

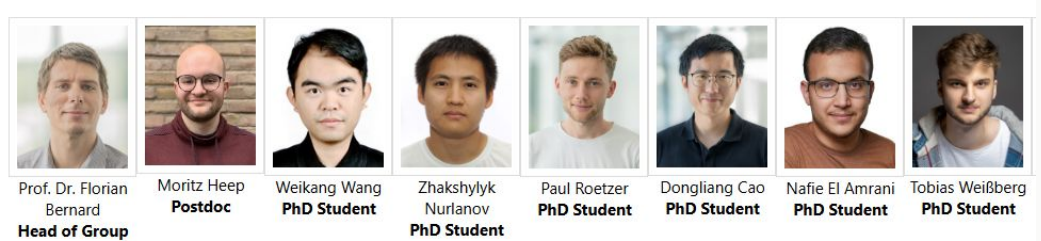
# **Master Lab, Master Seminar and BACHELOR PROJEKTGRUPPE**

OFFERED BY THE  
**LOVC, GML & AISD Groups**

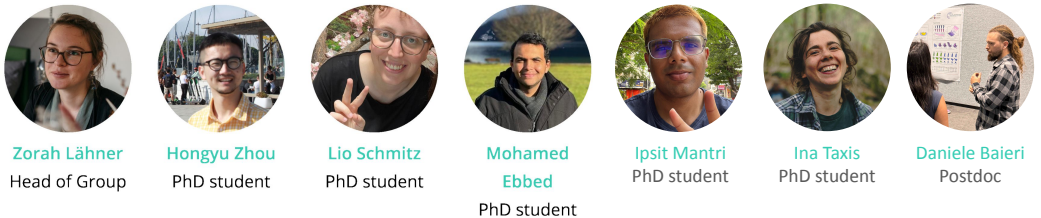
INSTITUTE OF COMPUTER SCIENCE II VISUAL COMPUTING DEPARTMENT

# Groups

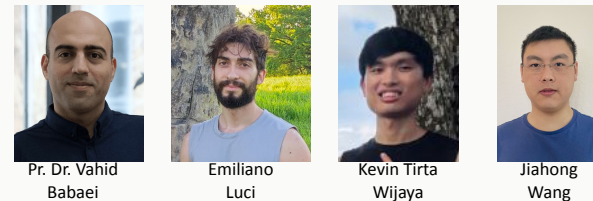
## LOVC Group (Prof. Dr. Florian Bernard):



## Geometry in ML Group (Prof. Dr. Zorah Lähner):



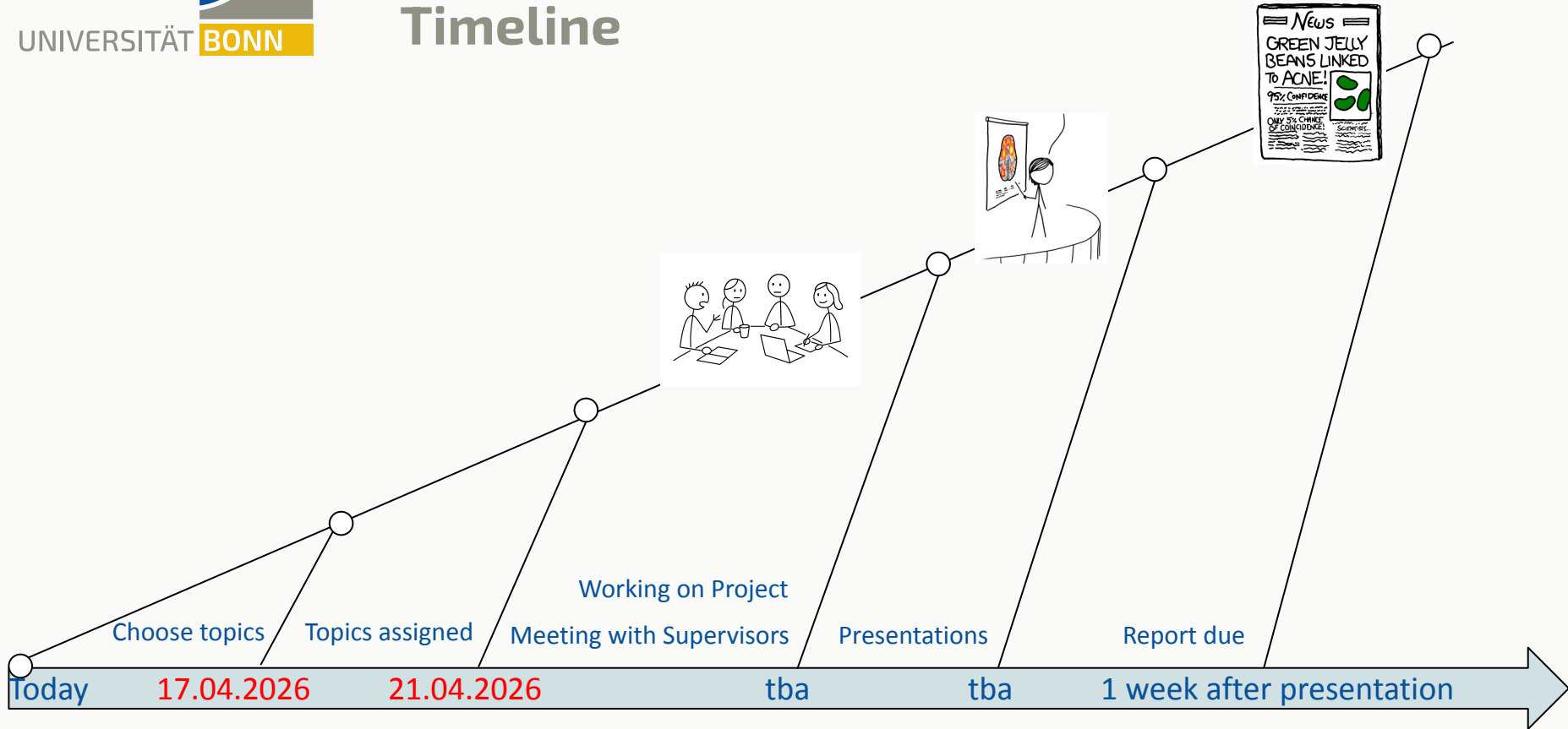
## AI aided Scientific Discovery Group (Prof. Dr. Vahid Babaei):



# Schedule

1. General rules for Bachelor Projektgruppe/Master Lab/Master Seminar
2. **16** Topics for Bachelor Projektgruppe/Master Lab/Master Seminar offered by Learning and Optimisation for Visual Computing Group (LOVC)
3. **4** Topics for Master Lab offered by AI aided Scientific Discovery Group (AISDG)
4. **9** Topics for Bachelor Projektgruppe/Master Lab/Master Seminar offered by Geometry in Machine Learning Group (GML)

# Timeline



# Overview

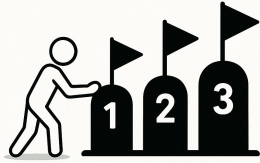
## Workload:

- Literature reading (Seminar, MLab, BPG)
- Implementation (MLab, BPG)

## Grading:

- Presentation
- Report

# Supervision

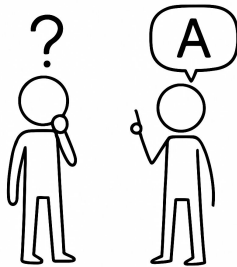


**MILESTONE  
SETTING**

Milestones setting



Meeting (usually weekly)



Answering questions



**GIVING ADVICE ON A  
PRESENTATION  
REHEARSAL**

Presentation practice

# Presentation

- Present your work at the end of the semester:  
20mins talk + 5mins Q&A/person
- Slides for the talk:  
Discuss the structure with your supervisor before you start.  
Trial talk is always a nice option to see if the talk matches the expectations
- Basic requirements:  
Slide numbers  
References for figures or text that you directly took from somewhere

# Report

- Hand in until **1 weeks after the presentation!**
- Written in LaTeX:
  - Template available at <https://cg.cs.uni-bonn.de/courses>.
  - BPG & M Lab** (around **10** pages) and **M Sem** (around **5** pages) in length. (excluding the reference)
- Sound and comprehensible summary of provided literature and the experiments in your own words.
- Adhere to scientific standards:
  - Provide proof for your statements(if any).
  - Use references to make your sources transparent.
- State the work division if working in group

## Report (NEW)

- **Only for Master Seminar.**
- It is possible to write the report as a blog post.
- The blog can:
  - Be published online (voluntarily).
  - Should be roughly equivalent to around 5 PDF pages.

## Embargo restrictions (MLab Only)

1. For those affected by embargo restrictions, pls also apply to the examination office
2. Application should be done together with registration

## Topic selection

- Interested in a topic?

