VeGaSMedical - Spatiotemporal Gaussian Modeling for Ultrasound Interpolation and Anatomical Mesh Generation

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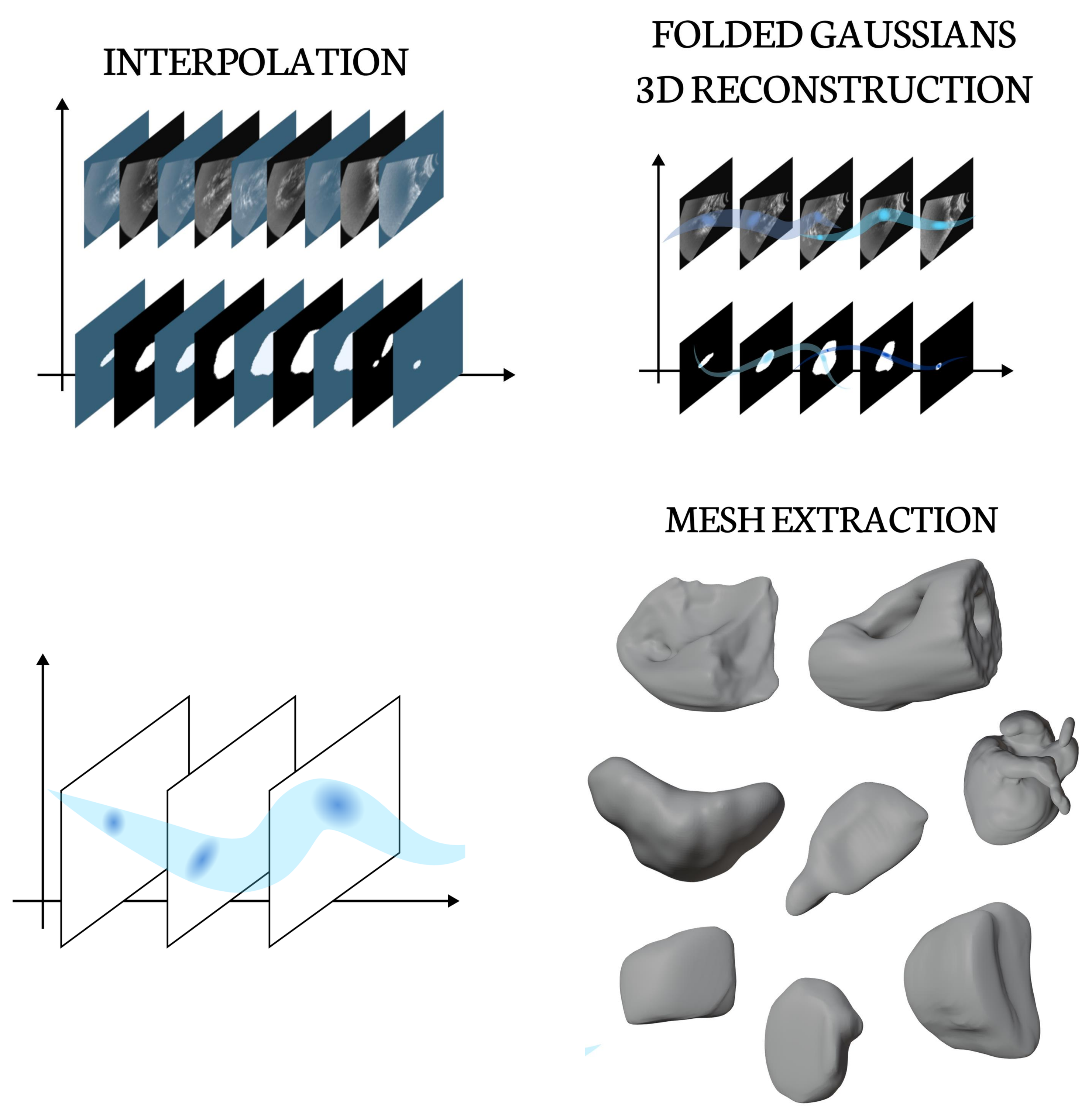
Abstract



