# Geometric Computing and Computer Vision

**Oleg Voynov, Artem Komarichev**

slides and images borrowed from a variety of sources, incl. slides by Denis Zorin, Alexey Artemov, and others

# 3D reconstruction demo

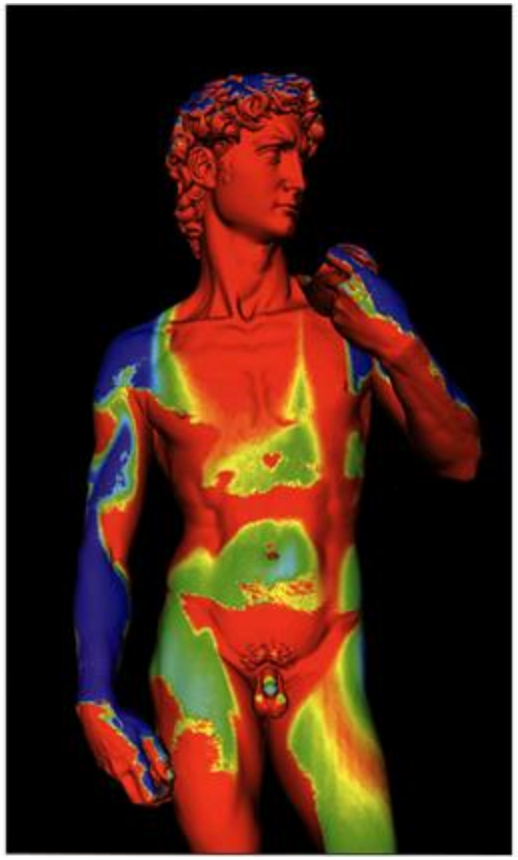
WHY IS THIS SO RELEVANT?