Contact Nafie El Amrani ([n.elamrani@uni-bonn.de](mailto:n.elamrani@uni-bonn.de)) ( $\geq 3$  topics - 17.04.2026)

- Slides for organization and topics are available on our homepage:

<https://lovc.cs.uni-bonn.de/index.php/teaching/>

<https://geometryinml.cs.uni-bonn.de/teaching/>

( slides only accessible while in Uni Bonn network)



# **Master Lab, Master Seminar and BACHELOR PROJEKTGRUPPE**

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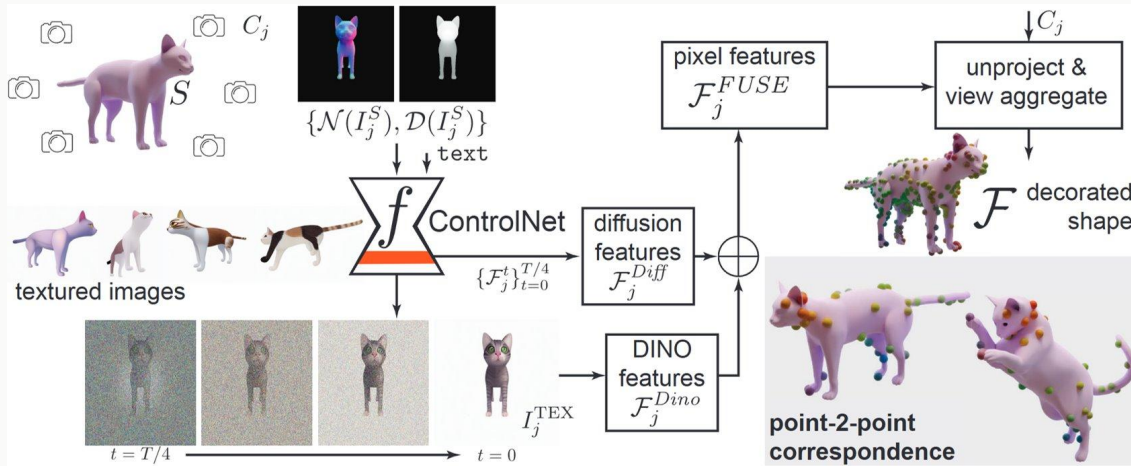
**Learning and Optimisation  
for Visual Computing (LOVC) GROUP**

INSTITUTE OF COMPUTER SCIENCE II VISUAL COMPUTING DEPARTMENT

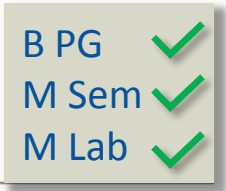
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# LOVC1: From Images to Geometry and Back

- Geometry descriptors can be obtained by rendering the geometry and applying a texture using diffusion models
- Feeding these features through ViTs returns a image features which are reprojected onto the geometry
- What if we already know, what the object looks like from a reference image? Can we use this reference to steer the diffusion process and obtain more accurate features?
- **Goal:** Explore and implement diffusion priors based on image inputs

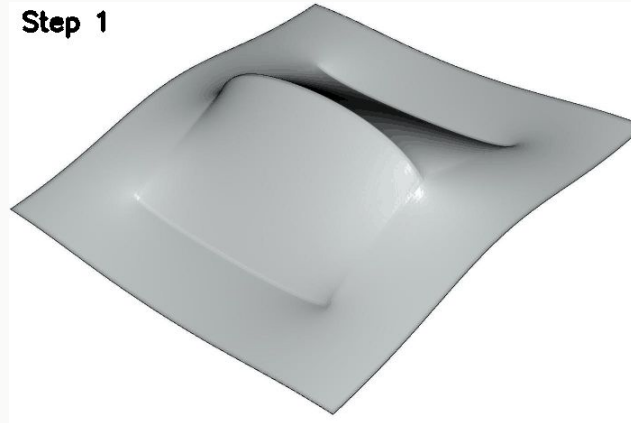


Dutt et al. *Diffusion 3D Features (Diff3F): Decorating Untextured Shapes with Distilled Semantic Features*. (CVPR, 2024)



## Domains

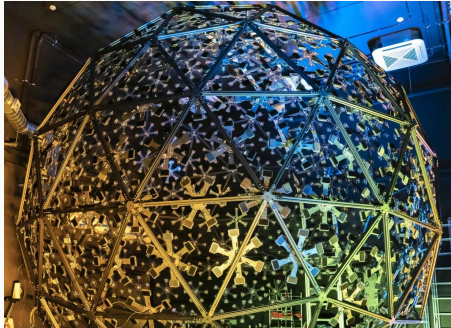
- Coarse-to-Fine approaches (for image processing tasks) and multigrid solvers (for solving PDEs) are well-established in their respective fields
- Combining both allows for example the reconstruction of a surface from its normals
- Performant solutions to PDEs in the image domain are underexplored
- **Goal:** Investigate multigrid strategies and apply them to irregular image domains



B PG ✓  
M Sem ✓  
M Lab ✓

# LOVC3: One Target to Calibrate them All

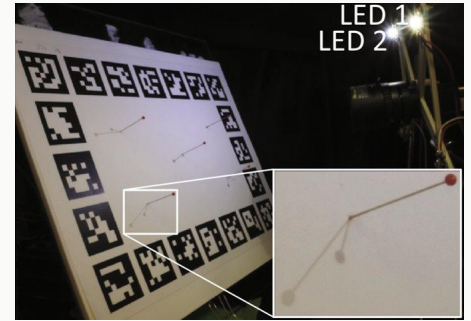
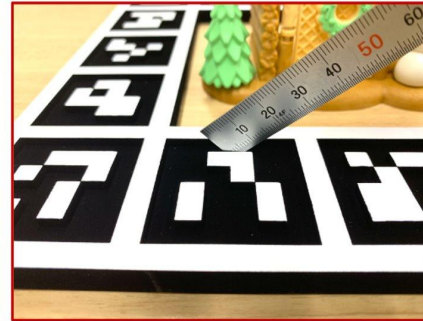
- Modern lightstages combine a multitude of components, e.g. cameras and lights but potentially also laser scanners.
- All these components need to be calibrated (positions, orientations, etc.)
- **Goal:** Combine all these modalities in a single calibration target



Light dome



Camera and laser scanner calibration [2]



Camera Calibration [1]

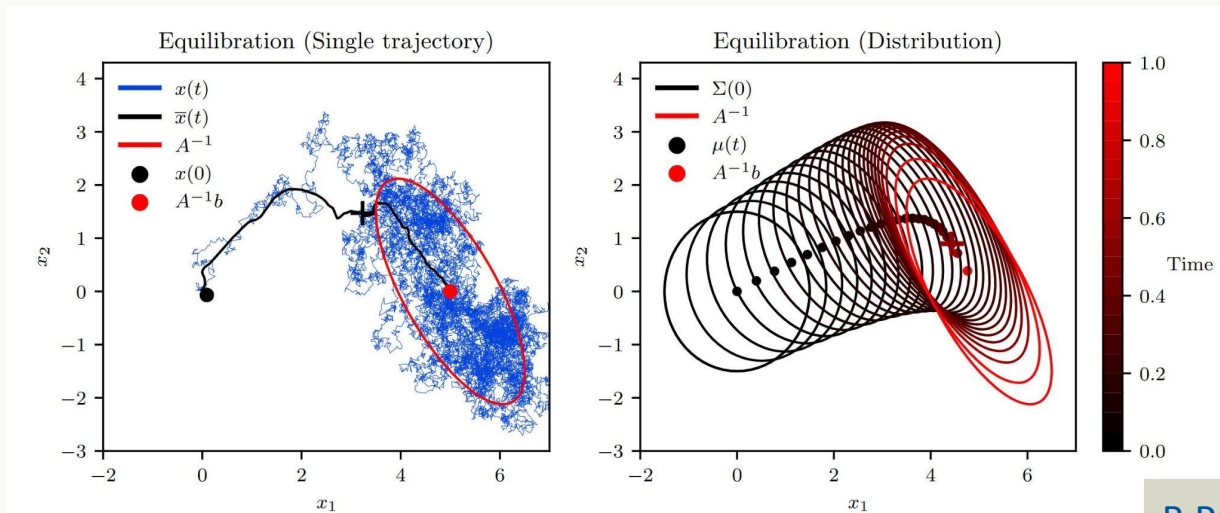
[1] H. Santo, M. Waechter, W.-Y. Lin, Y. Sugano and Y. Matsushita: Light Structure from Pin Motion: Geometric Point Light Source Calibration. (IJCV, 2020)  
 [2] L. Makabe, H. Santo, F. Okura, and Y. Matsushita: Shape-coded aruco: Fiducial marker for bridging 2d and 3d modalities. (WACV, 2022)

B PG ✓  
 M Sem ✓  
 M Lab ✓

# LOVC4: Thermodynamic Linear Algebra

- While quantum computing received a lot of attention, thermodynamic computing might be a more feasible approach for the near future.
- The idea is to use thermal fluctuations of a particle to perform various computational tasks

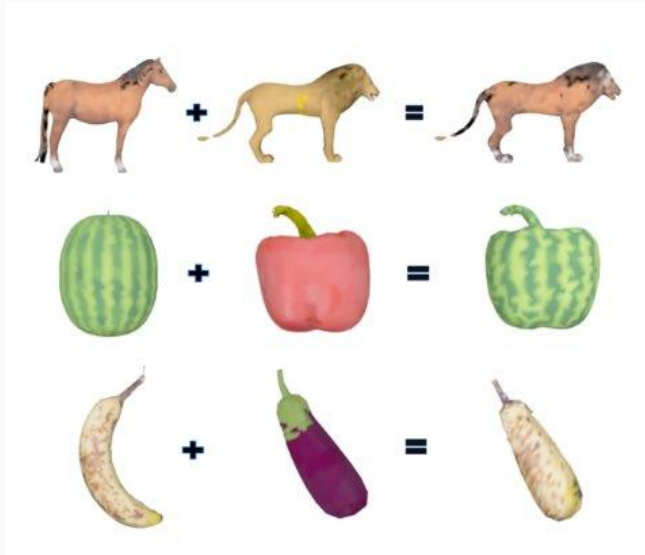
Matrix Solver:  $Ax = b$



B PG ✓  
M Sem ✓  
M Lab ✓

[1] M. Aifer, et al.: Thermodynamic linear algebra. (Unconventional Computing, 2024)

