AMBER: Adaptive Mesh Generation by Iterative Mesh Resolution Prediction

Motivation

- Adaptive meshing is crucial for **simulation**
  - Yet, it often requires **human expertise**
- A mesh is characterized by its local element density, i.e., its **sizing field**
  - A sizing field thus **reconstructs the mesh**
- We combine
  - Message Passing Networks (MPNs) and
  - automatic online label acquisition

  for **iterative mesh generation**, where each mesh **guides** the next one.

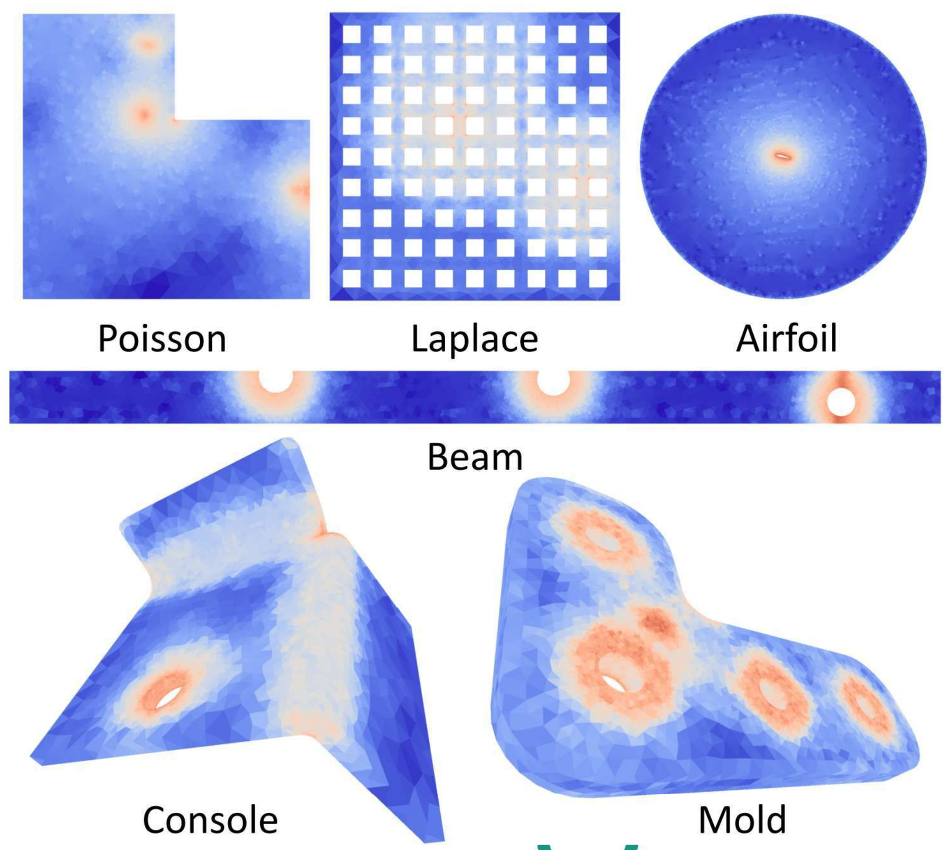
Inference

1. Input an **unseen geometry** (e.g., an .stl file)
2. Generate a coarse **uniform mesh**
3. Iteratively
   - **Encode** the mesh as a graph
   - **Predict** a sizing field with a MPN
   - **Generate** an adapted mesh

Training

1. **Collect** a few (~20) **expert meshes**
2. **Generate** coarse uniform meshes
3. **Iteratively**
   - **Project** expert sizing field to mesh
   - **Encode** the mesh as a graph
   - Train MPN to **predict** sizing field
   - **Generate** an adapted mesh
   - Add this mesh to a **replay buffer**

