

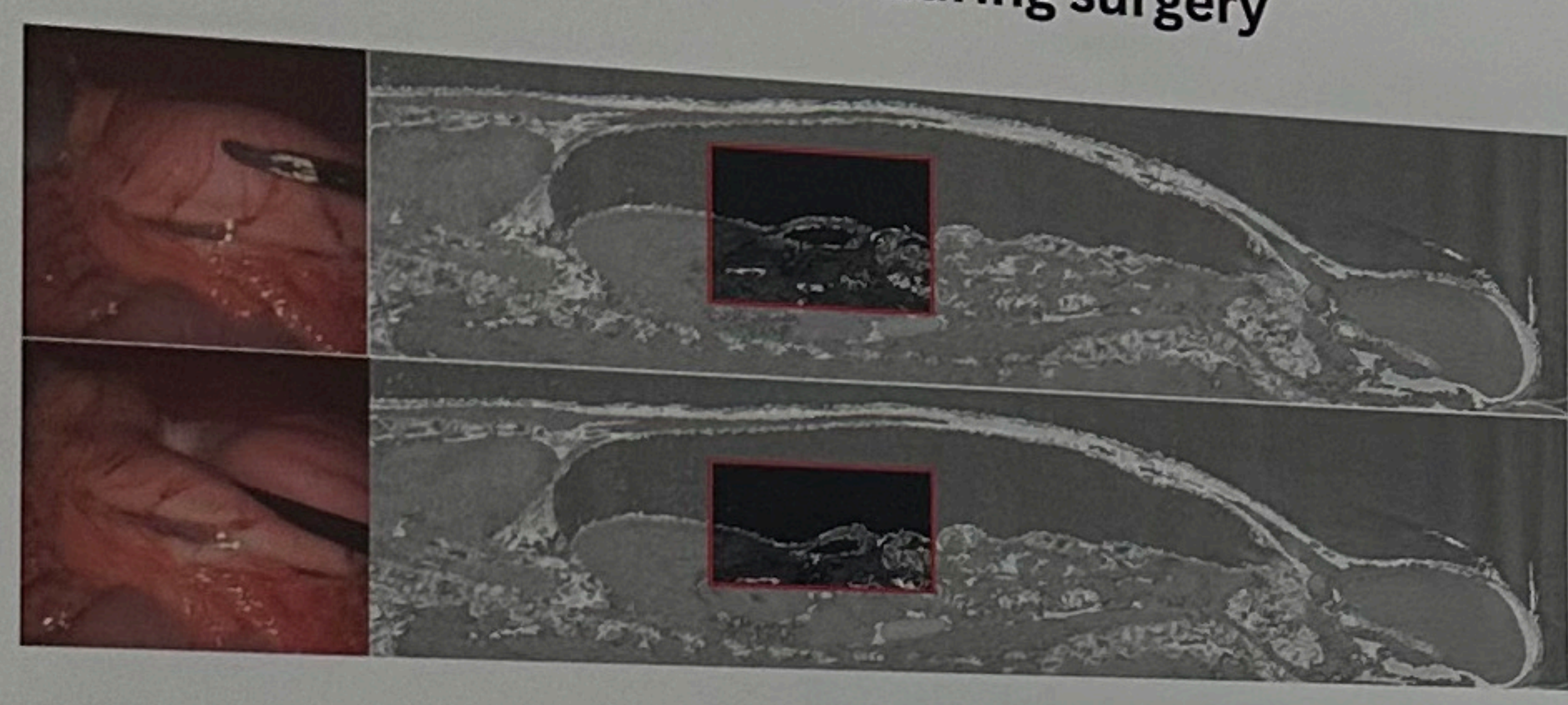
BridgeSplat: Bidirectionally Coupled CT and Non-Rigid Gaussian Splatting for Deformable Intraoperative Surgical Navigation