# LOVC5: DenseMatcher: Learning 3D Semantic Correspondence



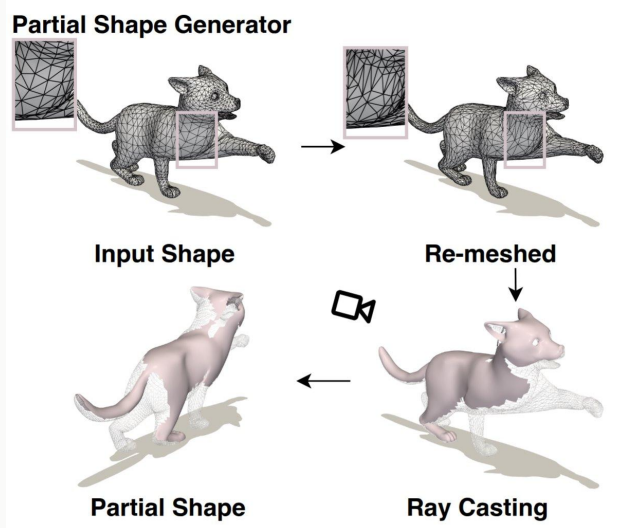
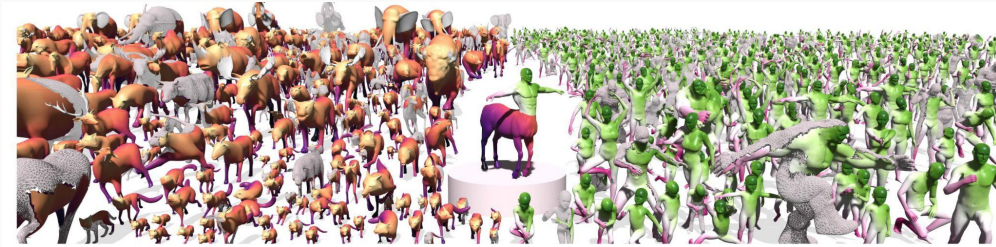
- DenseMatcher estimates dense 3D correspondences using 2D foundation model backbones and functional maps.
- It uses part labels as a soft supervision during training.
- Fully understand and be able to present the core idea of the paper. (M Sem)
- Reproduce the results and apply the method to new unseen categories and evaluate its performance. (B PG)
- Integrate an unsupervised soft label predictor (semantic matching) to avoid the need for the part labels for training (B PG, M Lab)

|       |   |
|-------|---|
| B PG  | ✓ |
| M Sem | ✓ |
| M Lab | ✓ |

Zhu, et al.: DenseMatcher Banana: Learning 3D Semantic Correspondence for Category-Level Manipulation from One Demo (ICLR 2025)

# LOVC6: Extending BeCoS benchmark

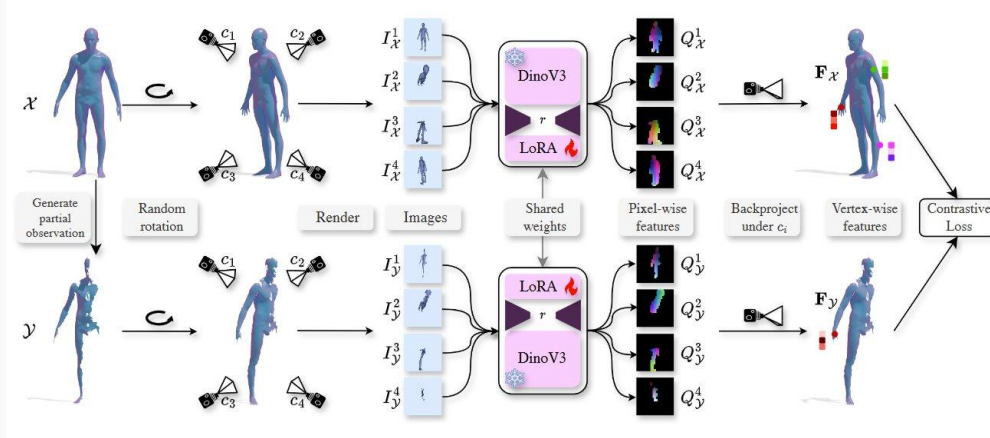
- BeCoS is a benchmark that provides ground truth correspondences between thousands of 3D deformable shapes from multiple categories.



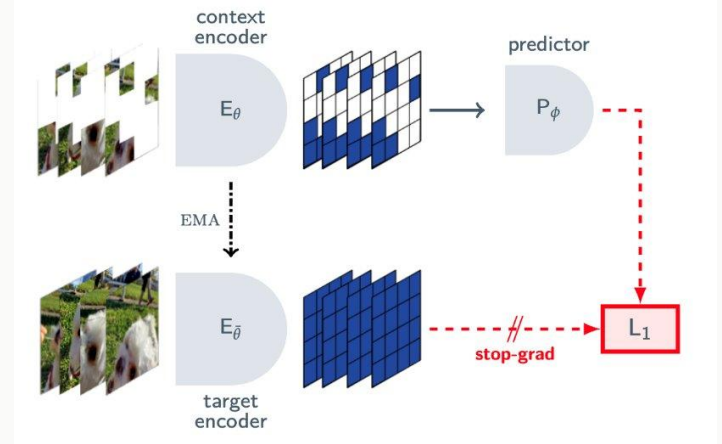
- Reproduce (part of) the results. (B PG, M Lab)
- The results of current shape matching methods on BeCoS are suboptimal. Investigate the reason behind this lack of performance and propose new ways to deal with matching of a highly non-isometric dataset. (B PG, M Lab)

|       |   |
|-------|---|
| B PG  | ✓ |
| M Sem | ✗ |
| M Lab | ✓ |

# LOVC7: Self-Supervised Pre-Training for Robust Non-Rigid 3D Shape Matching



V. Ehm, et al.: Teaching DINOv3 About Partial 3D Geometry: A Self-Supervised Geometry-Aware Approach (CVPR 2026)

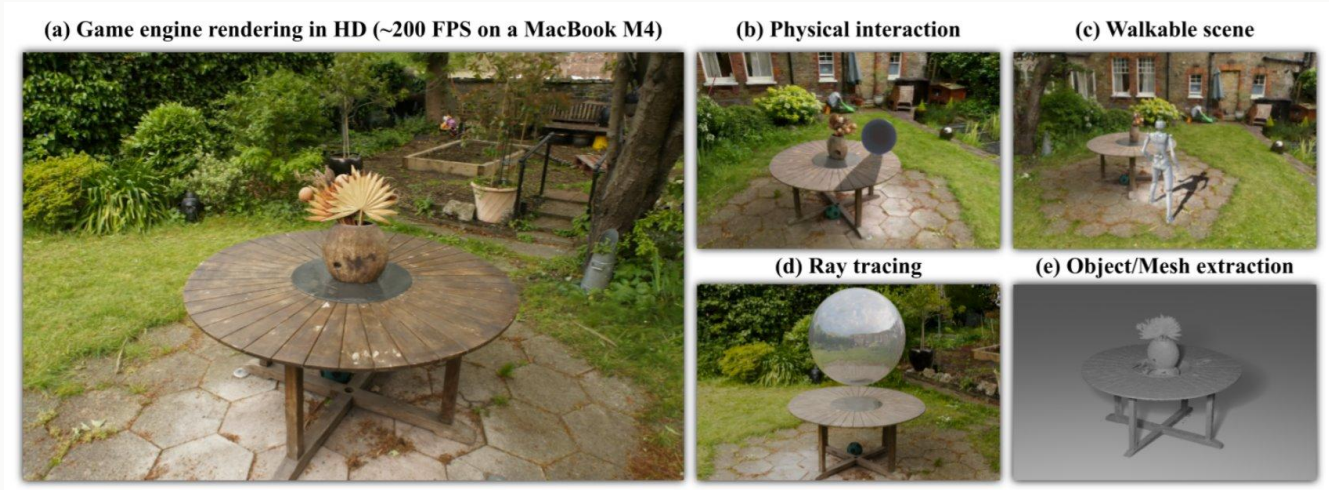


M. Assran, et al.: V-JEPA 2: Self-Supervised Video Models Enable Understanding, Prediction and Planning (arXiv 2025)

- Understand the core idea of the two papers. (B PG, M Sem, M Lab)
- Implement Teaching DINOv3 paper and find possible ways to integrate the idea of JEPA into the pipeline. (B PG, M Lab)
- Extend the idea of JEPA to improve the performance of self-supervised pre-training for non-rigid 3D shape matching (M Lab)

|       |   |
|-------|---|
| B PG  | ✓ |
| M Sem | ✓ |
| M Lab | ✓ |

# LOVC8: MeshSplatting: Differentiable Rendering with Opaque Meshes



*J. Held, et al.: MeshSplatting: Differentiable Rendering with Opaque Meshes (CVPR 2026)*

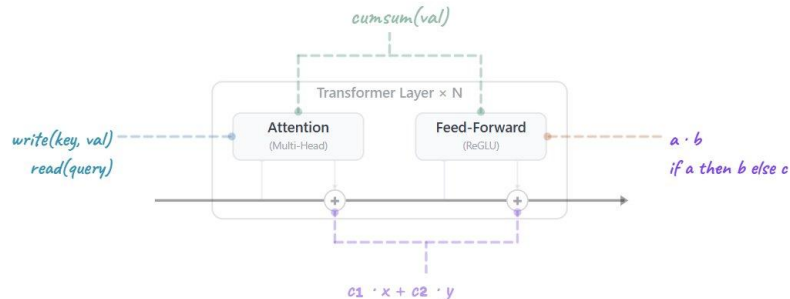
- Understand the core idea of the two papers. (B PG, M Sem, M Lab)
- Run official code implementation on other datasets and find possible drawbacks of this method. (B PG, M Lab)
- Improve the proposed method in terms of mesh reconstruction quality or image rendering quality or training speed (M Lab)

B PG ✓  
M Sem ✓  
M Lab ✓

# LOVC9: Transformers are Computers

- Can Transformer architecture simulate a universal computer?
- Turns out, yes! It can even be realized in weights!
- Their computation model is Append-only Lookup Machine (ALM)

BUILD THE MODEL (DONE ONCE)



- **M Sem**: explain the computational model, how operations are encoded into weights, compare to RAM. Prepare report, presentation.
- **B PG**: run official code, add 1-2 new toy programs, measure runtime/memory/KV-cache, compare compilation choices and programs.
- **M Lab**: reproduce results, study efficiency and differentiability bottlenecks, extend with one new idea. Write research-style report.

