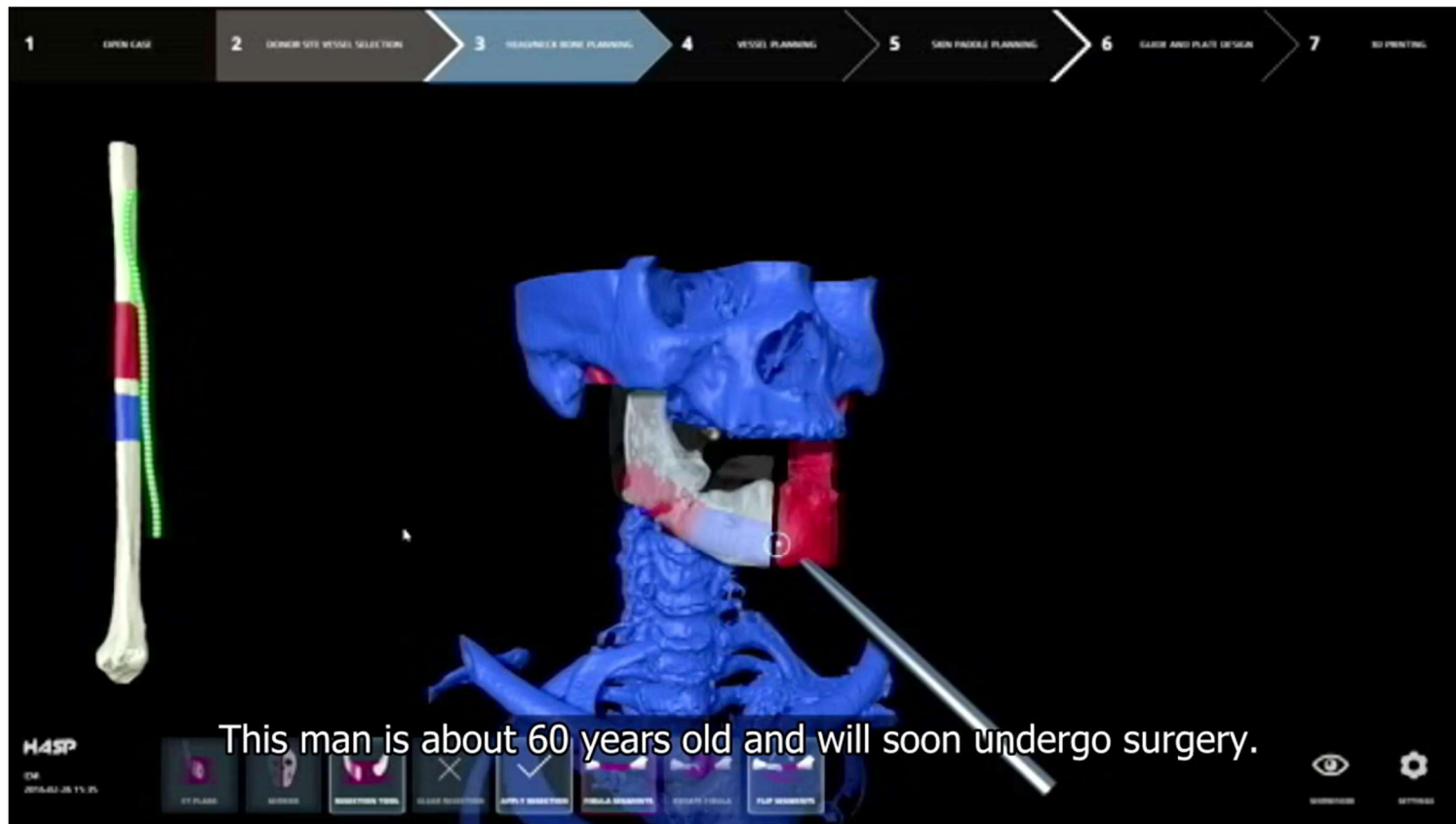
- A central problem in cranio-maxillofacial (CMF) surgery is to restore the normal anatomy of the facial skeleton after defects, i.e., malformations, tumours, and trauma to the face
- Collaboration between the Centre for Image Analysis and the units of Oral & Maxillofacial Surgery at Uppsala University Hospital and Mount Sinai Hospital, New York





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## In the Swedish TV news



Andreas Thor  
Andres Rodriguez Lorenzo  
Fredrik Nysjö

*Video clip from SVT [3 minutes]*

Ingela.Nystrom@it.uu.se



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## Aims with CMF surgery planning