# Digital Michelangelo

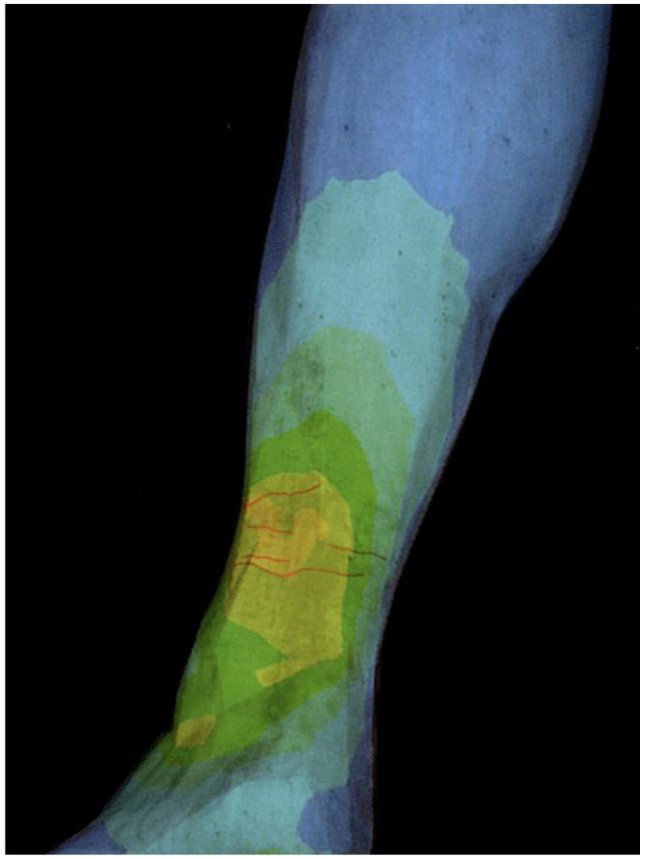
## Cultural heritage preservation

Photo

3D reconstruction



Deposition of rainwater,
dust, and other contaminants



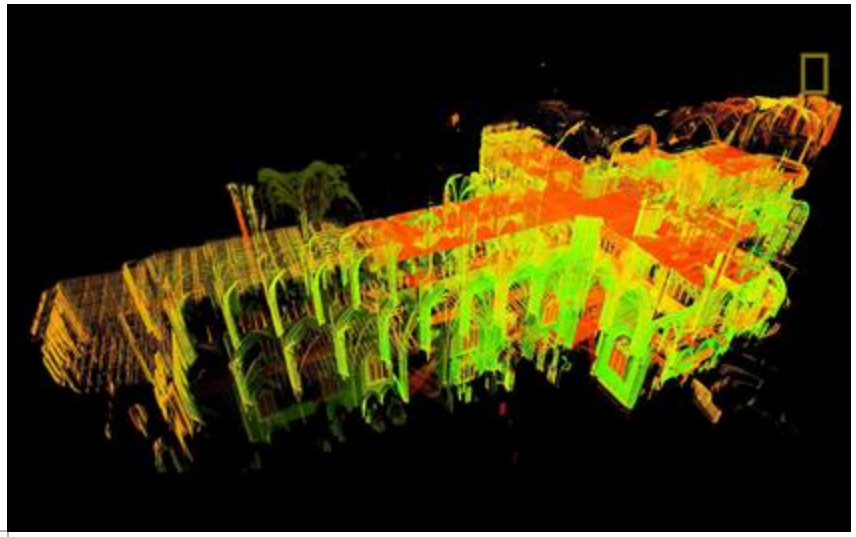
Tensile stresses in the left leg with the statue
tilted 3 degrees forward, as it was in 1871

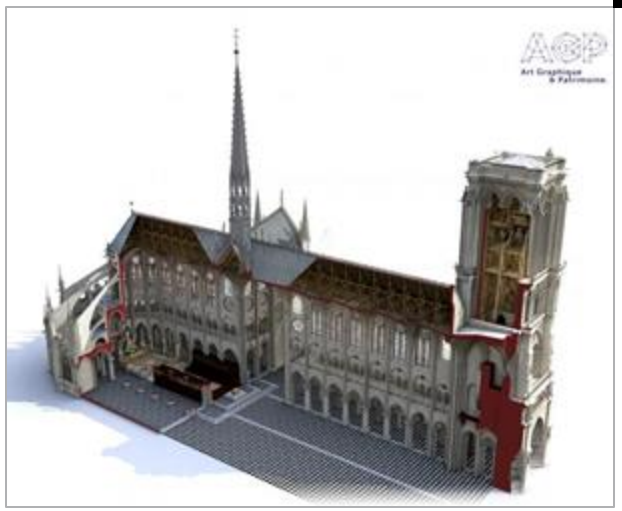
# NOTRE-DAME DE PARIS

In 2019 there was a fire in the cathedral after which it was severely damaged

## POINT CLOUD OF NOTRE DAME

In 2015, art historian Andrew Tallon performed a complete laser scan of the cathedral. He produced a 3D digital model of Notre Dame