[Can LLMs Be Computers? | Percepta](#)

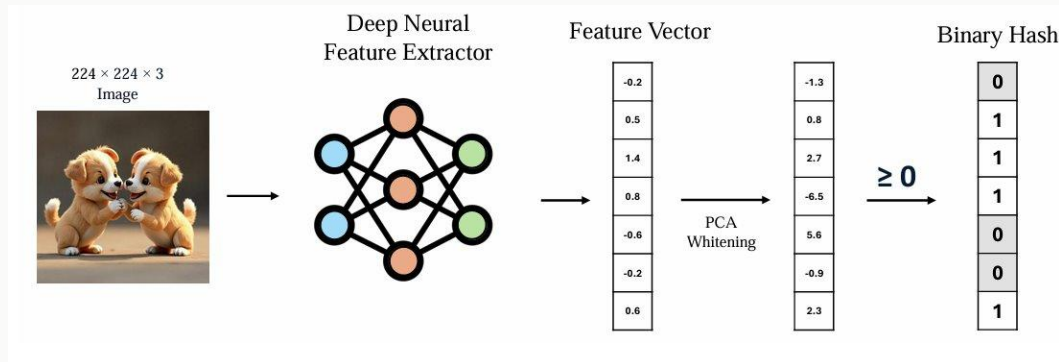
[Constructing an LLM-Computer | Percepta](#)

[Percepta-Core/transformer-vm: Compile programs directly into transformer weights. Includes a 2D convex-hull KV cache with  \$O\(\log n\)\$  inference.](#)

B PG ✓  
M Sem ✓  
M Lab ✓

# LOVC10: Perceptual Hashes under Semantic AI Edits

- Perceptual hashes are designed to be stable under benign transformations (brightness, contrast, small crop, rotation, scale, compression)
- Useful for near-duplicate matching, retrieval
- Prone to optimizable collision attacks (in contrast to cryptographic hashes)



- **M Sem**: read CertPHash and 1-2 attack/evaluation papers. Explain certification, evaluation, summarize results. Prepare report, presentation.
- **B PG**: reproduce baselines, build a small semantic-edit benchmark or diffusion-guided generated benchmark, evaluate baselines.
- **M Lab**: reproduce baselines, build a semantic-edit benchmark, extend with adversarial and diffusion-guided generative attacks.

B PG ✓  
M Sem ✓  
M Lab ✓

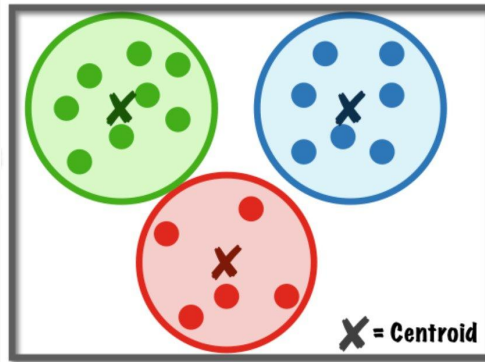
*CertPHash: Towards Certified Perceptual Hashing via Robust Training. Yang et al. USENIX 2025. Yuchen413/CertPhash*  
*Provenance Detection for AI-Generated Images: Combining Perceptual Hashing, Homomorphic Encryption, and AI Detection Models. Singhi et al. 2025.*

# LOVC11: Does perfect Perceptual Hash exist?

- Research Question: Given a finite real-world image dataset and a benign transformation family, when does there exist a perfect perceptual hash that is **invariant within each benign class and separating across all other images**?
- We want to find conditions for Perceptual Hash function  $h(\cdot)$  such that it is:

**Invariant:** if  $x \sim y$ , then  $d(h(x), h(y)) \leq \tau$ , and

**Selective:** if  $x \not\sim y$ , then  $d(h(x), h(y)) > \tau$ .

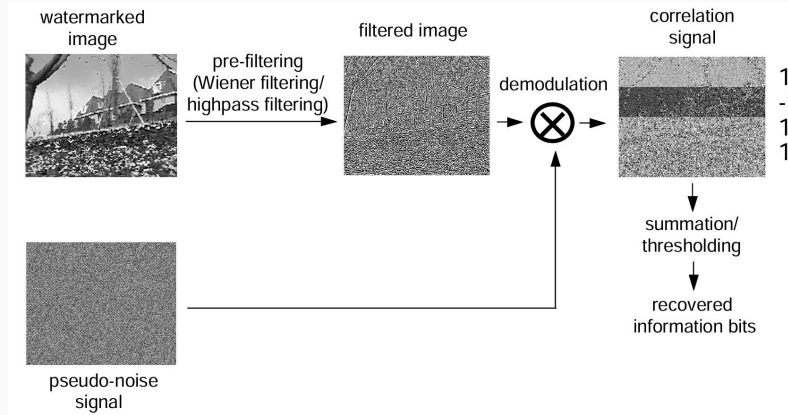


- **M Sem:** read the literature, formalize the problem, define a perfect perceptual hash, state 1 sufficient condition and 1 impossibility case.
- **B PG:** reproduce baselines hashes, build a benchmark on different datasets, measure distances, report separability margin.
- **M Lab:** formalize problem, develop a theory with at least one proposition, validate experimentally. Write research-style report.

B PG ✓  
M Sem ✓  
M Lab ✓

# LOVC12: Modernizing Classical Watermarking

- Classical watermarking techniques, like Spread Spectrum, are great! They are fast, simple, imperceptible.
- They lack adaptive robustness to geometric transformations, limited payload support, weaker blind detection.
- Let's modernize them!

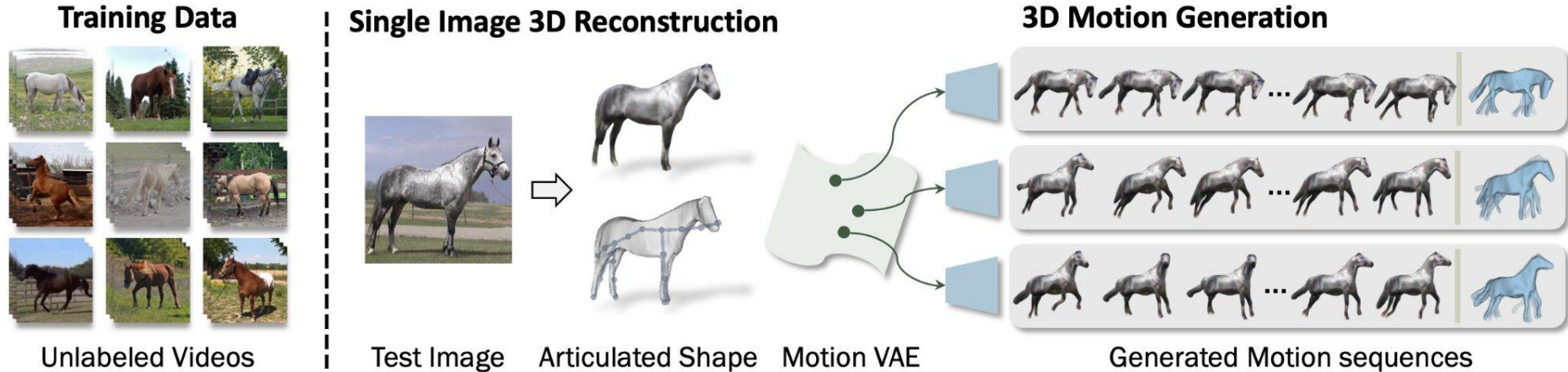


- **M Sem:** review classical SS / SS-FM watermarking, explain their drawbacks vs modern methods, propose hybrid design.
- **B PG:** reproduce SS, SS-FM baselines, add payload using ECC, add blind detection with calibrated threshold, speed/robustness study.
- **M Lab:** reproduce baselines, add payload and blind detection, add one novel robustness mechanism. Write research-style report.

*Spread Spectrum Watermarking: Malicious Attacks and Counterattacks. Hartung et al. 1999.*  
*Rotation, scale and translation invariant spread spectrum digital image watermarking. Ruanaidh et al. 1998*

|       |   |
|-------|---|
| B PG  | ✓ |
| M Sem | ✓ |
| M Lab | ✓ |

# LOVC13: Ponymation: Learning Articulated 3D Animal Motions from Unlabeled Online Videos

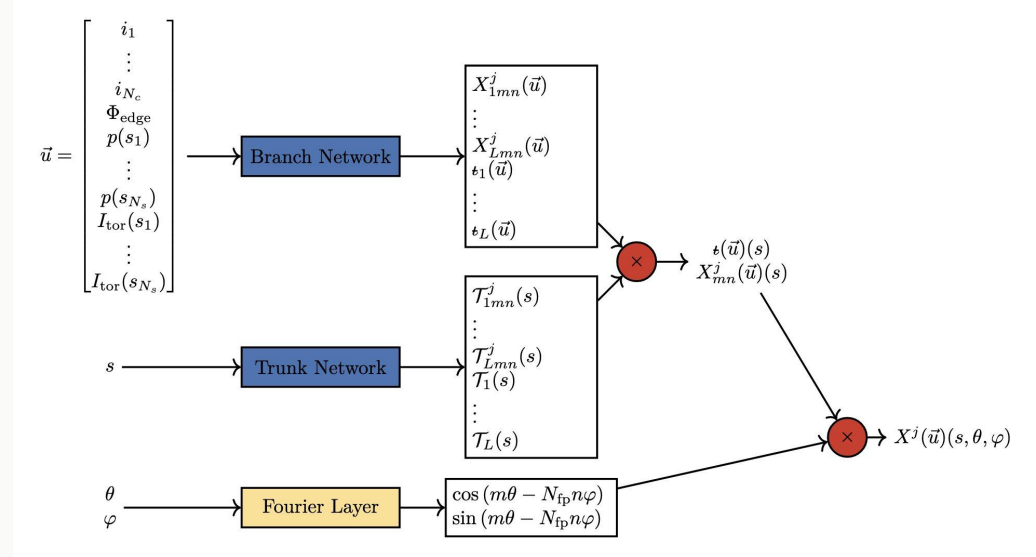
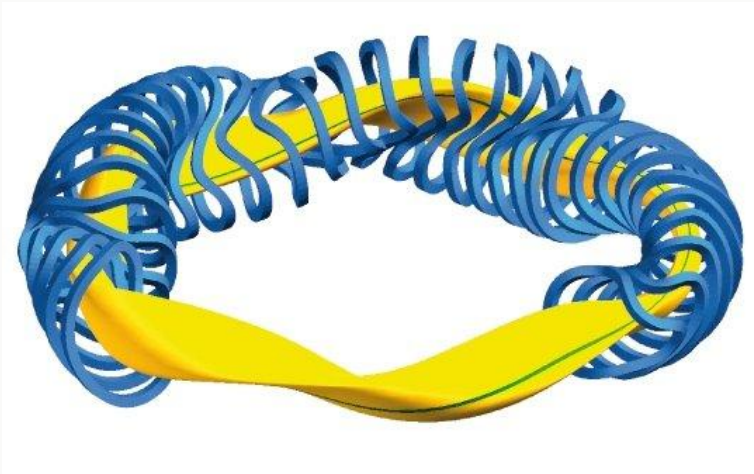