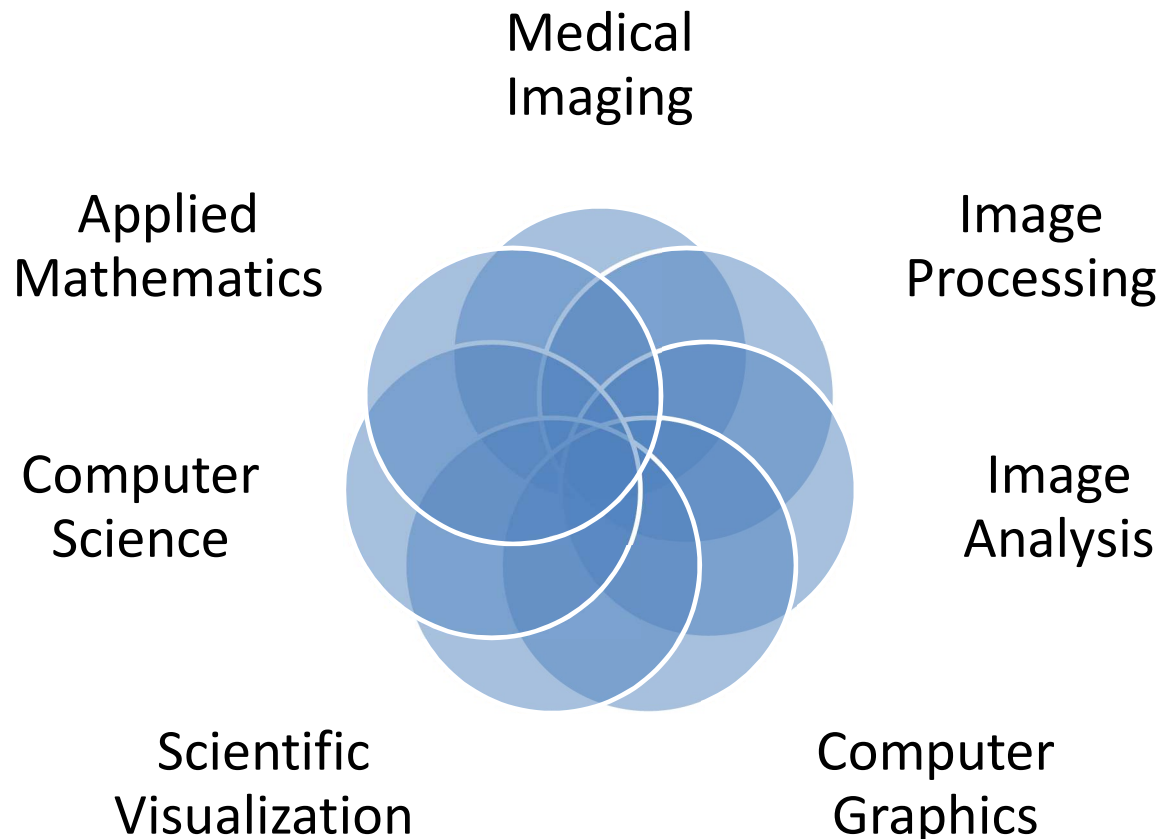
- Careful pre-operative planning of the cranio-facial reconstruction can
  - improve the precision and predictability
  - reduce morbidity
  - reduce the time in the operating room (and thereby also cost)
  - be used in medical training
- Analysis of Computed Tomography (CT) images





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# Medical visualization – a multi-disciplinary topic



Visualization provides a way to see the unseen

Ingela.Nystrom@it.uu.se

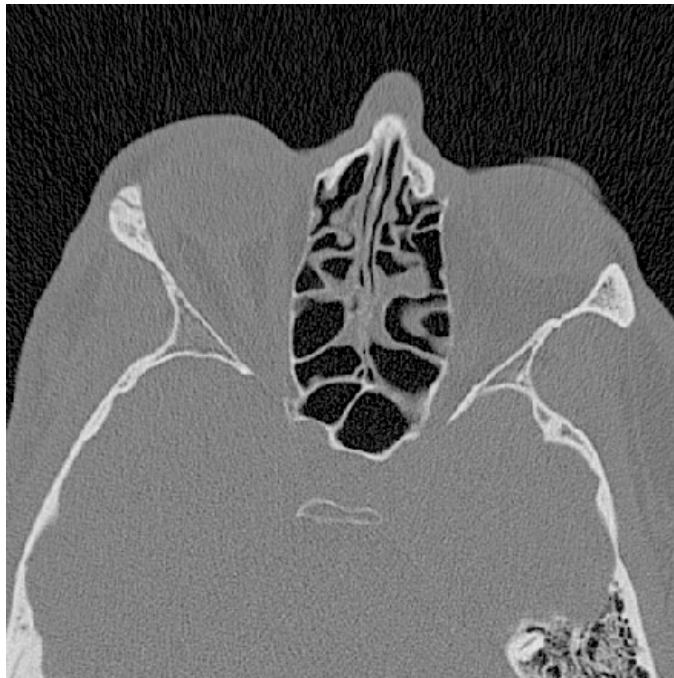
*– We make the invisible visible!*



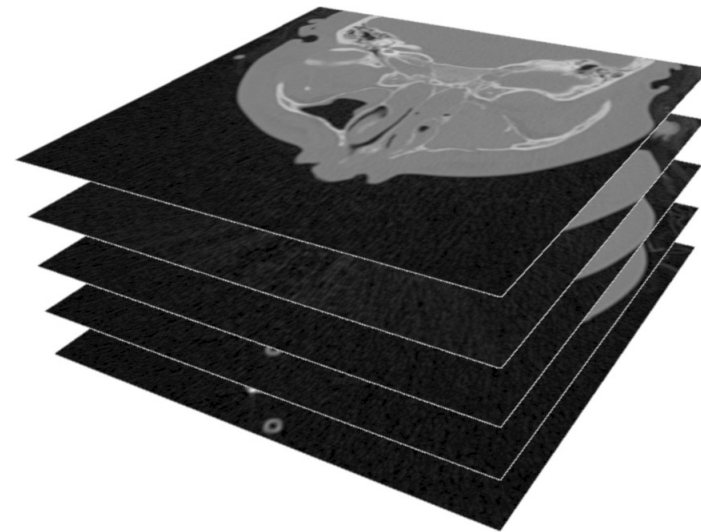


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## Three-dimensional (3D) computed tomography (CT) images of the skeleton



