



# GASP: Gradient-Aware Shortest Path Algorithm for Boundary-Confined 2-Manifold Reeb Graph Visualization

Sefat E Rahman, Tushar M Athawale, Paul Rosen



# Motivation: Reeb Graph

Reeb graphs summarize the topology of scalar functions on manifolds.



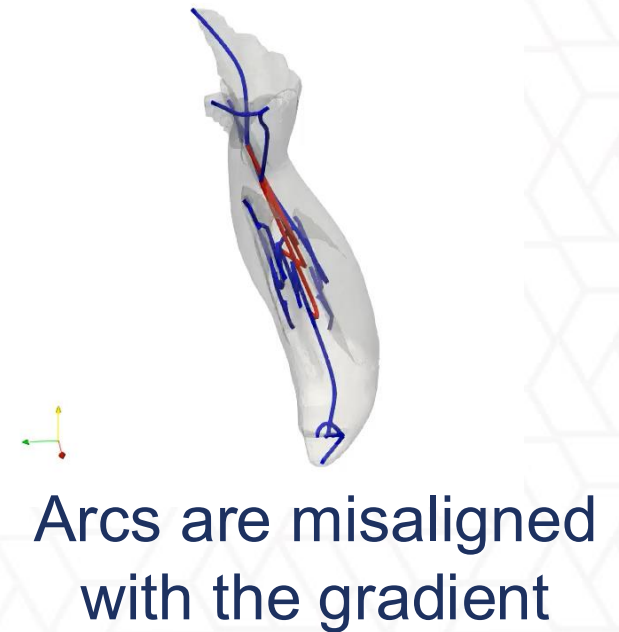
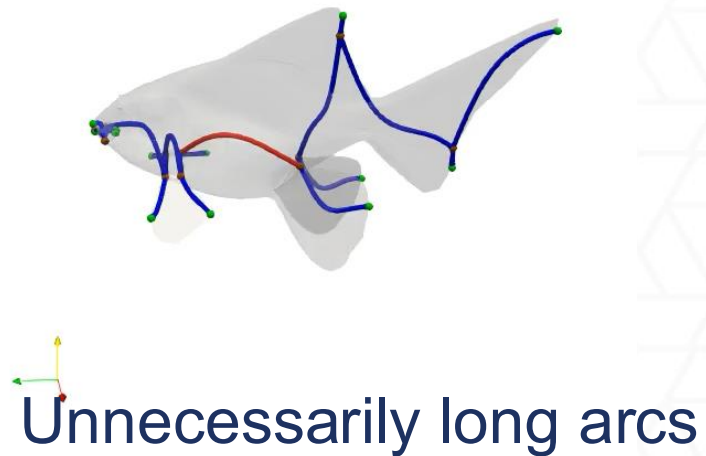
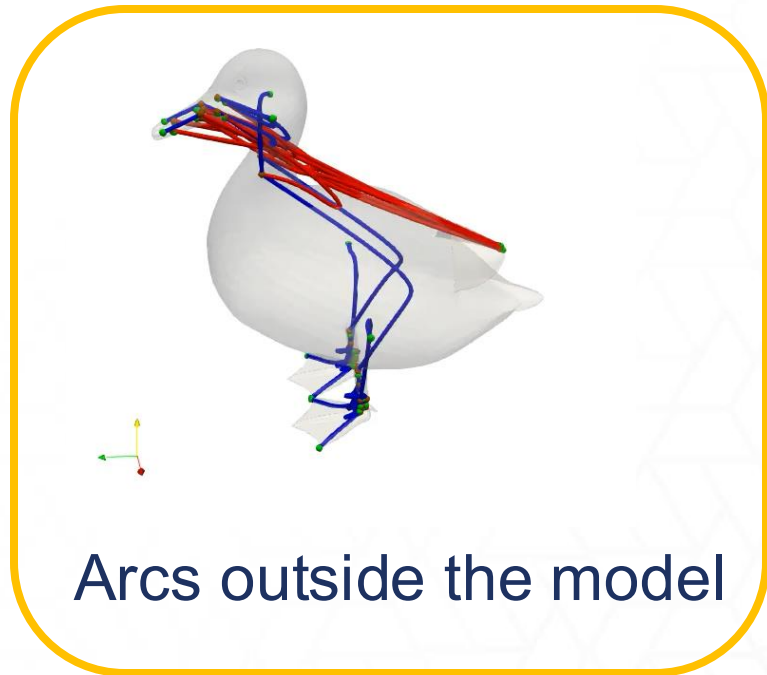
Manifold with a Scalar function