- Understand and present the core idea of the paper. (B PG, M Sem, M Lab)
- Run official code implementation on other datasets and find possible drawbacks of this method. (B PG, M Lab)
- Make the method work on unstructured image data. (M Lab)

|       |   |
|-------|---|
| B PG  | ✓ |
| M Sem | ✓ |
| M Lab | ✓ |

Li, R., Wu, S., Jakab, T., Rupprecht, C., & Vedaldi, A. (2024). Ponymation: Learning Articulated 3D Animal Motions from Unlabeled Online Videos. ECCV 2024.

# LOVC14: Learning surrogate models for stellarator design



- Understand and present the core idea of (1). (M Sem)
- Evaluate different neural network architectures for surrogate modelling for (2) (M Lab, BPG)

Merlo, A., et al. (2023). Physics-regularized neural network of the ideal-MHD solution operator in Wendelstein 7-X configurations. *Nuclear Fusion*, 63, 066020.

Cadena, S. A., Merlo, A., Laude, E., et al. (2025). ConStellaration: A dataset of QI-like stellarator plasma boundaries and optimization benchmarks. *NeurIPS 2025*. arXiv:2506.19583

B PG ✓  
M Sem ✓  
M Lab ✓

# LOVC15: Back to 3D - Few-Shot 3D Keypoint Detection with Back-Projected 2D Features

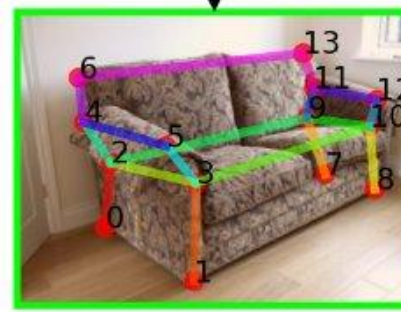
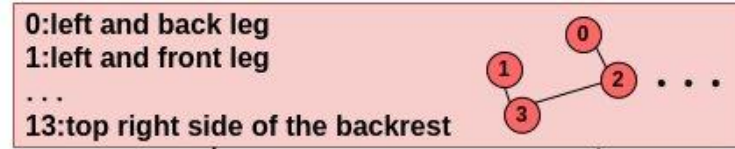
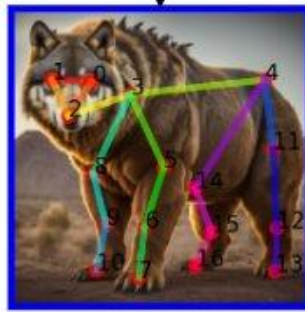
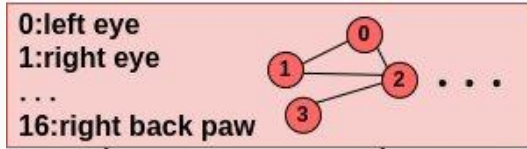


- Understand the core idea of the paper. (B PG, M Sem, M Lab)
- Run official code implementation on other datasets and find possible drawbacks of this method. (B PG, M Lab)
- Improve possible drawbacks within the pipeline including (1) better semantics, or (2) symmetry-aware. (M Lab)

B PG ✓  
M Sem ✓  
M Lab ✓

Wimmer, Thomas, Peter Wonka, and Maks Ovsjanikov. "Back to 3d: Few-shot 3d keypoint detection with back-projected 2d features." CVPR 2024

# LOVC16: CapeX - Category-Agnostic Pose Estimation from Textual Point Explanation



- Understand the core idea of the paper. (B PG, M Sem, M Lab)
- Run official code implementation on other datasets and find possible drawbacks of this method. (B PG, M Lab)
- Improve possible drawbacks within the pipeline including (1) better feature learning, or (2) alleviating symmetry ambiguity. (M Lab)

B PG ✓  
M Sem ✓  
M Lab ✓

Wimmer, Thomas, Peter Wonka, and Maks Ovsjanikov. "Back to 3d: Few-shot 3d keypoint detection with back-projected 2d features." CVPR 2024

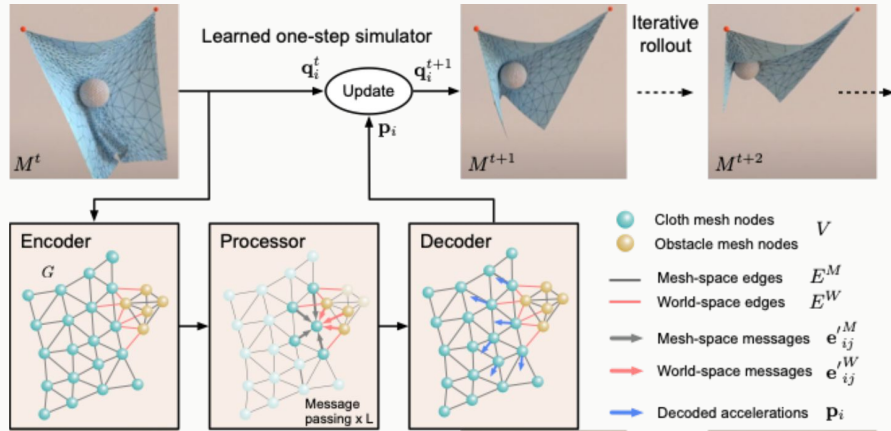
# Master Lab

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**AI aided Scientific Discovery Group (AISD) GROUP**

INSTITUTE OF COMPUTER SCIENCE II VISUAL COMPUTING DEPARTMENT

# AISDG 1: Mesh-based Neural Surrogate Modeling



(a) FlagDynamic



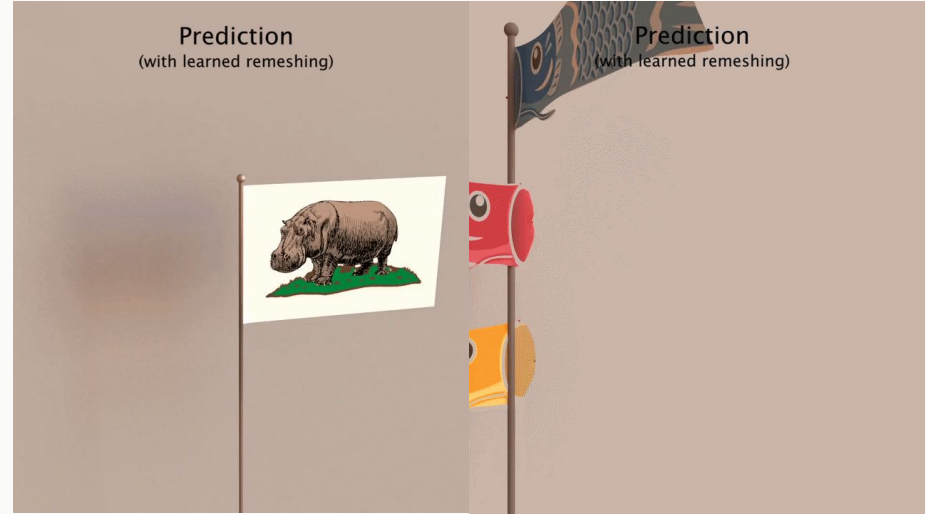
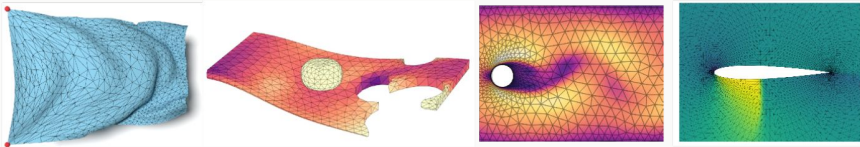
(b) DeformingPlate



(c) CylinderFlow



(d) Airfoil

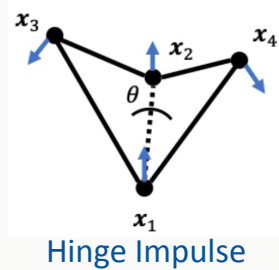
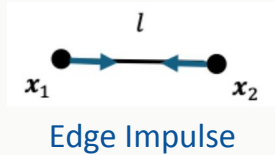