Cross-sectional CT image of  
the facial skeleton

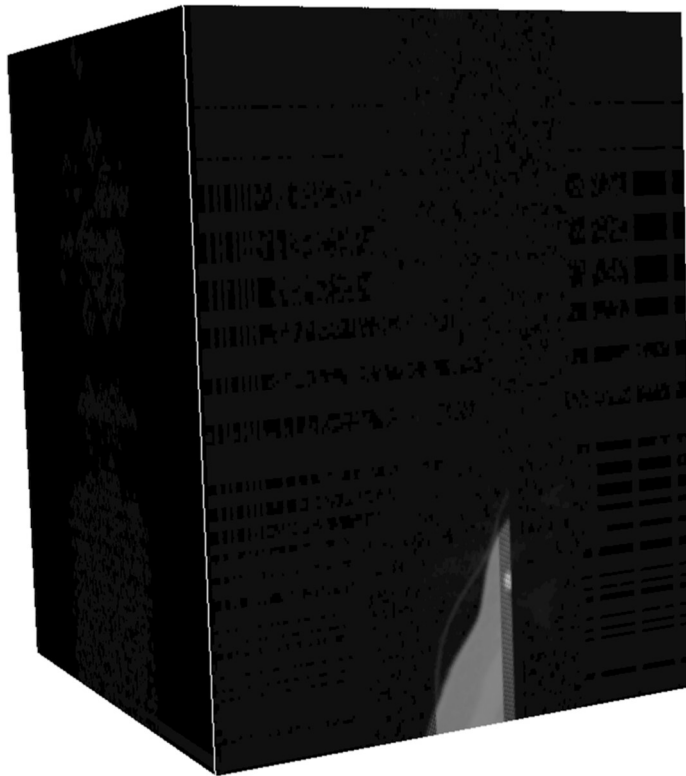


Stack of CT slices forming a  
volume (3D) image



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## Volume visualization

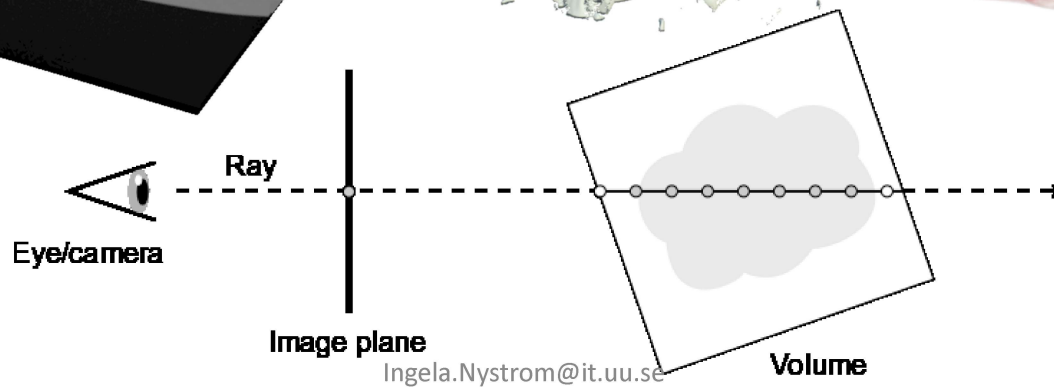


Multi-planar reformatting (MPR) [Video clip 15 seconds]



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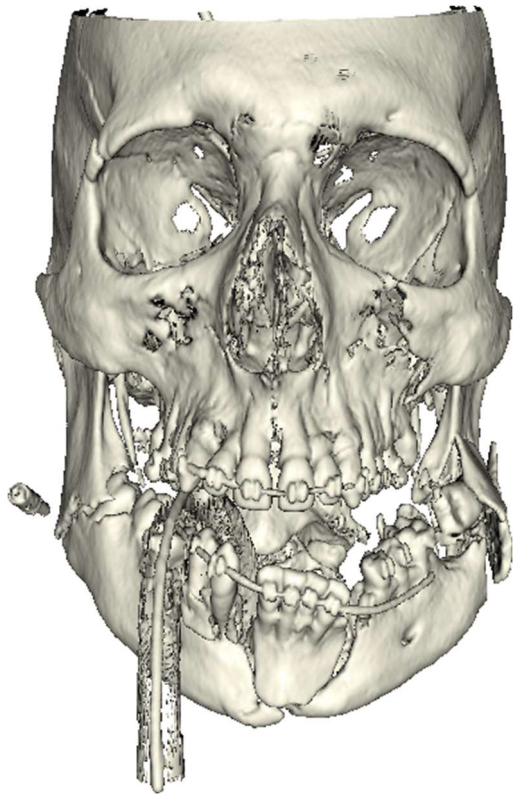
# Volume visualization





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## Lighting and shadows



Standard local illumination  
(VTK toolkit)