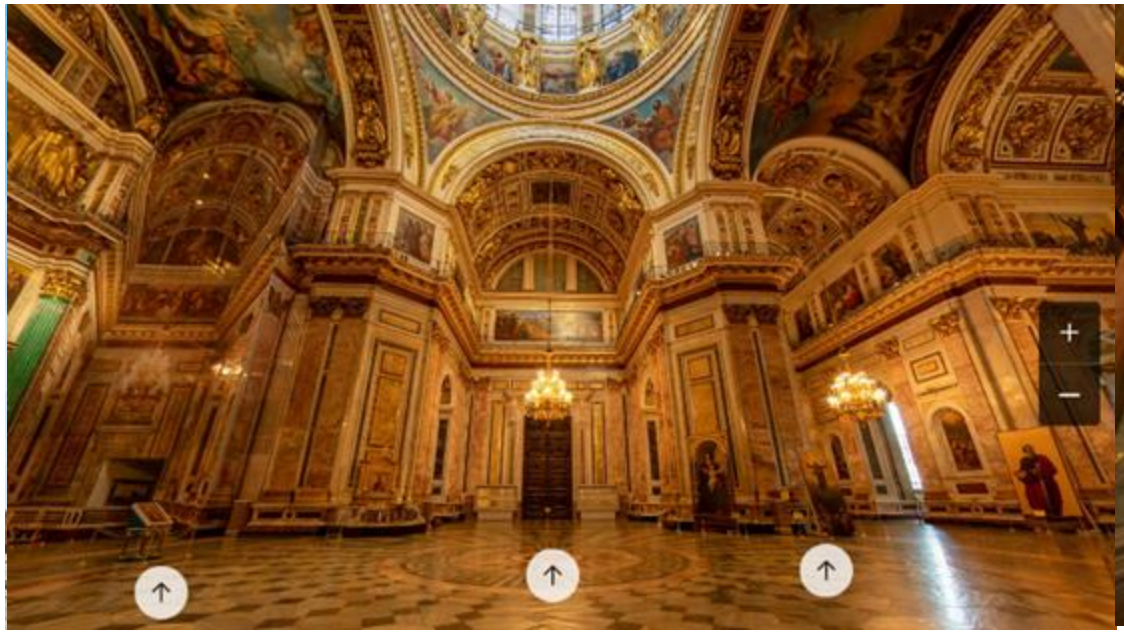

## 3D MODEL OF NOTRE DAME

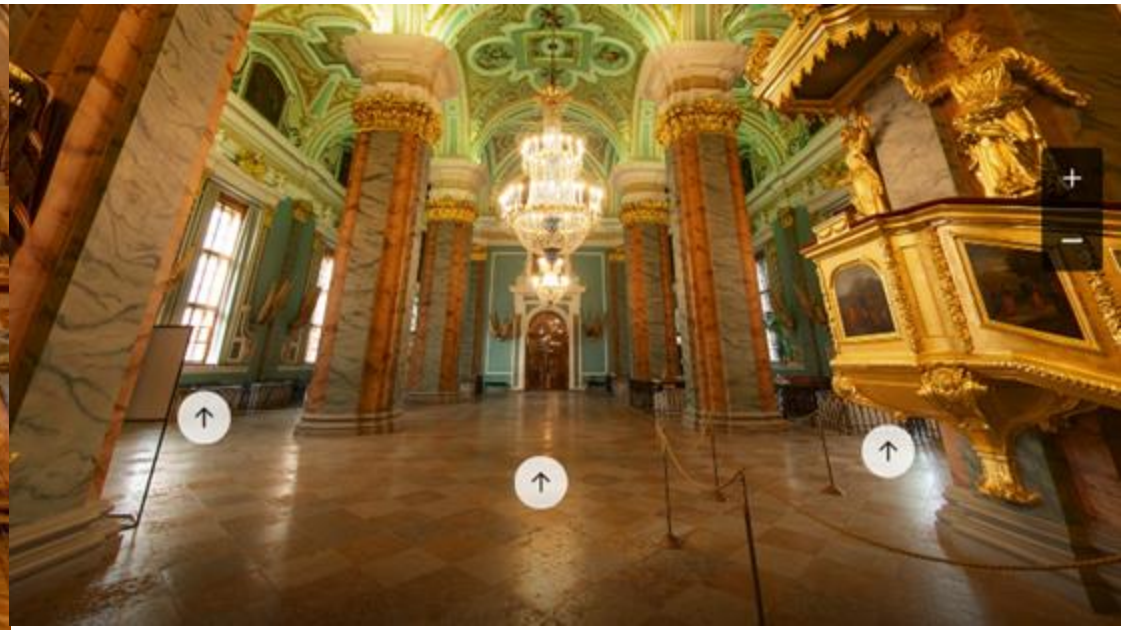
From 2010 to 2013, AGP specialist Laurence Stephanon also worked on the historical reconstruction of Notre Dame. The result was a grandiose 3D model covering 14 stages of construction, from 1163 to the present day.