Datasets



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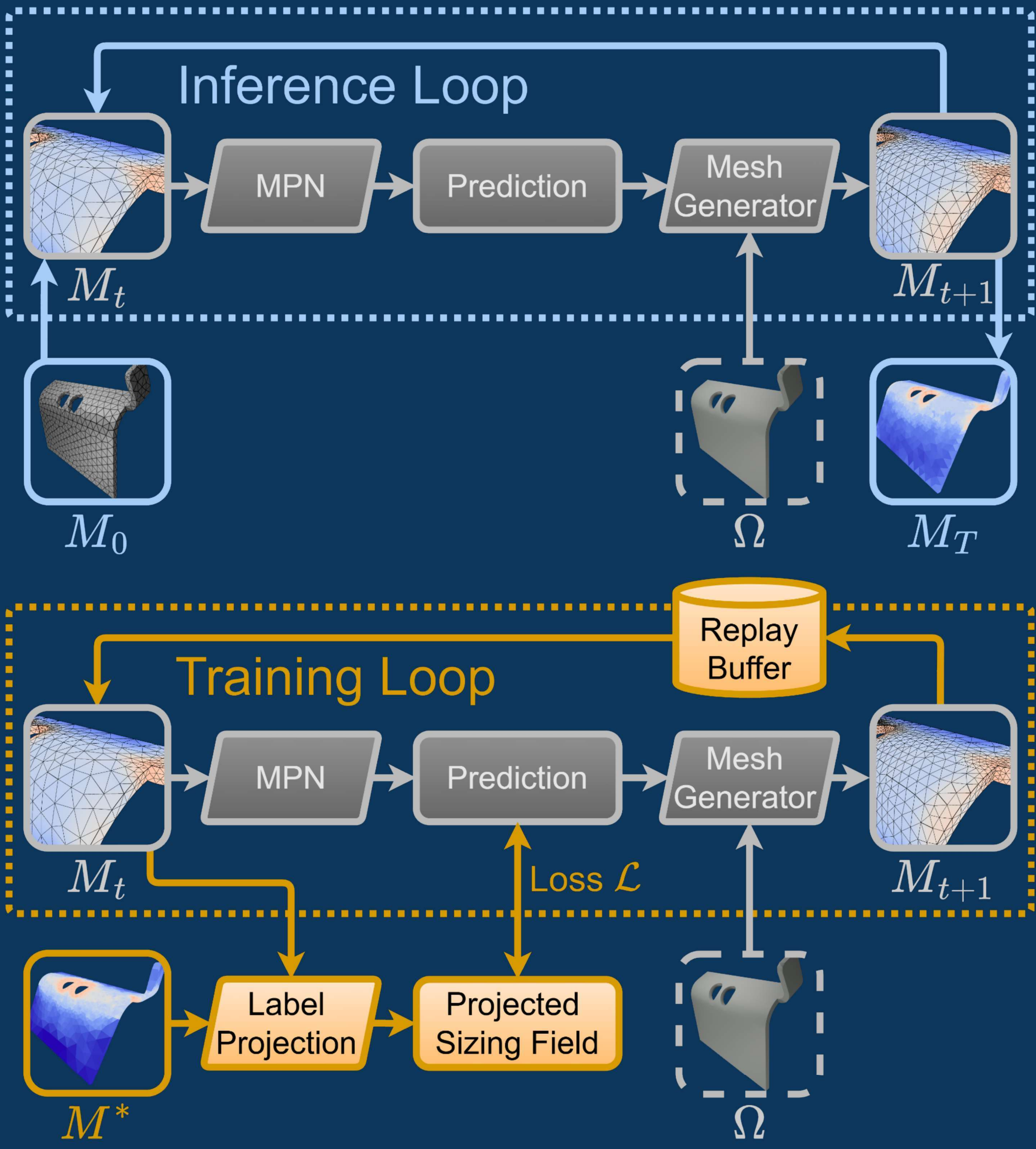