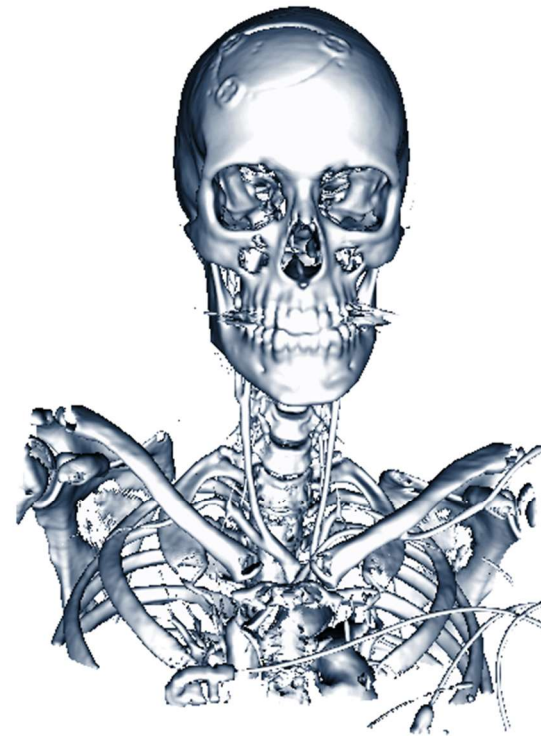
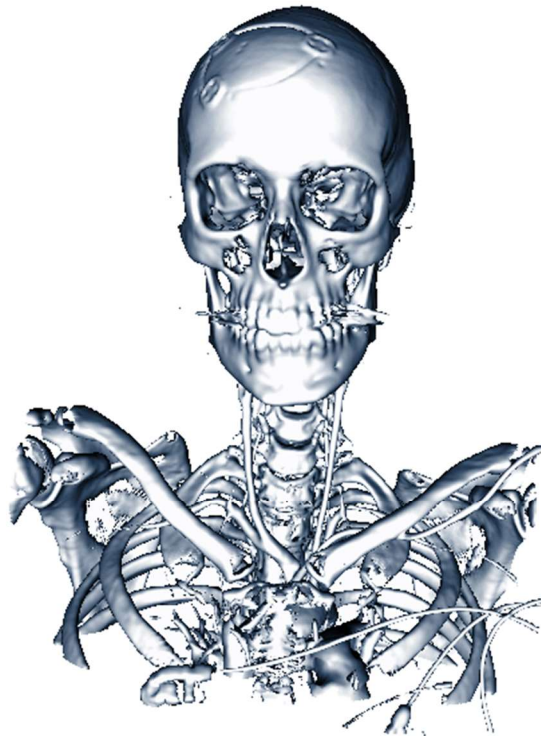


Physically-based shading +  
image-based lighting +  
shadow mapping +  
ambient occlusion



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# Stereo rendering



*Update rate 60 Hz*



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## From 2D to 3D interaction



Haptic 3D input device with  
force feedback

*Update rate 1 kHz*

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Stereoscopic mirror display with  
haptic 3D input and head-tracking

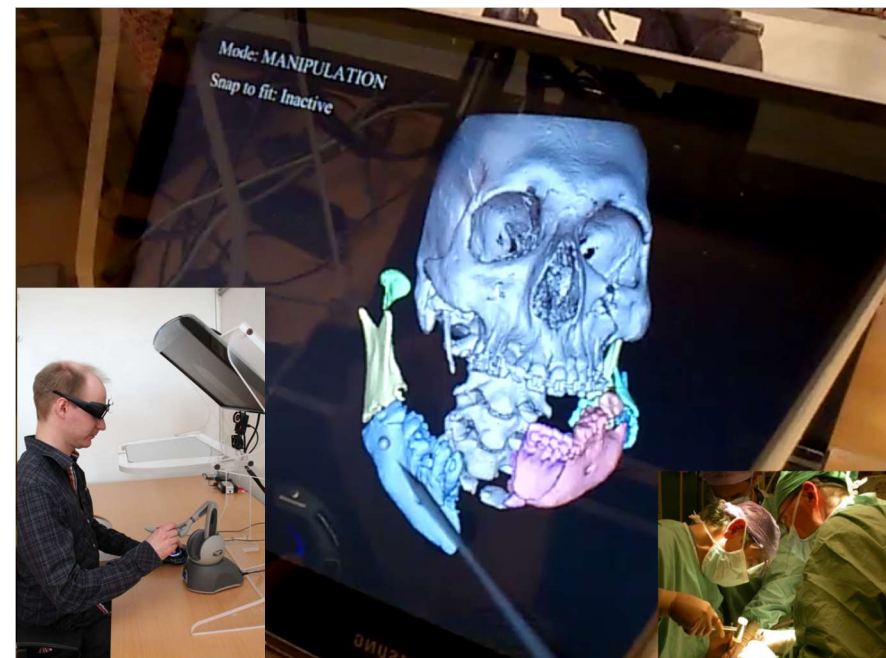


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## 3D bone puzzle



3D computed tomography (CT)  
scan of a complex jaw fracture



Planning system where the user can virtually  
test how to assembly the bones before surgery



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## 3D bone puzzle: Snap-to-fit



Pontus Olsson

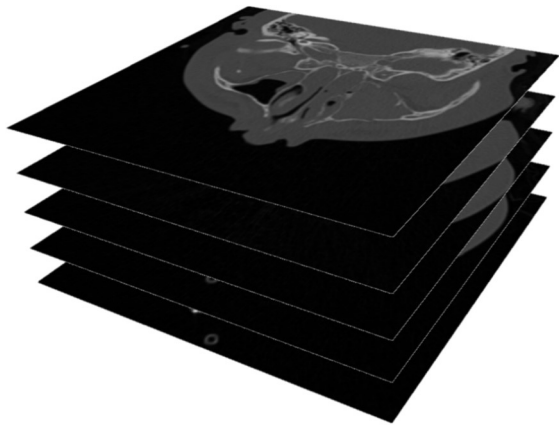
*Video clip [90 seconds]* [Ingela.Nystrom@it.uu.se](mailto:Ingela.Nystrom@it.uu.se)