WHY IS THIS SO RELEVANT?

# ONLINE TOURS

We can create unique online tours and tours that would be especially relevant to people who can't visit these places



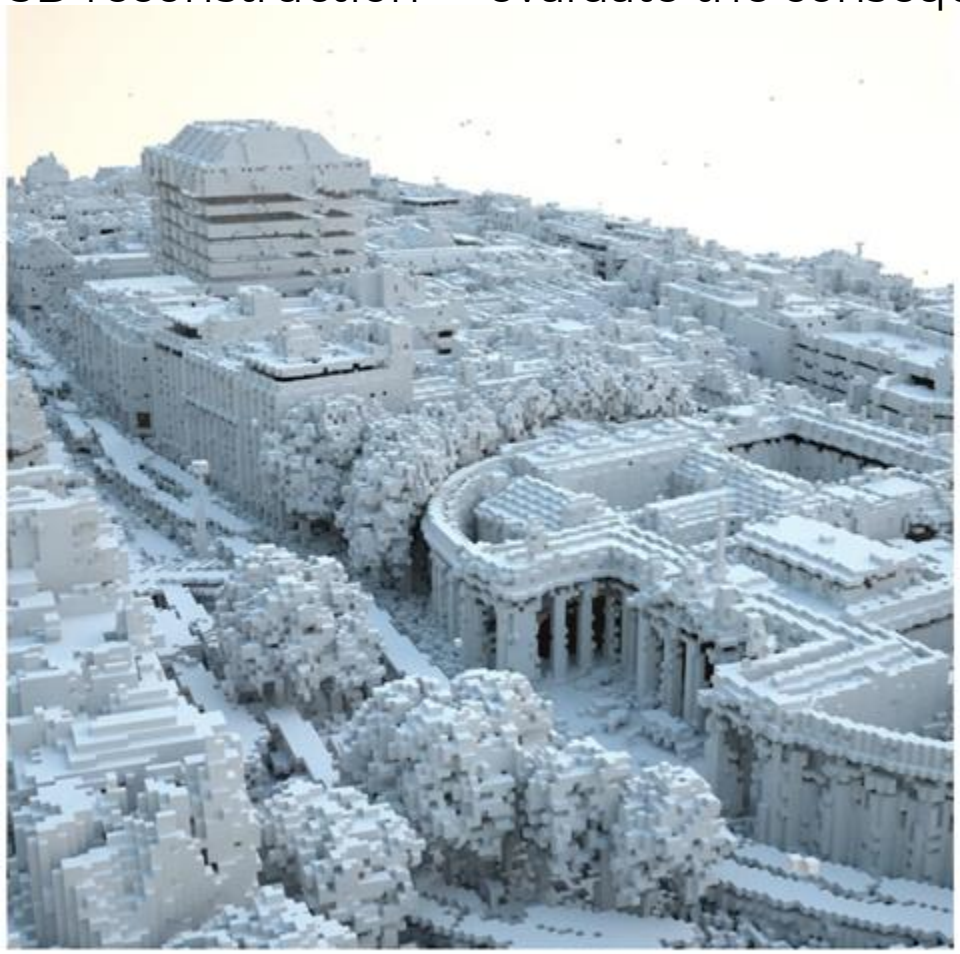


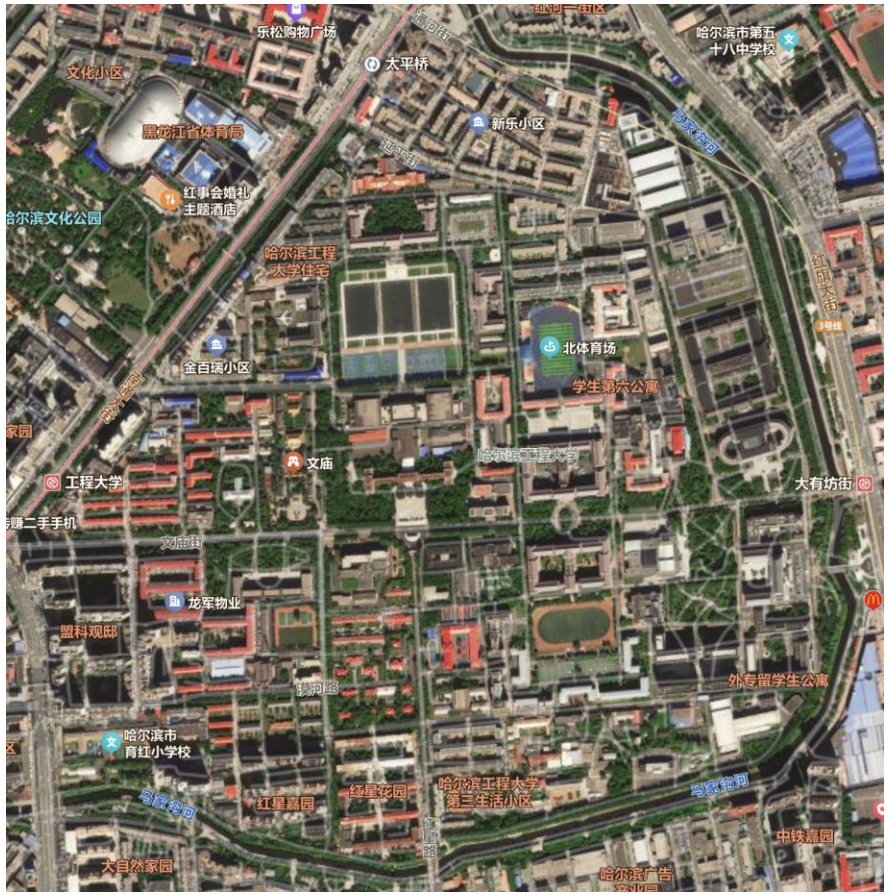
ST. ISAAC'S CATHEDRAL and  PETER AND PAUL CATHEDRAL
(VK online tour)

WHY IS THIS SO RELEVANT?