- Goal 1: Extend it to fluid-solid interactions
  - Foundation model for Lagrangian systems

|       |   |
|-------|---|
| B PG  | ✗ |
| M Sem | ✗ |
| M Lab | ✓ |

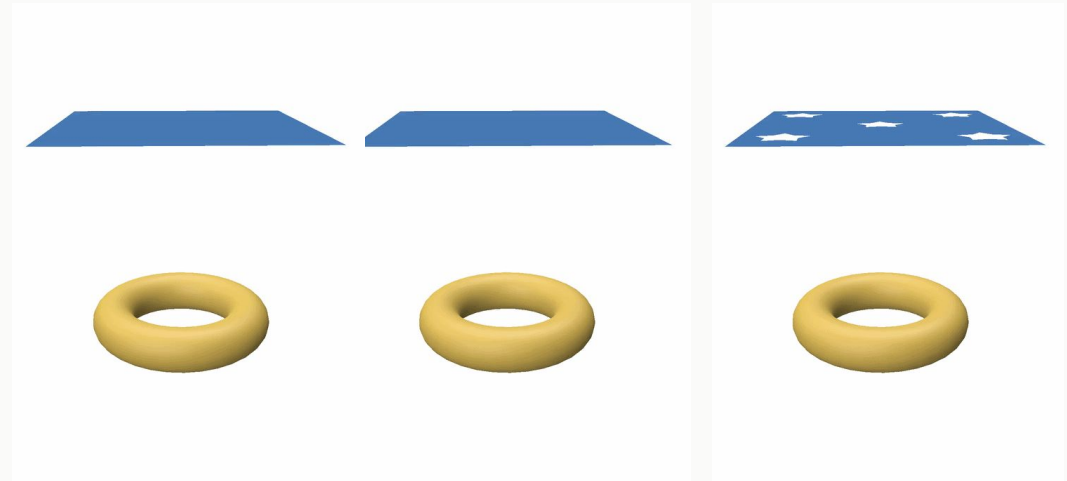
# AISDG 1: Mesh-based Neural Surrogate Modeling

- Goal 2: Look at per-element formulation



Edge impulse --> Edge stress

Auto recover strain-stress constitutive relation



MeshGraphNets

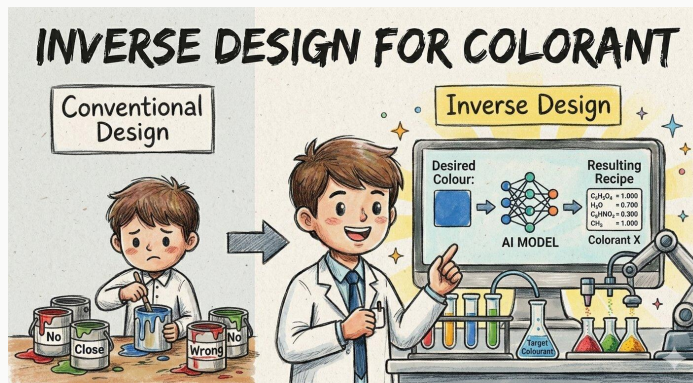
MomentumGNN (ours)

MomentumGNN  
(star-perforated)

- Goal 3: Investigate constraints
  - Collision-free dynamics
  - Dry frictions

|       |   |
|-------|---|
| B PG  | ✗ |
| M Sem | ✗ |
| M Lab | ✓ |

## AISDG 2: Inverse Design of Dyes/Pigments



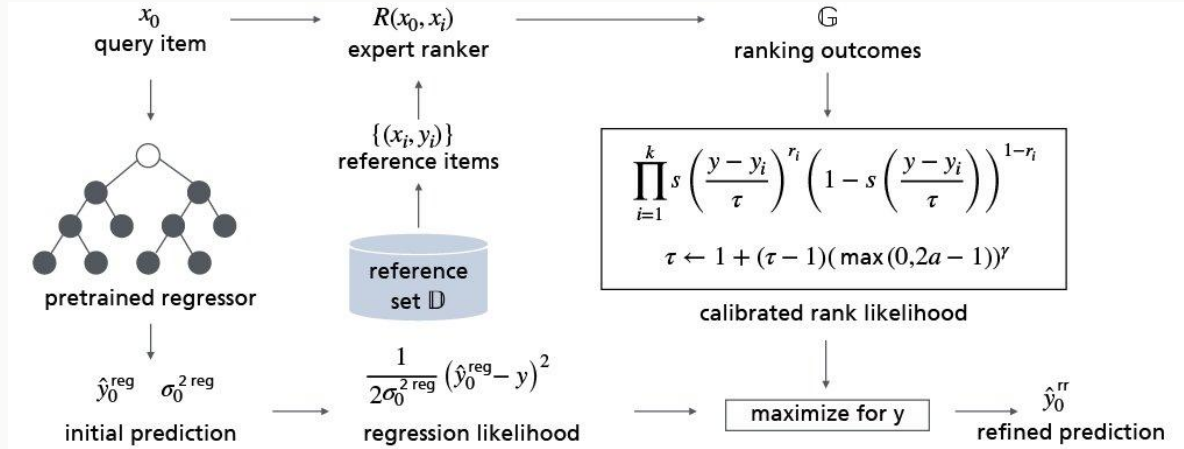
- Build a database of molecule (design) → color (performance) from online sources (e.g., <https://www.worlddyevariety.com/>)
- Experiment with autoinverse to automatically propose a molecule that will display the desired color
- Validate the proposed design with Density Functional Theory (DFT) software like ORCA (<https://orca-manual.mpi-muelheim.mpg.de/>)

B PG

M Sem

M Lab

# AISDG 3: Improving Regression Predictions with Rankings



- Extend the idea from pairwise comparisons to listwise comparisons.
- Experiment how systematic ranking bias and different reference sampling strategy affect the performance

|       |   |
|-------|---|
| B PG  | ✗ |
| M Sem | ✗ |
| M Lab | ✓ |



# Master Lab, Master Seminar and BACHELOR PROJEKTGRUPPE

OFFERED BY THE

**Geometry in Machine Learning (GML) GROUP**

[geometryinml.cs.uni-bonn.de](http://geometryinml.cs.uni-bonn.de)

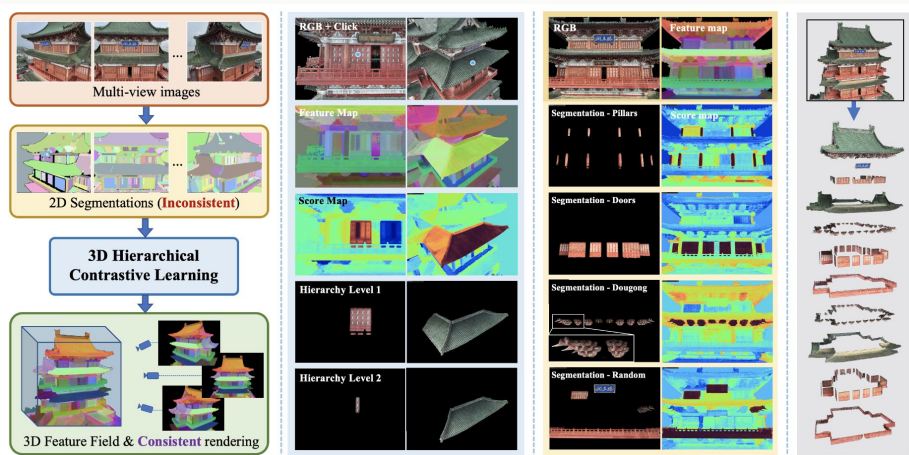
INSTITUTE OF COMPUTER SCIENCE II VISUAL COMPUTING DEPARTMENT

# GML1: Segmentation on 3DGS (M Sem)

3D Gaussian Splatting (3DGS)?



Segmentation on 3DGS via Contrastive learning



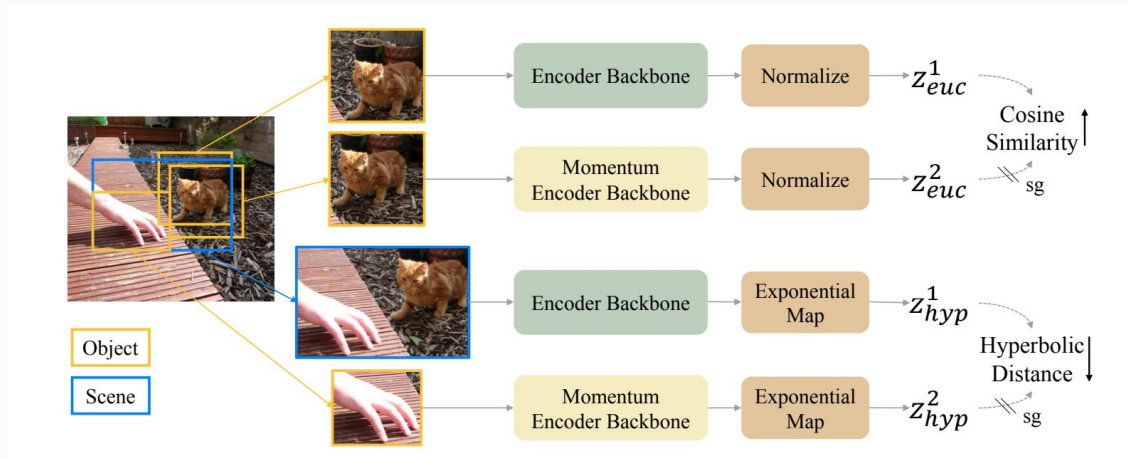
- B PG ✓
- M Sem ✓
- M Lab ✓

## Goal: Integrate Hyperbolic learning into 3DGS Segmentation

### Hyperbolic learning?

Euclidean space -> Hyperbolic space (where learning happens)