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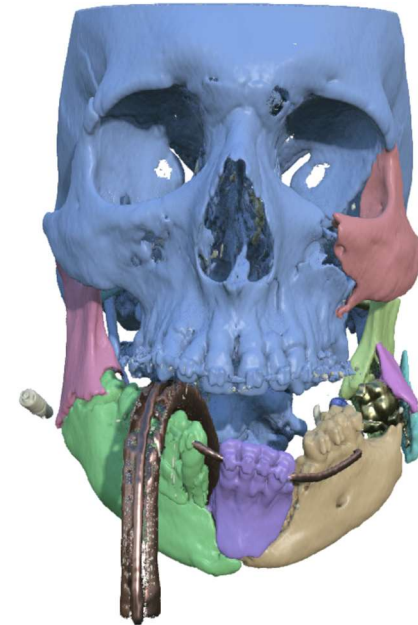
## Individual bone extraction (segmentation) in CT images



Stack of CT slices



3D bone model obtained  
by intensity thresholding



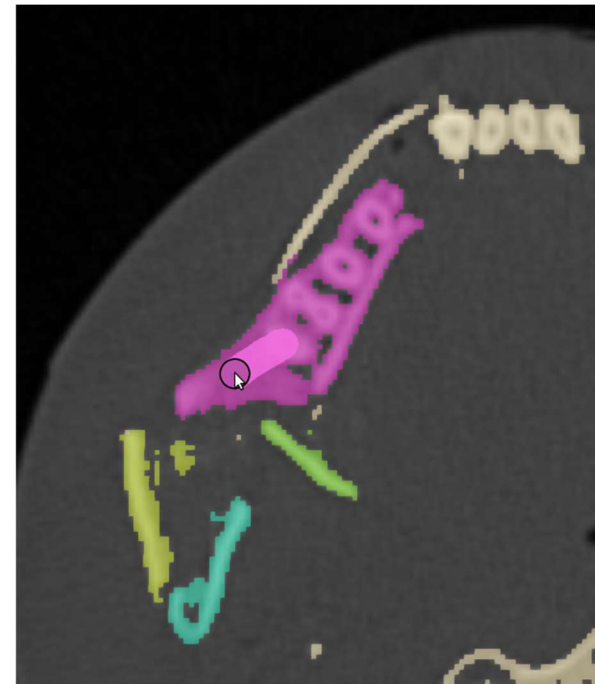
Segmented bones



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## Segmentation of individual bones and bone fragments

- Very tedious and time-consuming to do by hand!
- Computers cannot separate the bones automatically
- We need to use **semi-automatic** or **interactive** methods

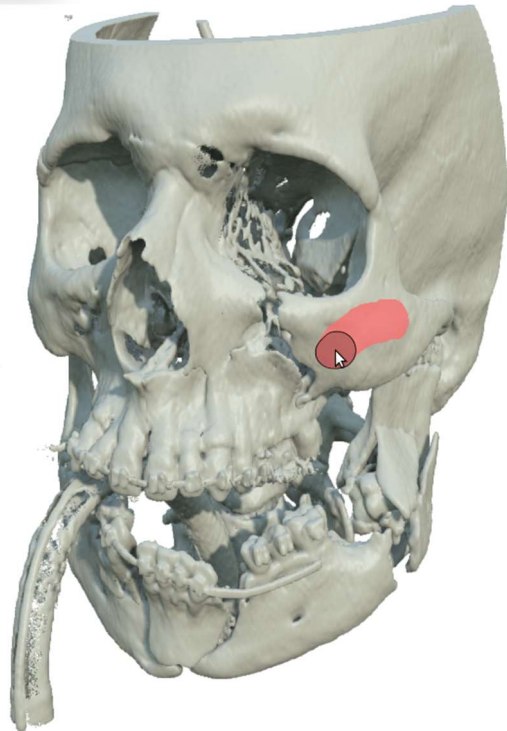


Manual slice-by-slice marking  
of the individual bones

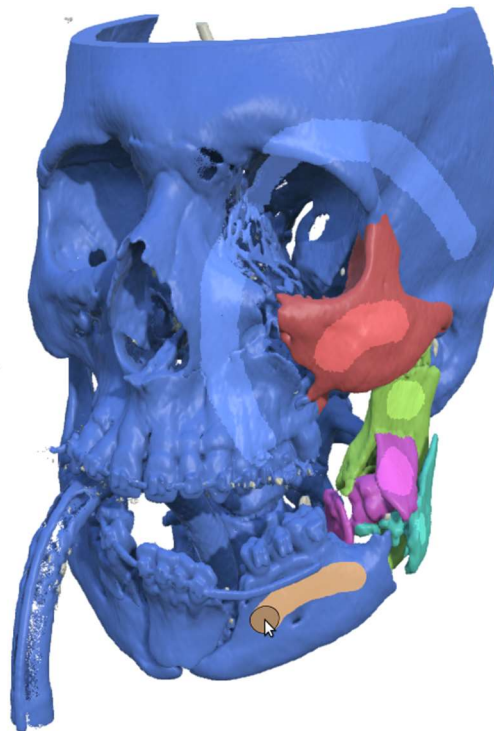


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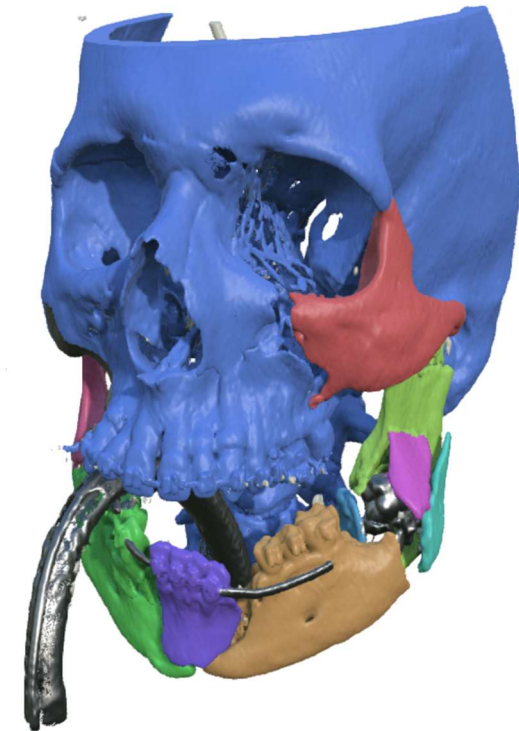
## 3D painting interface