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Motivation

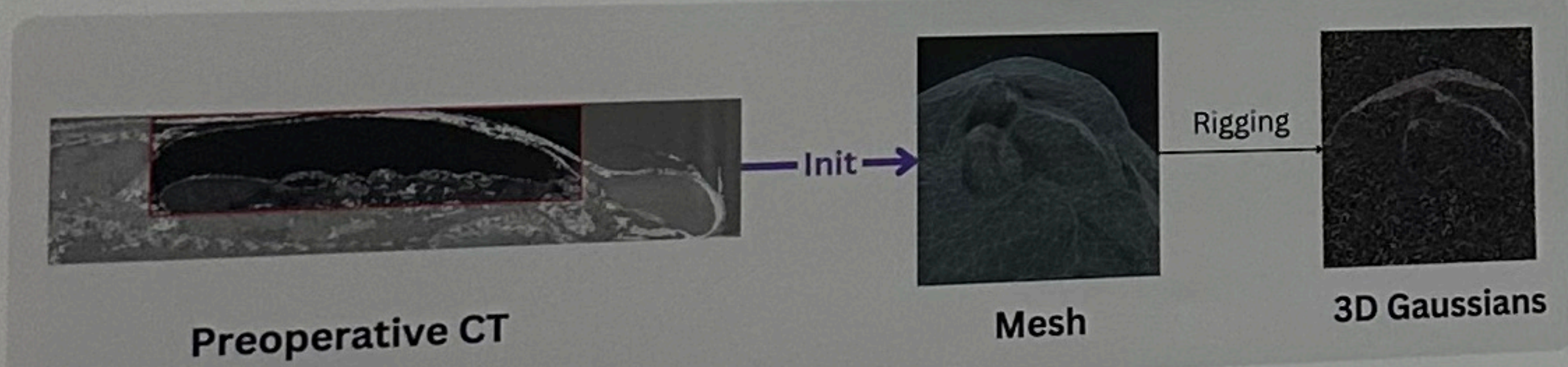
- Currently, there are no (deformable) navigation systems for visceral surgery
- Problem: Rigid registration is not sufficient for navigation in highly non-rigid scenes**
- Goal: Using initial rigid registration and monocular laparoscopic video to deform preoperative CT during surgery**



Preop: Coupling CT & 4DGS

- We parametrize **3D Gaussians w.r.t. a mesh of the abdominal cavity** extracted from preoperative CT