Reeb Graph

# Motivation: Problem

Existing visualization methods (like Geometric Barycenter) produce inaccurate or misleading results:

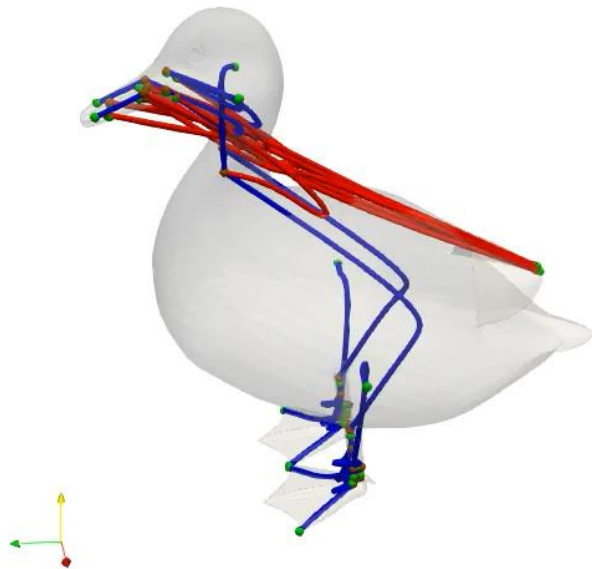


# Goal

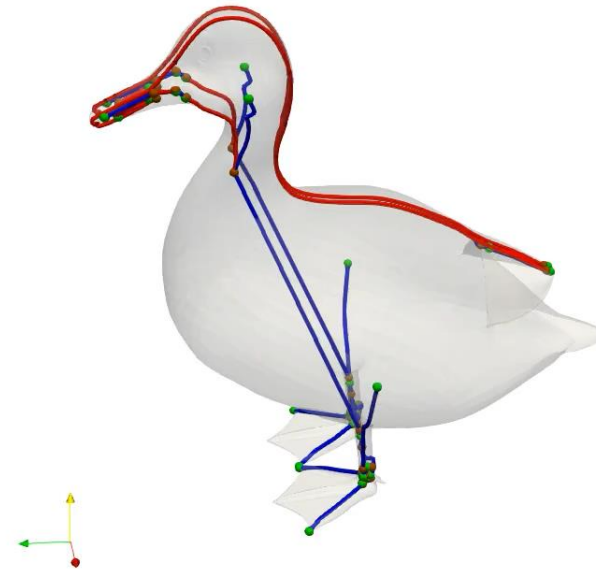
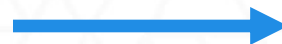
- ✓ Keeps arcs confined within the model boundary