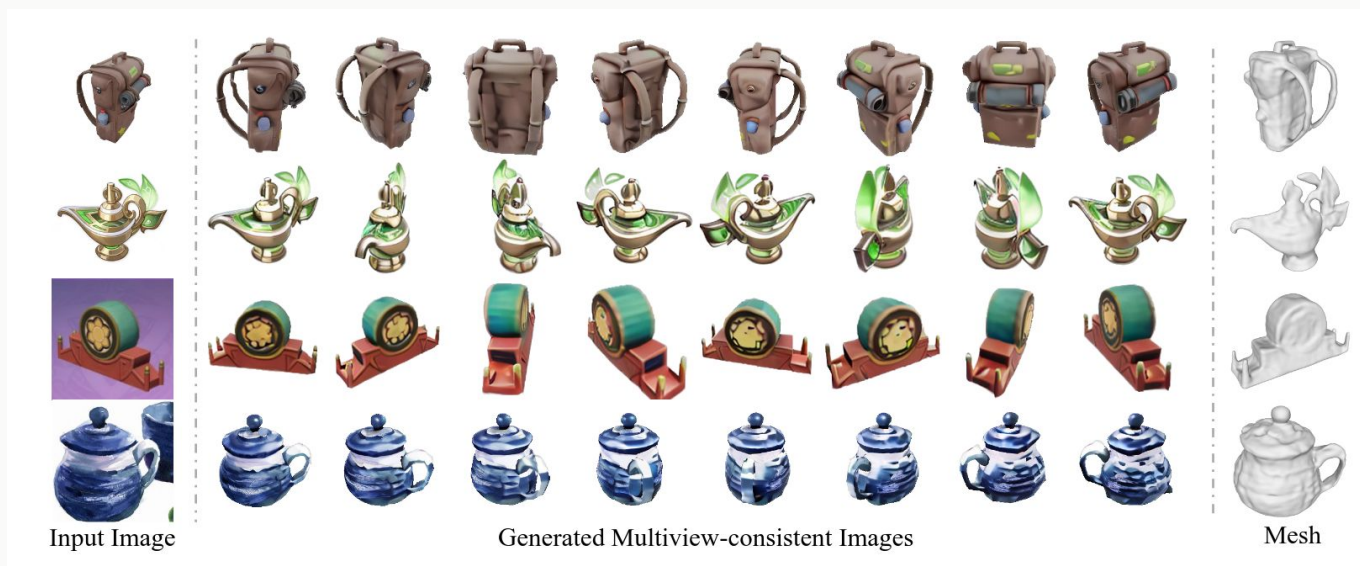
✓ Hierarchical structure



Hyperbolic Contrastive Learning for Visual Representations beyond Objects, Songwei Ge et al. CVPR 2023



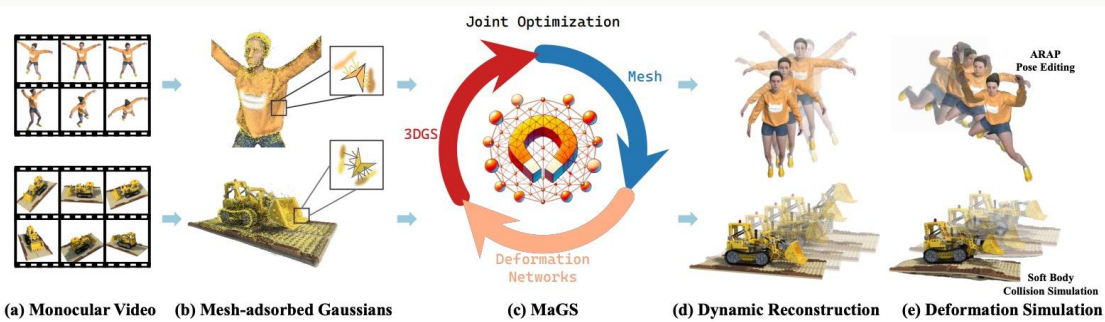
# GML2: Multi-view consistent image generation with 2D diffusion model



- Fully understand and able to present the core idea of the paper (M Sem)
- Reproduce the multiview-consistent image generation part (B PG & M Lab)
- Do multi-view consistent relighting using the same pipeline (B PG & M Lab)

B PG ✓  
M Sem ✓  
M Lab ✓

# GML3: Dynamic Scene Reconstruction



|       |   |
|-------|---|
| B PG  | ✗ |
| M Sem | ✓ |
| M Lab | ✗ |

TagSplat: Topology-Aware Gaussian Splatting for Dynamic Mesh Modeling and Tracking, Guo et. al CVPR 2026

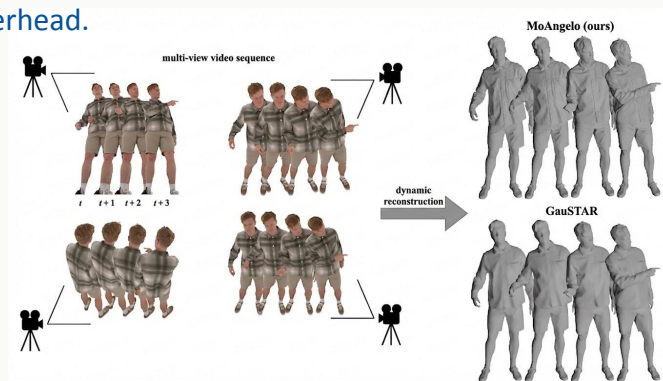
GauSTAR: Gaussian Surface Tracking and Reconstruction, Zheng et. al CVPR 2025

MaGS: Reconstructing and Simulating Dynamic 3D Objects with Mesh-adsorbed Gaussian Splatting, Ma et. al ICCV 2025

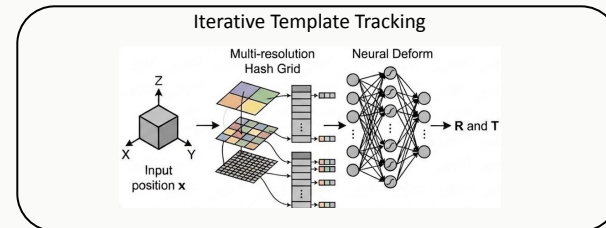
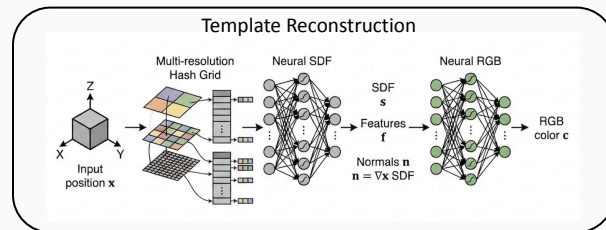
# GML3: Dynamic Scene Reconstruction

## Project Goals:

- Develop a **memory-efficient 4D scene representation** for dynamic scenes.
- Enable **joint optimization** across frames for improved temporal consistency.
- Overcome limitations of existing approaches:
  - Joint optimization methods suffer from reduced reconstruction quality.
  - Iterative approaches rely on 3D hash grids, which are difficult to scale to 4D.
  - Design a representation that efficiently incorporates time without excessive memory overhead.

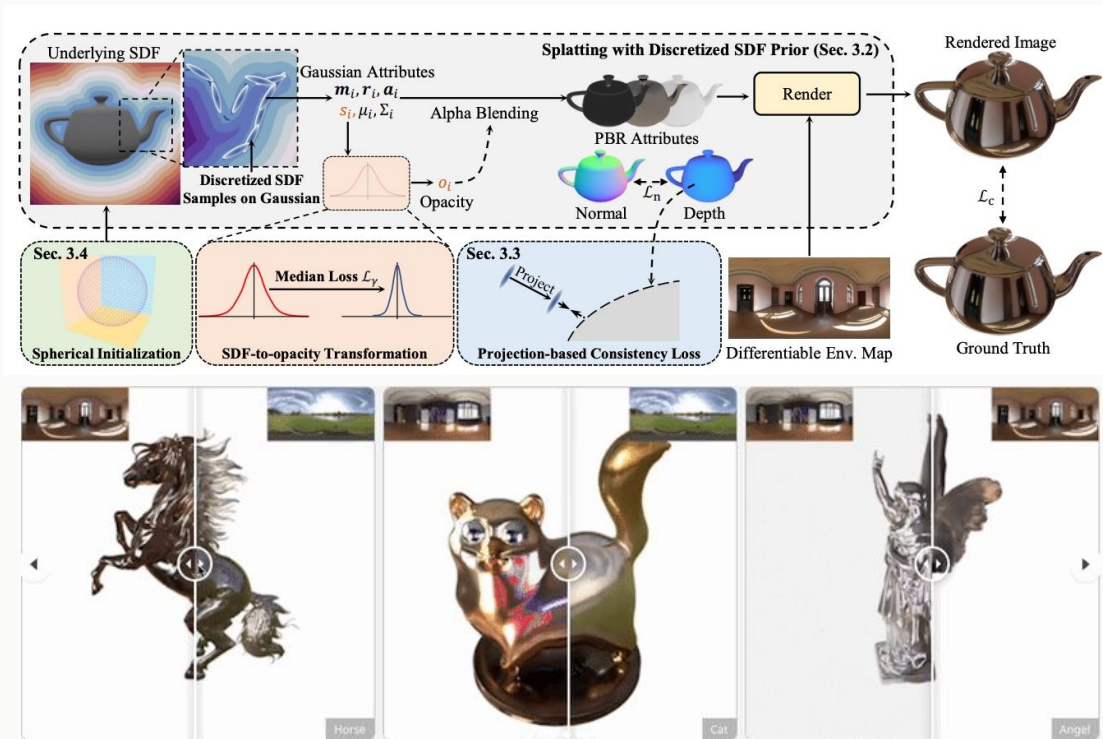


MoAngelo: Motion-Aware Neural Surface Reconstruction for Dynamic Scenes, Ebbed et. al 3DV 2026



|       |   |
|-------|---|
| B PG  | ✗ |
| M Sem | ✗ |
| M Lab | ✓ |

# GML4: Inverse Rendering on 3D Gaussians

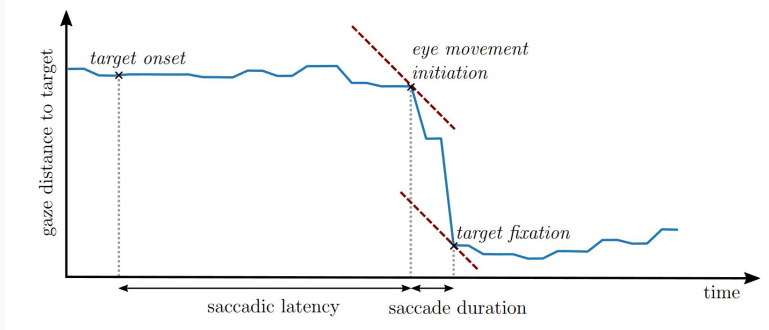
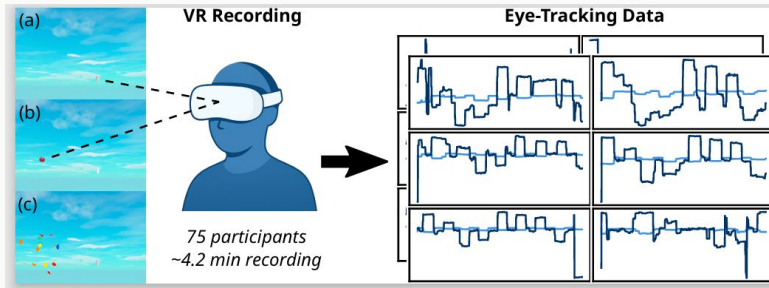