3D paintbrush



Marking of individual bones



Final segmentation



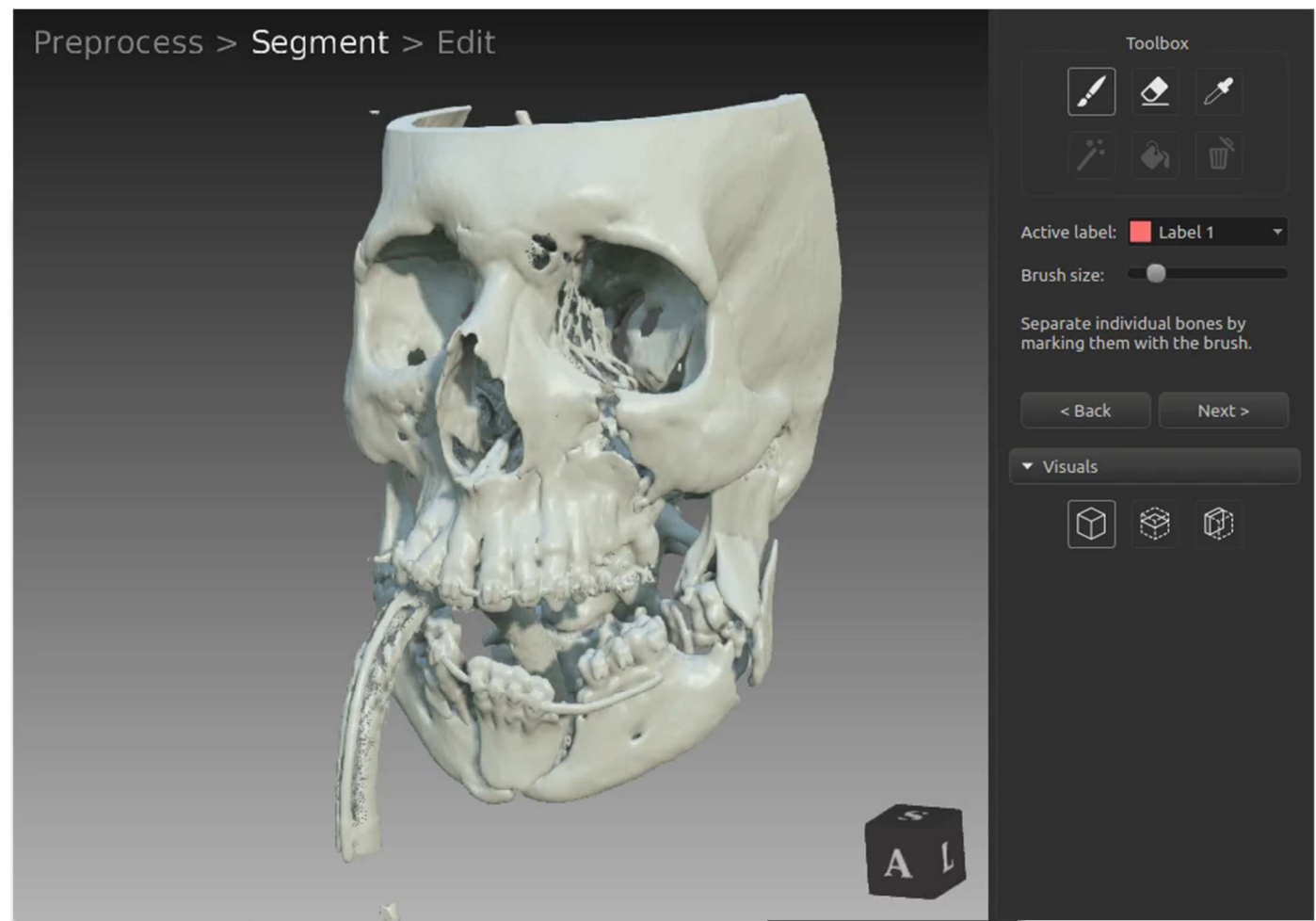
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Combines interactive  
3D painting with  
efficient graph-based  
segmentation and  
real-time rendering  
algorithms

Johan Nysjö

*Video clip [1 minute]*

## Our 3D segmentation tool: BoneSplit





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## HASP: a Haptics-Assisted Surgery Planning tool for complex surgery in the head and neck region



Daniel Buchbinder, Professor, MD, Co-Director, Institute for Head and Neck and Thyroid Cancer, Mount Sinai Beth Israel Hospital, New York

*3D interaction with 3D data using stereo graphics and haptics*



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## 3D modelling of patient-specific cutting guides, resection guides, fixation plates