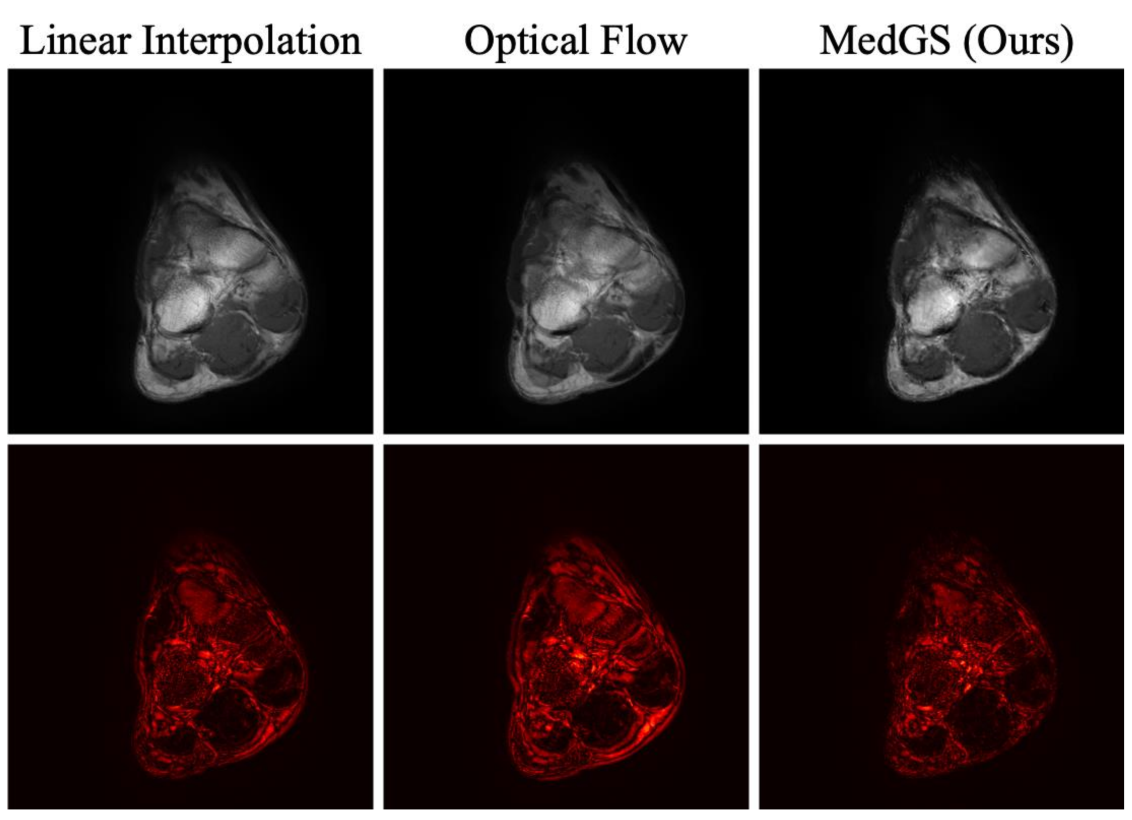
Multi-modal 3D medical imaging (ultrasound, MRI, and CT) enables detailed, non-invasive visualization of anatomy. However, reconstructing accurate 3D surfaces from noisy or incomplete frames remains a major challenge.
We introduce **MedGS**, a framework that uses Gaussian Splatting for interpolation and 3D modelling.

Key Features:

- Represents 2D imaging frames as Gaussian distributions in 3D space
- Enables robust frame interpolation and high-fidelity surface reconstruction
- Allows flexible editing and reduces reconstruction artifacts
- Accurately models complex anatomical structures

Method

MedGS utilizes the findings of VeGaS representation for efficient 3D medical image reconstruction. The model is trained using 2D medical images. Original images are used for interpolation, while binary masks guide mesh reconstruction.
For interpolation, the input frames are modelled as 3D Folded-Gaussians that capture both spatial and temporal information. To handle noise, we introduce **In-Between Frame Regularization**, which generates synthetic frames between real ones. This improves smoothness, reduces artifacts, and enhances interpolation accuracy. Temporal consistency is enforced by constraining each Gaussian's time spread, ensuring stable and coherent transitions.



Mesh Quality

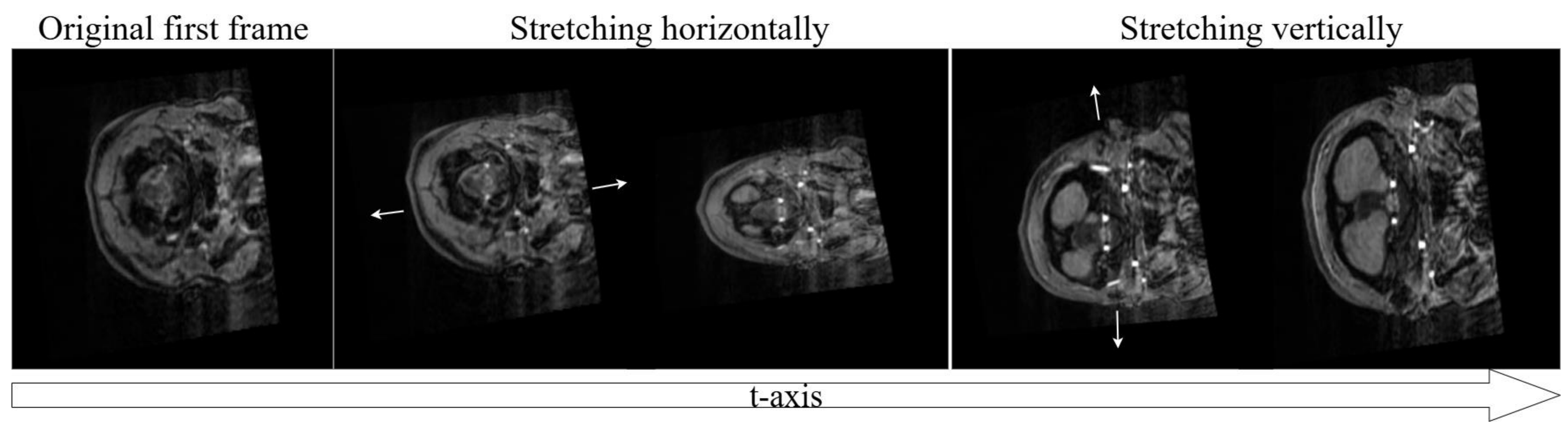
For mesh reconstruction, binary masks are trained directly without any regularization. The interpolated masks are subsequently converted into detailed 3D surfaces using the **Marching Cubes** algorithm