# URBAN PLANNING, MODELING, MAPPING

3D reconstruction -> evaluate the consequences of building a tunnel

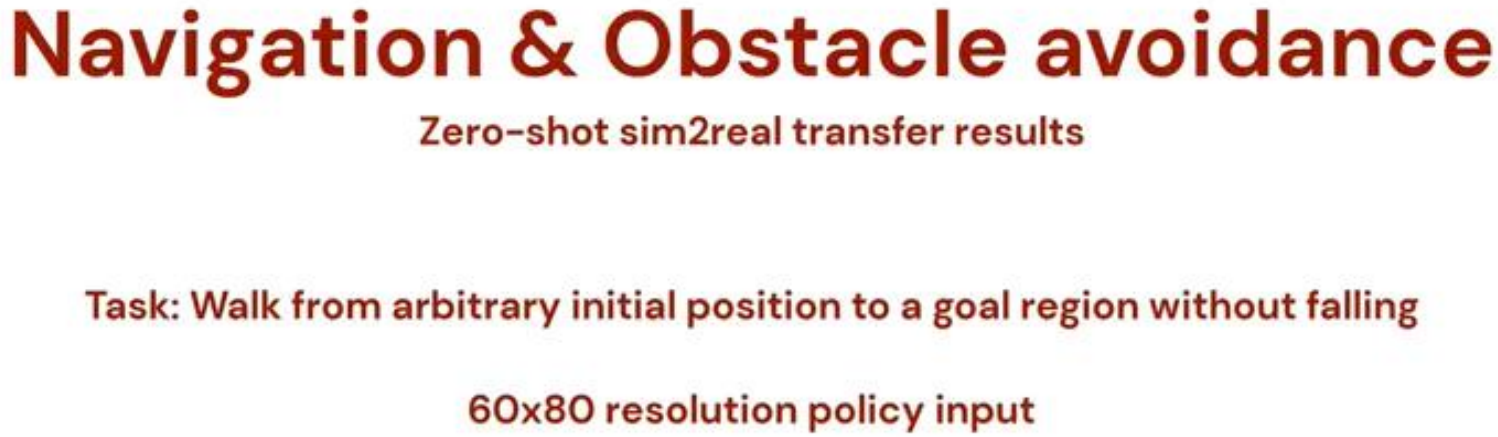




# ROBOTICS


The robot performs 3D reconstruction to