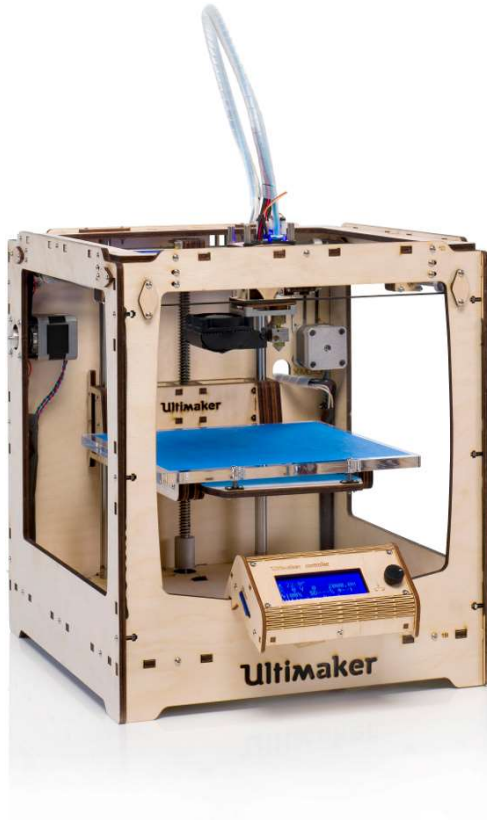


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## 3D printable results

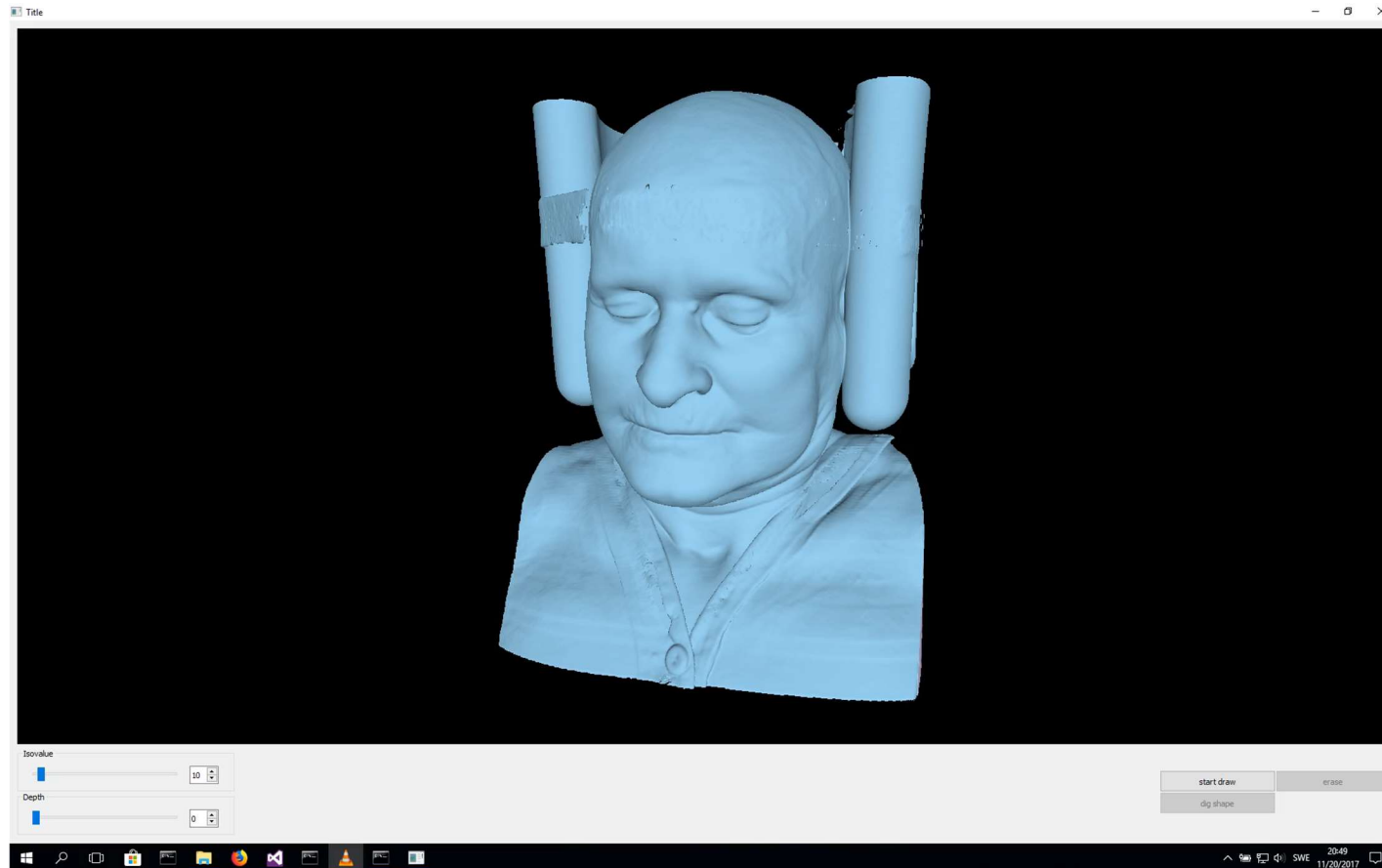


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# SoftCut: a tool for soft tissue resection