Initialization



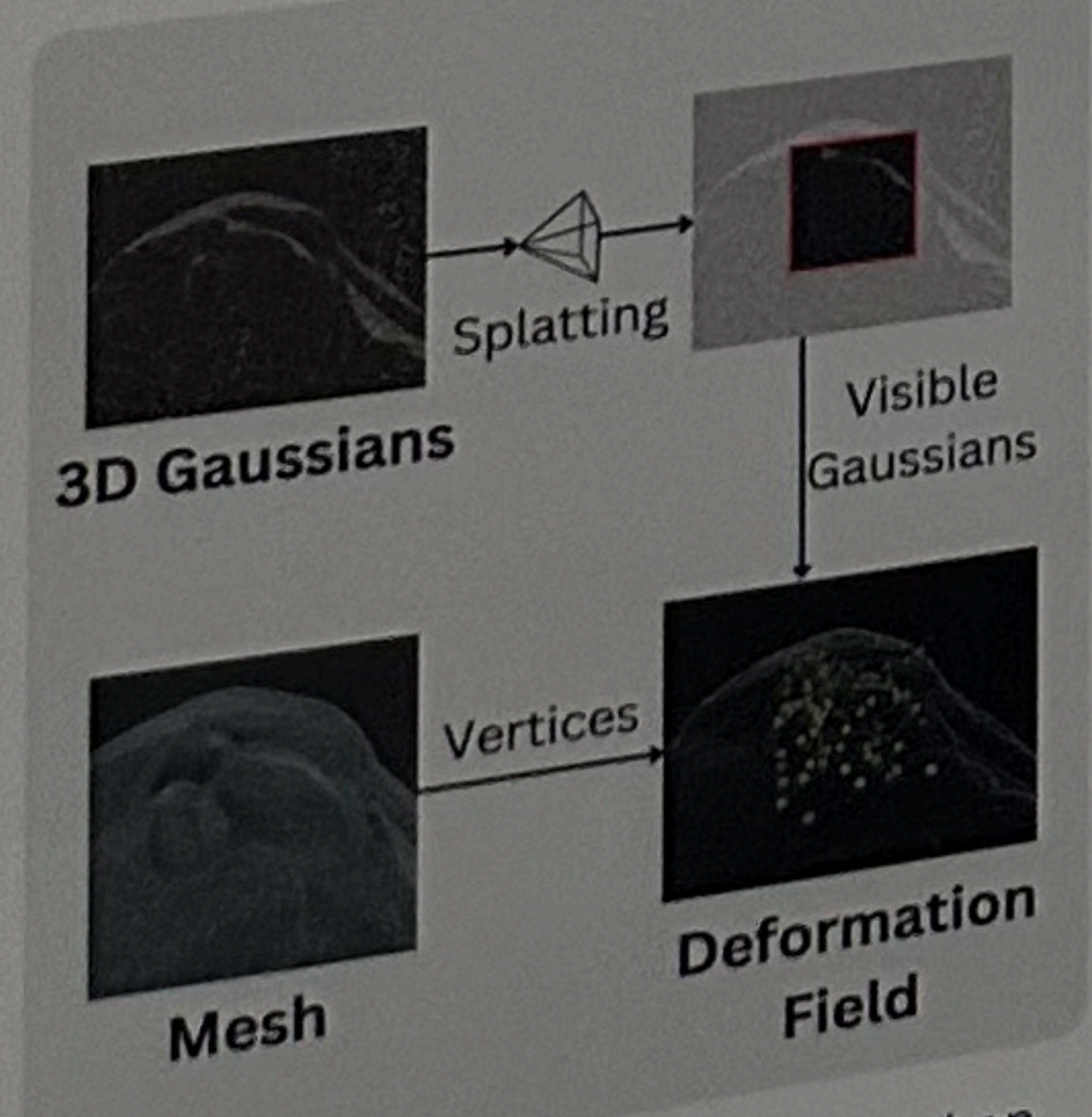
Intraop: Deforming CT via 4DGS

- Initial rigid registration & tracked imaging (laparoscope)**
- Satisfying the photometric loss drives **optimization of deformation field that can be propagated to CT**