Gaussian Splating with Discretized SDF for Relightable Assets, Zhu, et. al ICCV 2025

Relightable 3D Gaussians: Realistic Point Cloud Relighting with BRDF Decomposition and Ray Tracing, Cao, et. al ECCV 2024

|       |   |
|-------|---|
| B PG  | ✗ |
| M Sem | ✓ |
| M Lab | ✗ |

# GML5: Support Diagnostics of Parkinson's Disease with VR-based Eyetracking



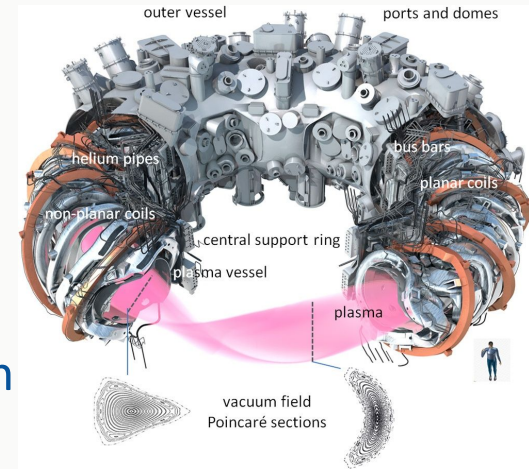
- Goal: Support diagnostic with eyetracking data from a simple VR game
- Distinguish between healthy controls, Parkinson's disease and other movement disorders
- Task: apply time series classification and finetune models

More info: [https://www.worldscientific.com/doi/epdf/10.1142/9789819824755\\_0016](https://www.worldscientific.com/doi/epdf/10.1142/9789819824755_0016)

|       |   |
|-------|---|
| B PG  | ✓ |
| M Sem | ✗ |
| M Lab | ✓ |

# GML6: Fusion Energy Generation

- Goal: safe and sustainable energy with fusion energy generation
- Requires plasma state (hot and high pressure)
- Current prototypes are not yet efficient enough
- Paper with dataset and background information: <https://arxiv.org/pdf/2506.19583>

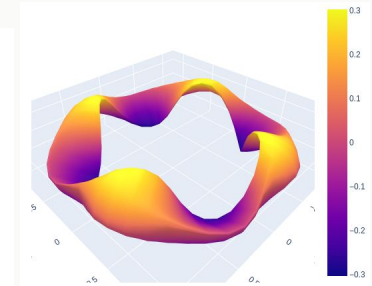
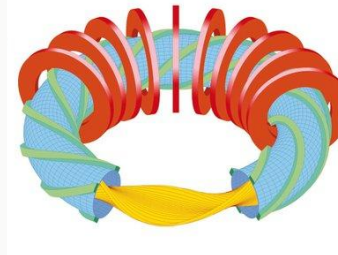
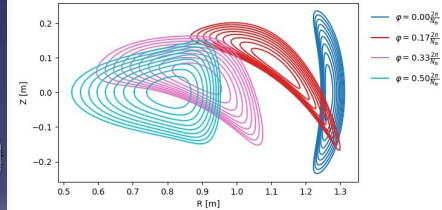
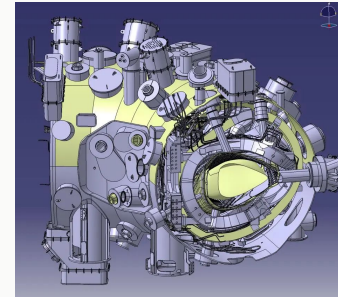


*MPI for Plasma Physics*

|       |   |
|-------|---|
| B PG  | ✓ |
| M Sem | ✗ |
| M Lab | ✓ |

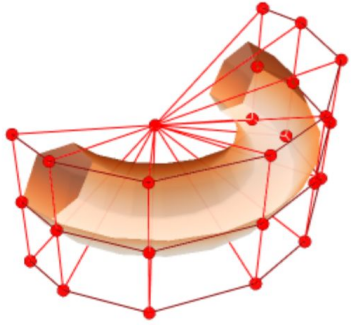
# GML7: Stellarator - Plasma Shape Optimization

- Stellarator: fusion generator type for continuous operation (But more complex shape)
- Based on magnetic confinement
- Challenge: Many parameters to optimize (stability, magnetic field properties, coil shape, ...)



|       |   |
|-------|---|
| B PG  | ✓ |
| M Sem | ✗ |
| M Lab | ✓ |

# GML8: Task: Improve B-Spline Surface Representation for Plasma Shapes



$$S(x) = \sum_{j=0}^{n-1} c_j B_{j,k;t}(x)$$



- Improve conversion between angle-based Fourier Representation and B-Spline Surfaces
- Apply local deformations and analyse impact on physics metrics

*This project is affected  
by embargo restrictions.*

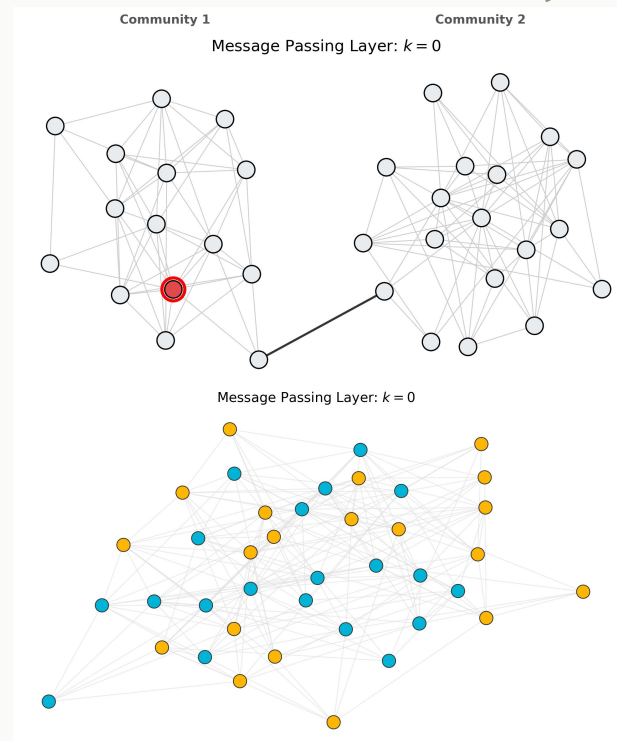
|       |   |
|-------|---|
| B PG  | ✓ |
| M Sem | ✗ |
| M Lab | ✓ |

# GML9. Diffeomorphic Spectral Rewiring for Graph Neural Networks (BPG/Lab/Seminar)

- **Graphs:** Mathematical way to represent complex interactions (e.g. Molecules, Social Networks, Road Traffic)
- **Graph Neural Networks:** Learning by asking, "Who are your neighbors?" Nodes update their state by aggregating data from 1-hop connections.
- **Why We Care:** Build deep GNNs to discover life-saving drugs faster or fluid dynamics simulations.

**Oversquashing:**

**Oversmoothing:**



# GML9. Diffeomorphic Spectral Rewiring for Graph Neural Networks (BPG/Lab/Seminar)

- Rewire the graph to remove bottlenecks
- **How?** *Learn* to rewire by smoothly (diffeomorphic) warping the graph's spectrum

## References:

- [Diffusion Improves Graph Learning](#)
- [Understanding over-squashing and bottlenecks on graphs via curvature](#)



B PG ✓  
M Sem ✓  
M Lab ✓

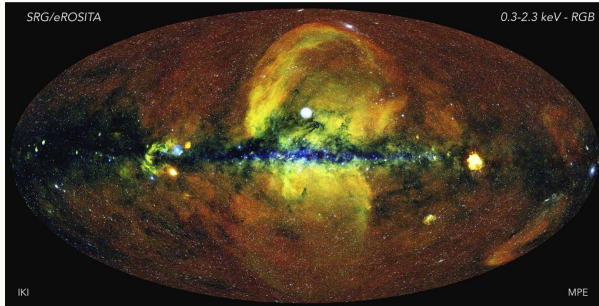
# Advertisement for non-project-based lab/seminars

Join introduction meetings or check out eCampus for more information!

## MA-INF 4244 Lab Deep Learning for the Physical Sciences

Introduction meeting: April 15th (tomorrow), 10:15 in room 3.035b

This semesters topic: astrophysics



|       |   |
|-------|---|
| B PG  | ✗ |
| M Sem | ✗ |
| M Lab | ✓ |

## MA-INF 2228 Seminar Vision and Graphics (Role-Based)

Introduction meeting: April 15th (tomorrow), 12:15 in room 3.035b

Concept: discussion-based seminar where each week you approach a paper from the perspective of a different role

|       |   |
|-------|---|
| B PG  | ✗ |
| M Sem | ✓ |
| M Lab | ✗ |



Paper Author



Archaeologist



Industry Practitioner



Scientific Peer Reviewer



Scientific Researcher



Private Investigator

**Thank you for you attention!**

**Any questions?**