determine where to grasp objects

# ROBOTICS

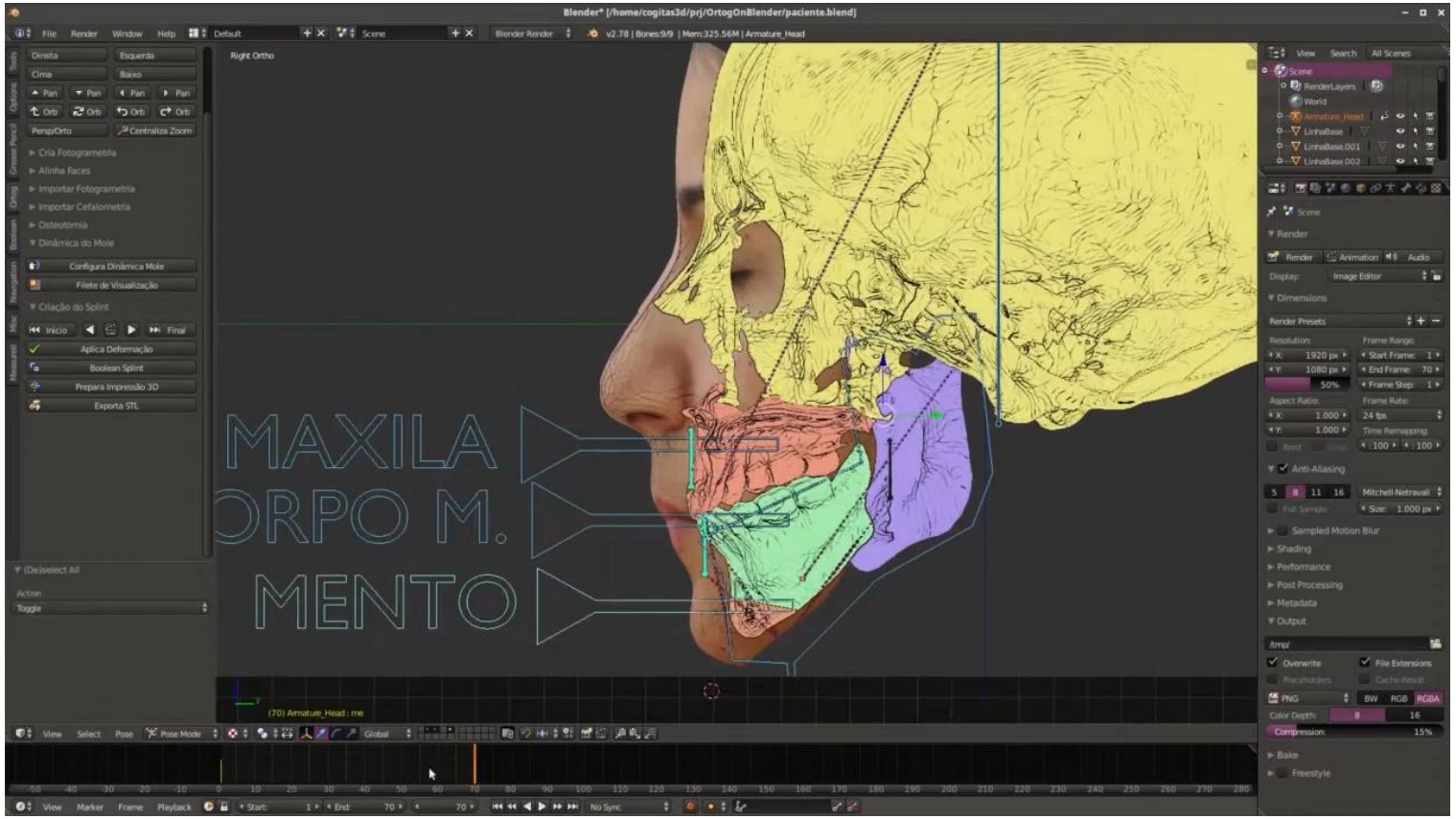



3D reconstruction was used to train the controlling algorithm in realistic simulation

WHY IS THIS SO RELEVANT?