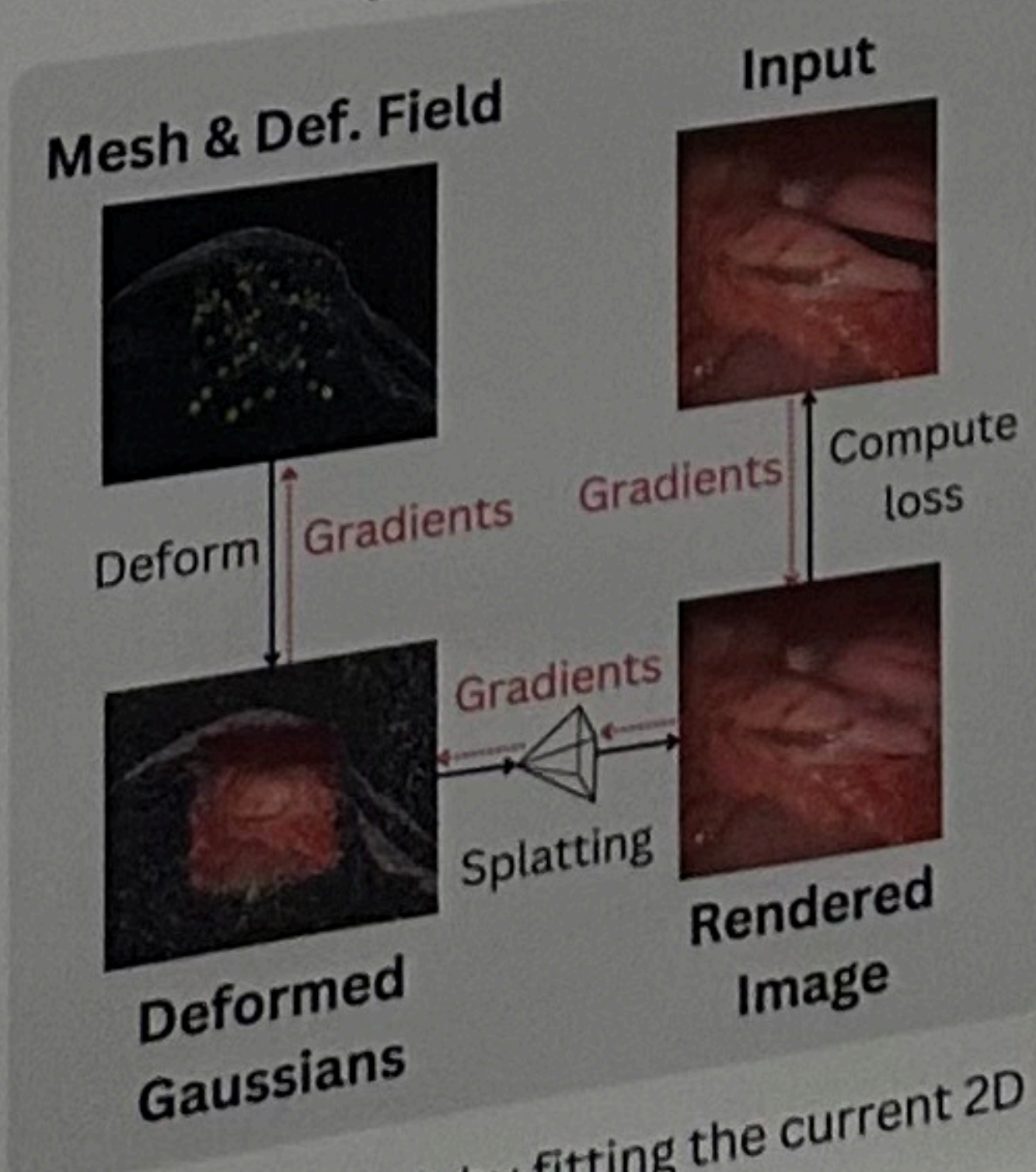


Optimization

First Frame



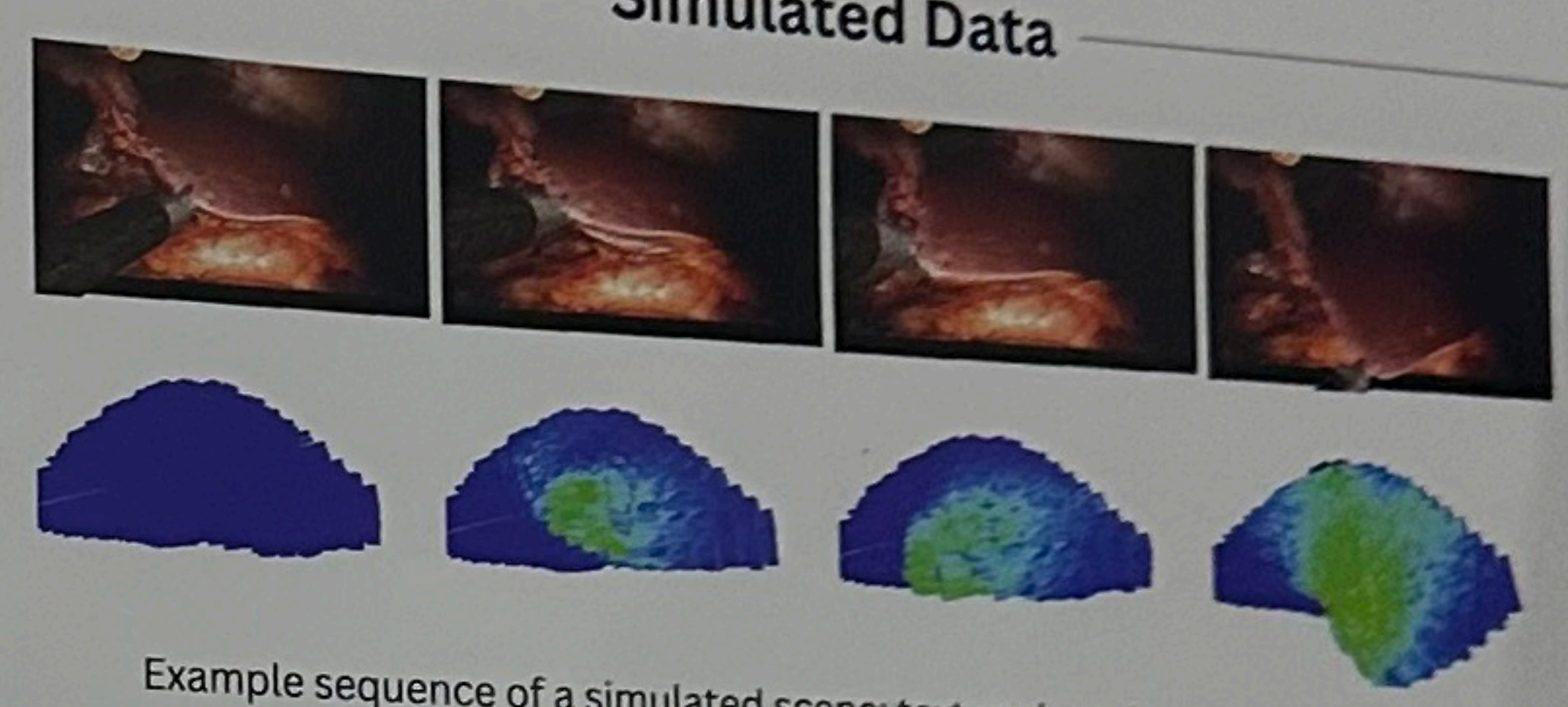
Initialize deformation field based on visible vertices