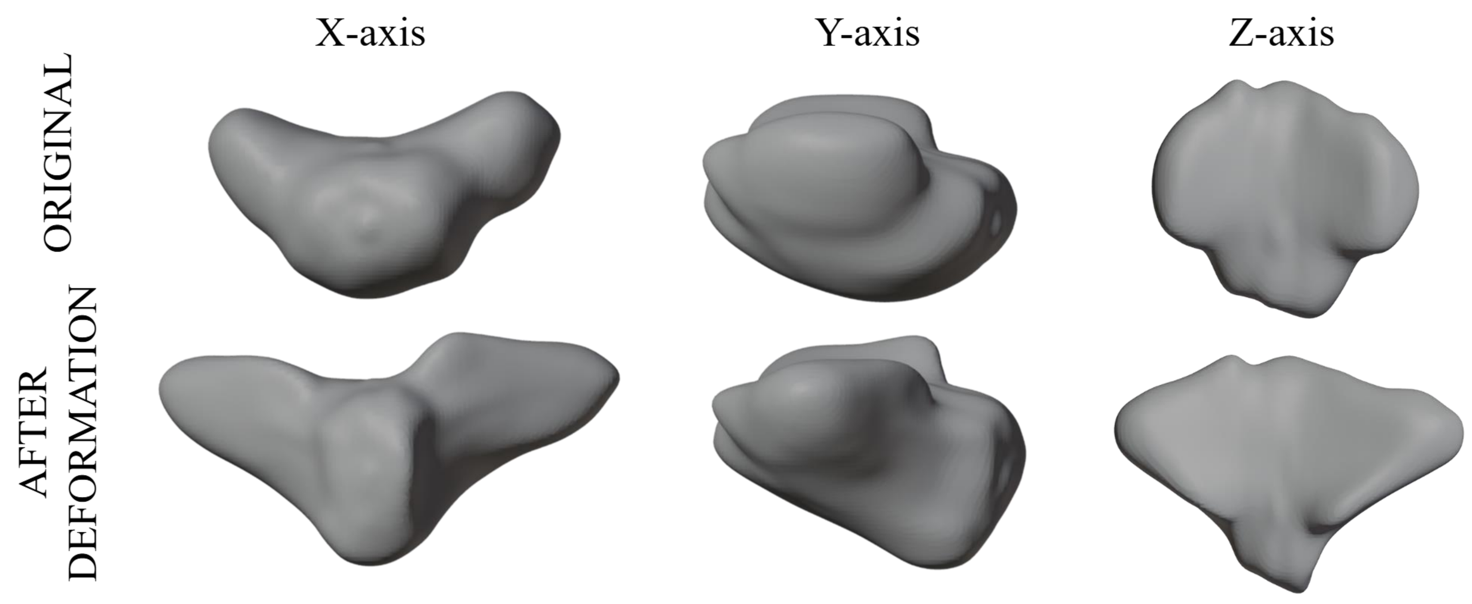
We present a table summarizing the averaged mesh reconstruction results, reporting Chamfer Distance (CD), Hausdorff Distance (HD), and 95th Percentile Hausdorff Distance (HD95).

Method	CD ↓	HD ↓	HD95 ↓
Baseline	0.228	0.755	0.390
FUNSR	0.228	0.835	0.400
Poisson	0.211	0.920	0.374
MedGS	**0.203**	**0.683**	**0.365**

Overall, **MedGS** provides a unified, noise-robust, and temporally consistent solution for 3D medical image reconstruction. Its design enables efficient interpolation, accurate mesh generation, and reliable modelling of complex anatomical structures, making it suitable for multi-modal imaging applications such as MRI, CT, and ultrasound.

Deformation Ability





- **MedGS** offers strong editing flexibility.
- Each model is built from 3D Folded-Gaussians, which can be conditioned on time to form 2D Gaussian components
- Each 2D Gaussian is defined by **three points** - the centre and two eigenvectors - allowing **manual adjustment** for realistic edits. This Enables intuitive, precise, and realistic modifications of reconstructed anatomy.

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Acknowledgments

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