# MEDICINE

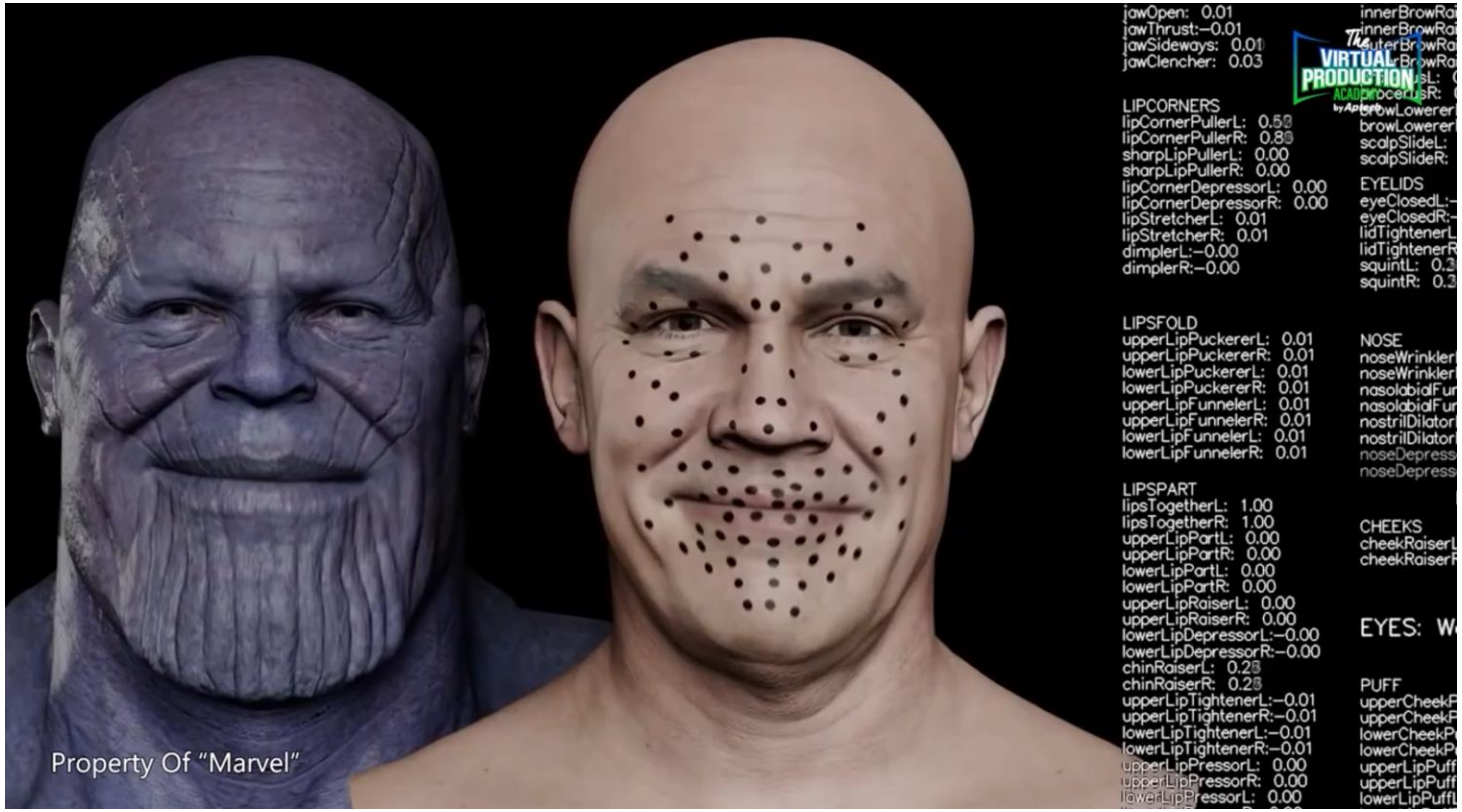
## Virtual Surgical Planning



WHY IS THIS SO RELEVANT?

# 3D AVATARS

Reconstruction of the human face can be applied both in medicine and in the entertainment industry. The idea of 3D avatars for virtual reality is quite popular.



# COURSE OBJECTIVES

- Learn how to perform 3D reconstructions (at basic level)
- Understand 3D reconstruction methods and the underlying general concepts
- Be able to further and broader study the topic
- Learn basics of Deep Learning
- Practice academic and technical English, improve programming skills

# CLASS ROADMAP

- **Applications of 3D Reconstruction**
- **Course objectives**
- Getting to know each other
- Introduction to COLMAP
- Setting up COLMAP and other software
- 3D Data Representations
- Course Program and Organization

**If you don't understand something, just ask**

# INSTRUCTOR

## Oleg Voynov

**Previously:**

MSc in Applied Mathematics and Physics

**Currently:**

Senior research engineer at
AI Center, Skoltech, Moscow, Russia
Researcher at AIRI, Moscow, Russia

**Research Interests:**

Deep learning for 3D Computer Vision,
3D Reconstruction, 3D Generative Modeling

# INSTRUCTOR

## Artem Komarichev

**Previously:**

Ph.D. in Computer Science,
Wayne State University, Detroit, USA
Supervisor: Prof. Zichun Zhong

**Currently:**

Head of Research Group, Skoltech, Russia

**Research Interests:**

3D Computer Vision
3D Geometric Deep Learning
Scene / Object Reconstructio and Analysis

# STUDENTS

Introduce yourself

- Your name
- Undegraduate / graduate student?
- Your major