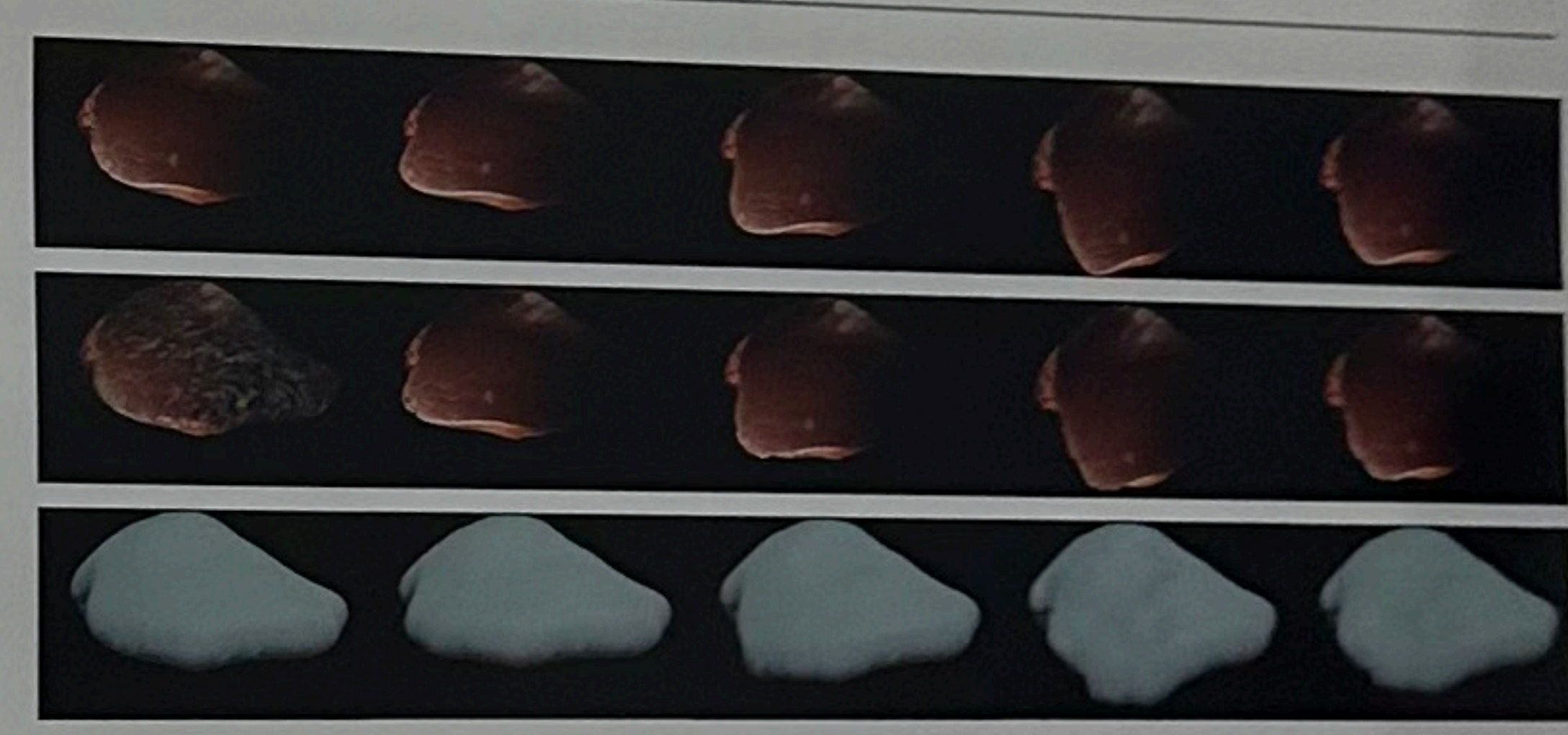
Deforming mesh by fitting the current 2D image observation