arXiv Paper **GitHub Repo** **Project Page**

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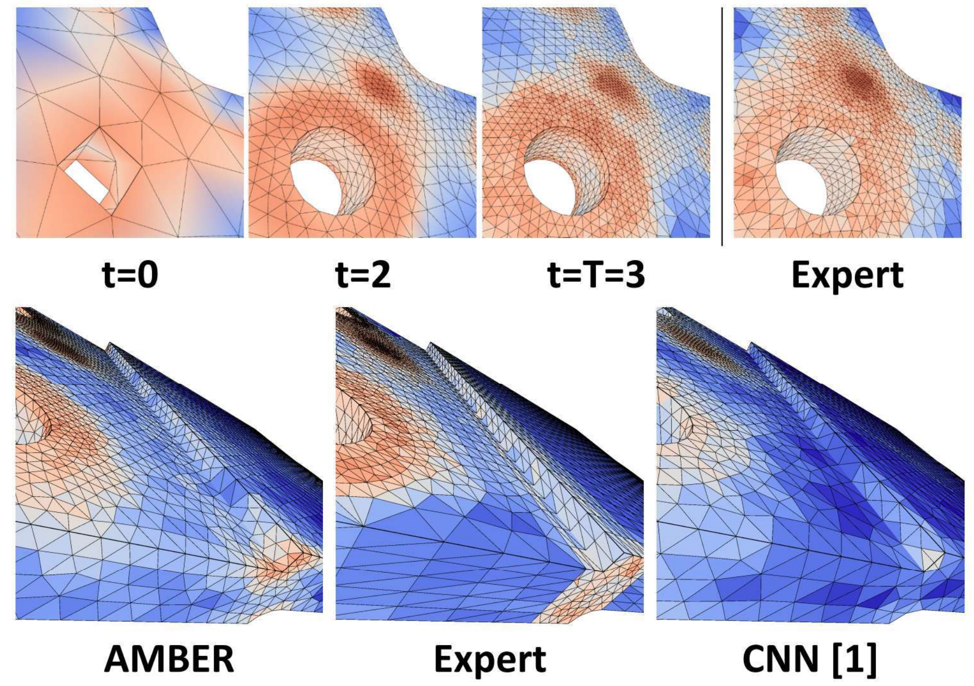
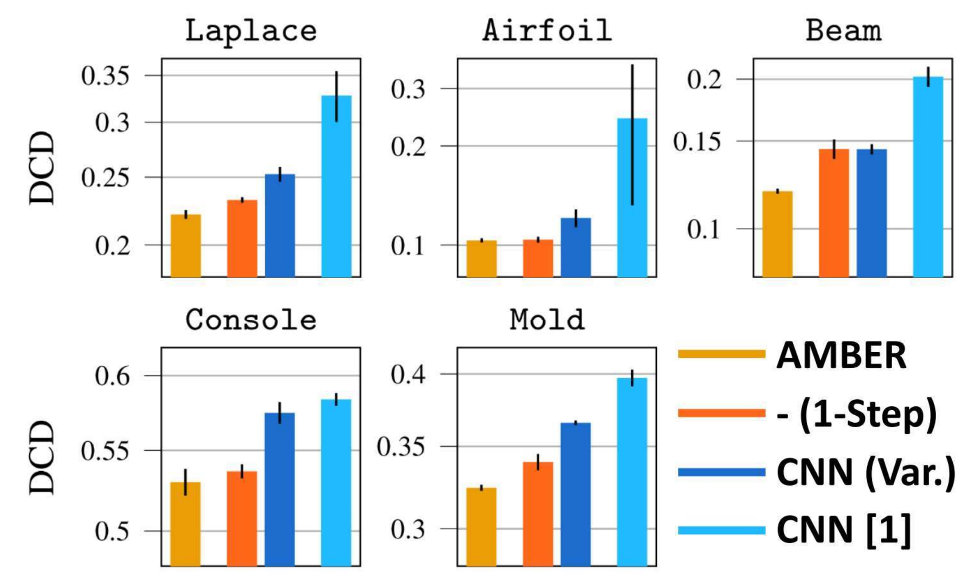
Experiments

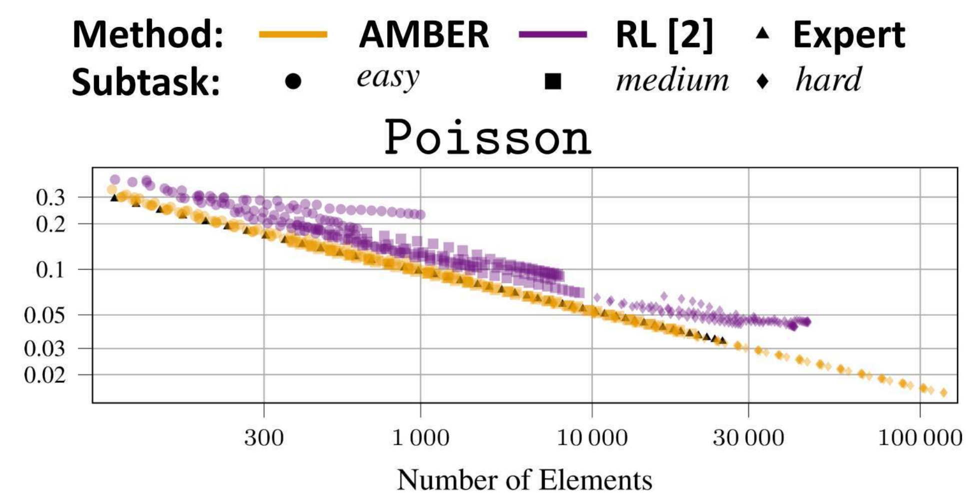
Accurate Iterative Mesh Generation



Closely Match Human Experts



Zero-Shot Generalization



References

[1] Huang, K., et al. *Machine learning-based optimal mesh generation in computational fluid dynamics*, 2021.
[2] Freymuth, N., et al. *Swarm reinforcement learning for adaptive mesh refinement*, 2023.

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