- Why did you choose this course?

# STUDENTS

Do you have experience with

- Python
- Jupyter
- numpy
- Deep Learning
- Machine Learning
- PyTorch / Tensorflow / JAX
- Computer Vision

Your laptop

- Win / Mac / Linux
- GPU

# COLMAP demo

- Install COLMAP
- Install Meshlab
- Run COLMAP
- Run Meshlab

# COURSE PROGAM PART 1

Foundations of 3D reconstruction and stereo vision

- Feature detection and matching, SIFT, RANSAC
- Pinhole camera model, lens distortion models, homogeneous coordinates, rigid transformations, multi-view geometry
- Structure from motion, Bundle adjustment
- Dense two-view and multi-view stereo reconstruction

# COURSE PROGAM PART 2

Introduction into Deep Learning and Computer Vision

- Foundations of Learning (perceptron, backpropagation, etc.)
- Neural Architectures for Vision (CNNs, Transformers, etc.)
- Deep Learning Applications

Fundamentals of Volumetric Rendering and Radiance Fields

- Introduction into Volumetric Rendering
- Concept of Radiance Fields
- Introduction into 3D Gaussian Splatting (3DGS)

Current Research and Future Direction

- 3DGS problems to address

# EVALUATION

Programming exercises in class / at home: basic application of learned knowledge

Course project, basic: obtain 3D reconstruction with COLMAP for you data, improve the baseline

Course project, advanced: try to improve 3D Gaussian Splatting method

# HOMEWORK

Setup miniconda

https://www.anaconda.com/docs/getting-started/miniconda/install

Install Jupyter

https://jupyter.org/install

Install numpy and go through the tutorial

https://numpy.org/doc/stable/user/quickstart.html

# Have fun!