Results

Simulated Data

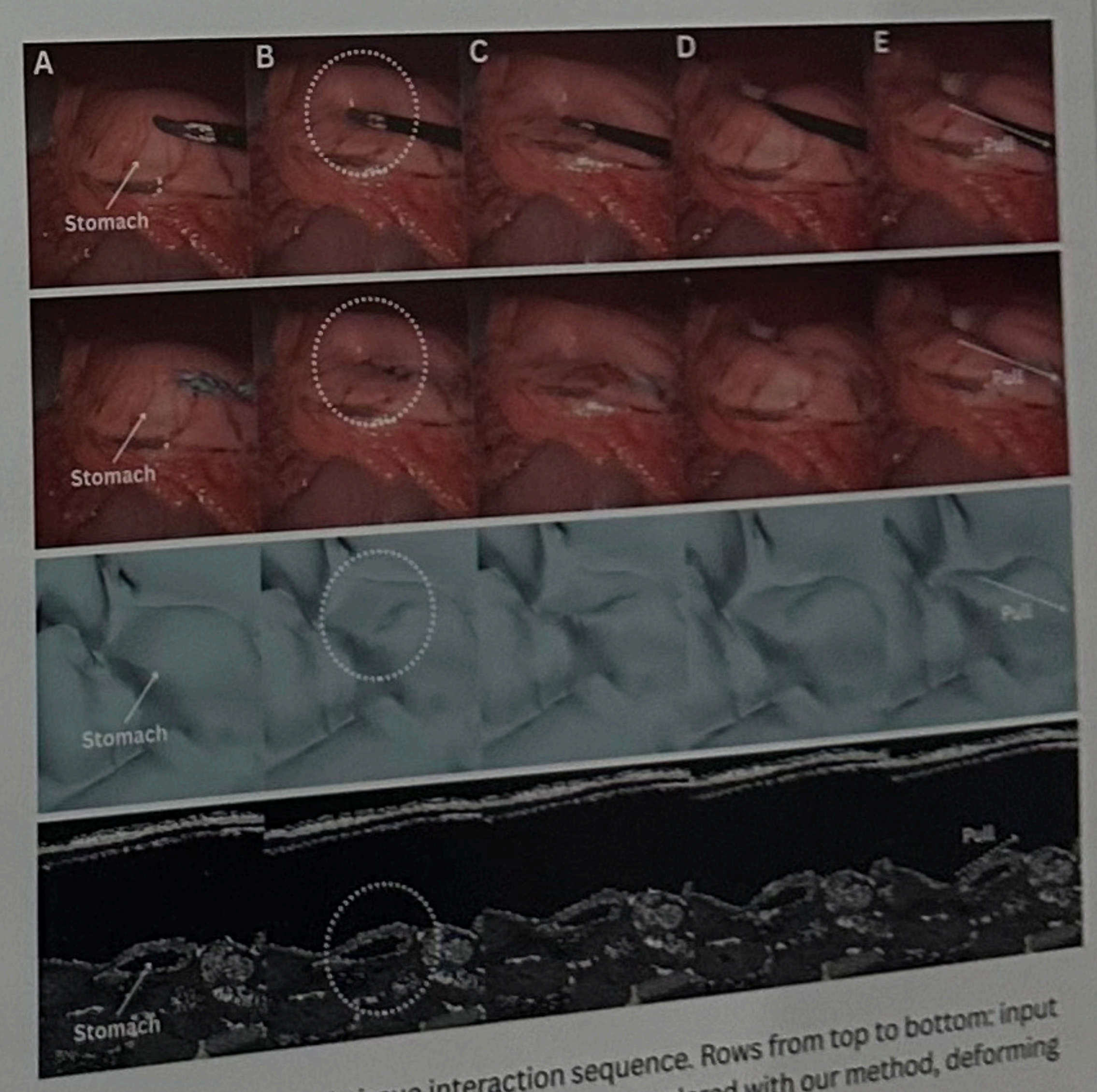


Example sequence of a simulated scene: textured mesh, tool, and a realistic background, underneath the 3D model with stress



Exemplary results on a simulated sequence. Input image, rendered image from Gaussian Splatting, and deformed mesh

Clinical Data



Examples from a tool-tissue interaction sequence. Rows from top to bottom: input images acquired by the laparoscope, images rendered with our method, deforming mesh, and deforming CT

Quant. Evaluation on Simulated Data

Metric	SimIn	SimDown	SimLeft	SimCircular	SimUp
Euclidean Distance (mm)	0.11±0.19	0.14±0.27	0.09±0.16	0.10±0.19	0.12±0.24
Max Euclidean Distance (mm)	3.17	4.29	2.78	4.15	2.84

Quantitative evaluation on the simulated dataset with Euclidean distance and maximum error (in mm) on five simulated tool-tissue interaction sequences