*Video clip [1 minute]*

Ingela.Nystrom@it.uu.se

Ludovic Blache

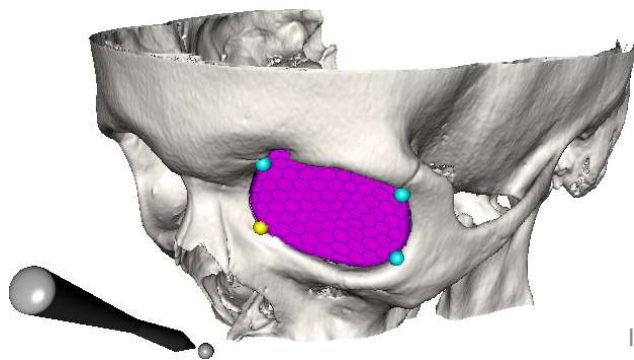




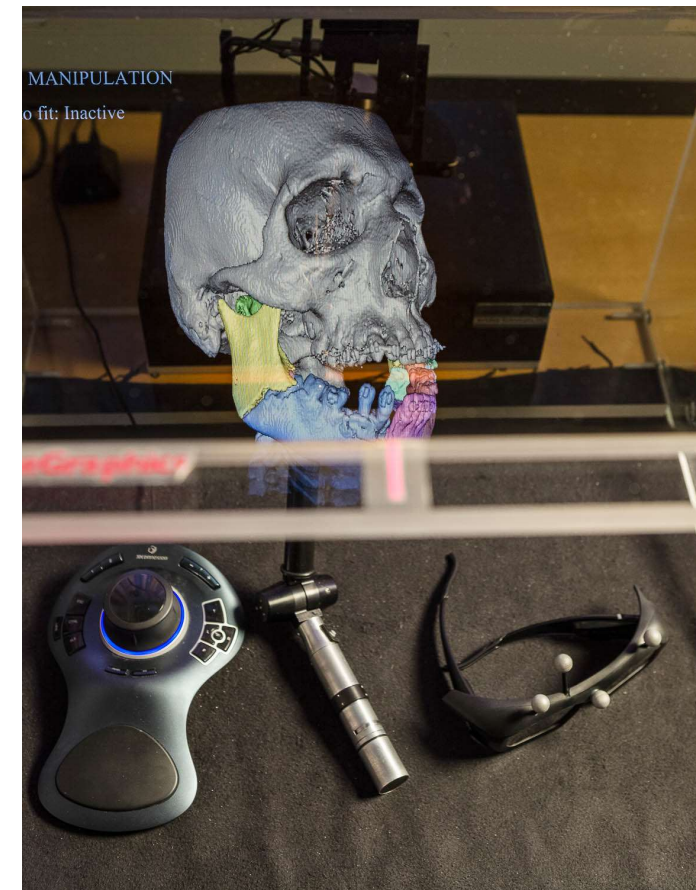
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## Our system: *Interactive Medical 3D Image Analysis*

- **Visualization** to show the volume structures
- **Haptic feedback** for interaction
- **Image processing and segmentation**
- **Evaluation** of accuracy, precision, and efficiency



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# Acknowledgements

## Centre for Image Analysis, UU

- Colleagues over the years

## Dept. of Surgical Sciences, UU

### – Oral & Maxillofacial Surgery

- Jan Michaél Hirsch
- Andreas Thor

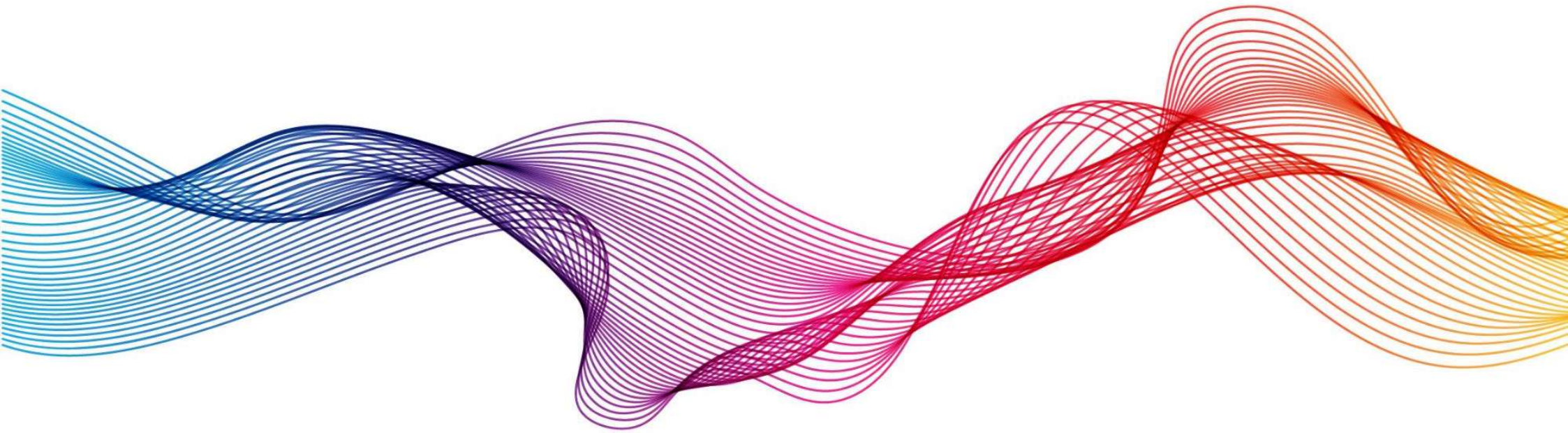
### – Plastic Surgery

- Daniel Nowinski
- Andres Rodriguez Lorenzo



# InfraVis

## Scientific Discovery Through Visualization Support



Swedish  
Research  
Council

National Research  
Infrastructure  
for Data Visualization



CHALMERS  
UNIVERSITY OF TECHNOLOGY



UNIVERSITY OF  
GOTHENBURG



KTH  
VETENSKAP  
OCH TEKNIK

li.u LINKÖPING  
UNIVERSITY



LUND  
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Linnaeus University

Mittuniversitetet  
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# Interactive Visualization for Surgery Planning and Medical Training

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*Keynote at Sunetdagarna on April 25, 2024*