Produces compact (short) arcs

Aligns arcs with the scalar field gradient



Geometric Barycenter



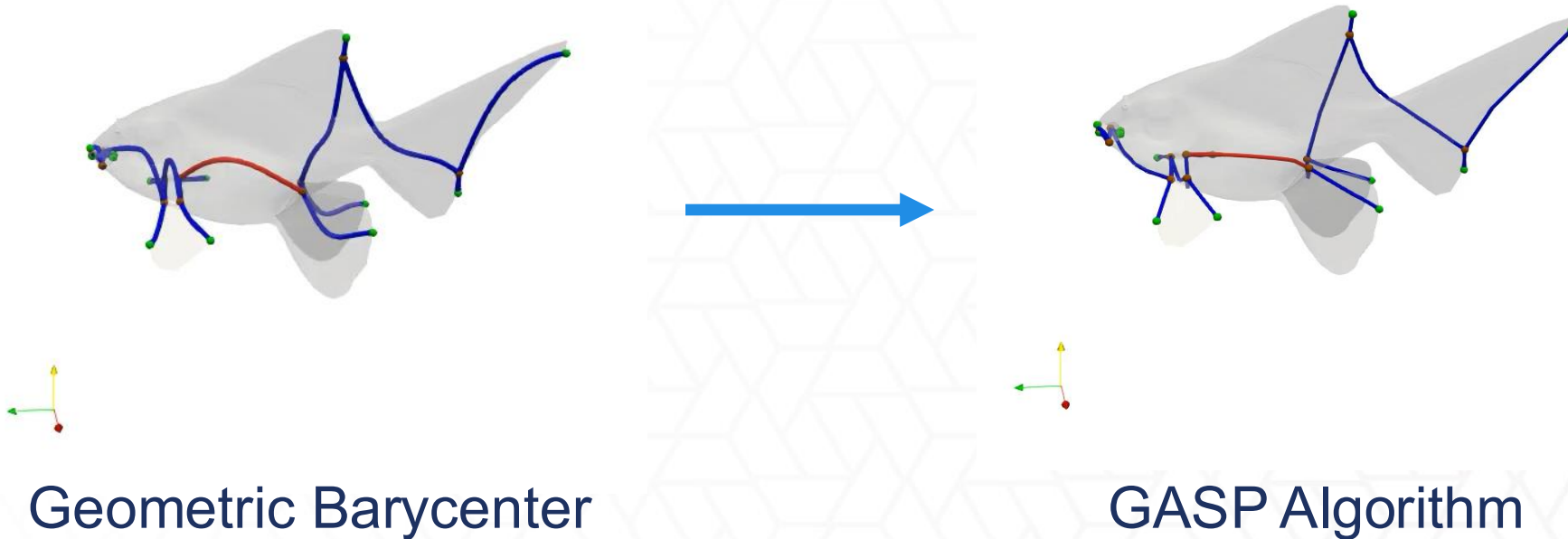
GASP Algorithm

# Goal

Keeps arcs confined within the model boundary

✓ Produces compact (short) arcs

Aligns arcs with the scalar field gradient

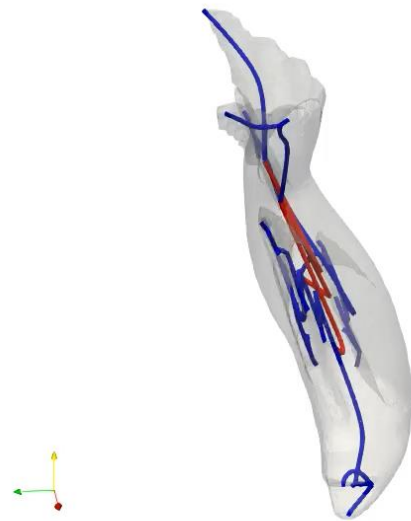


# Goal

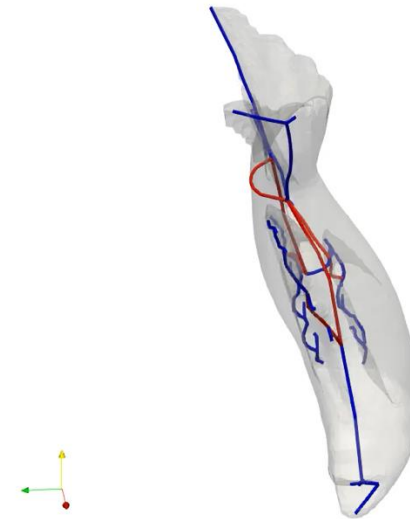
Keeps arcs confined within the model boundary

Produces compact (short) arcs

✔ Aligns arcs with the scalar field gradient

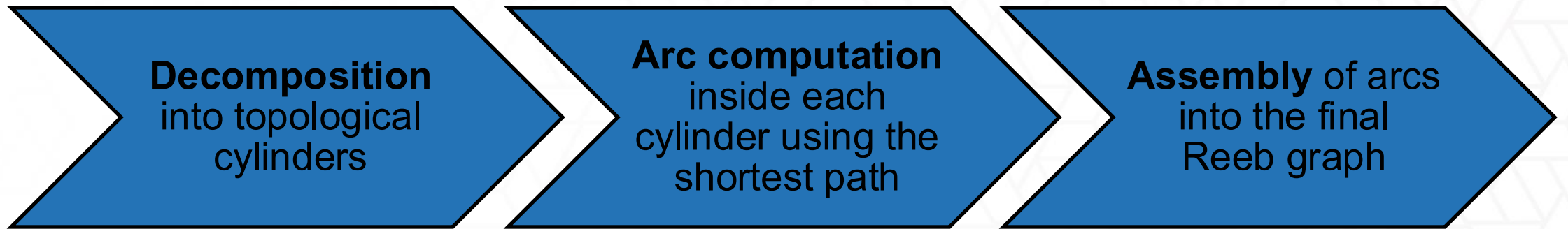


Geometric Barycenter



GASP Algorithm

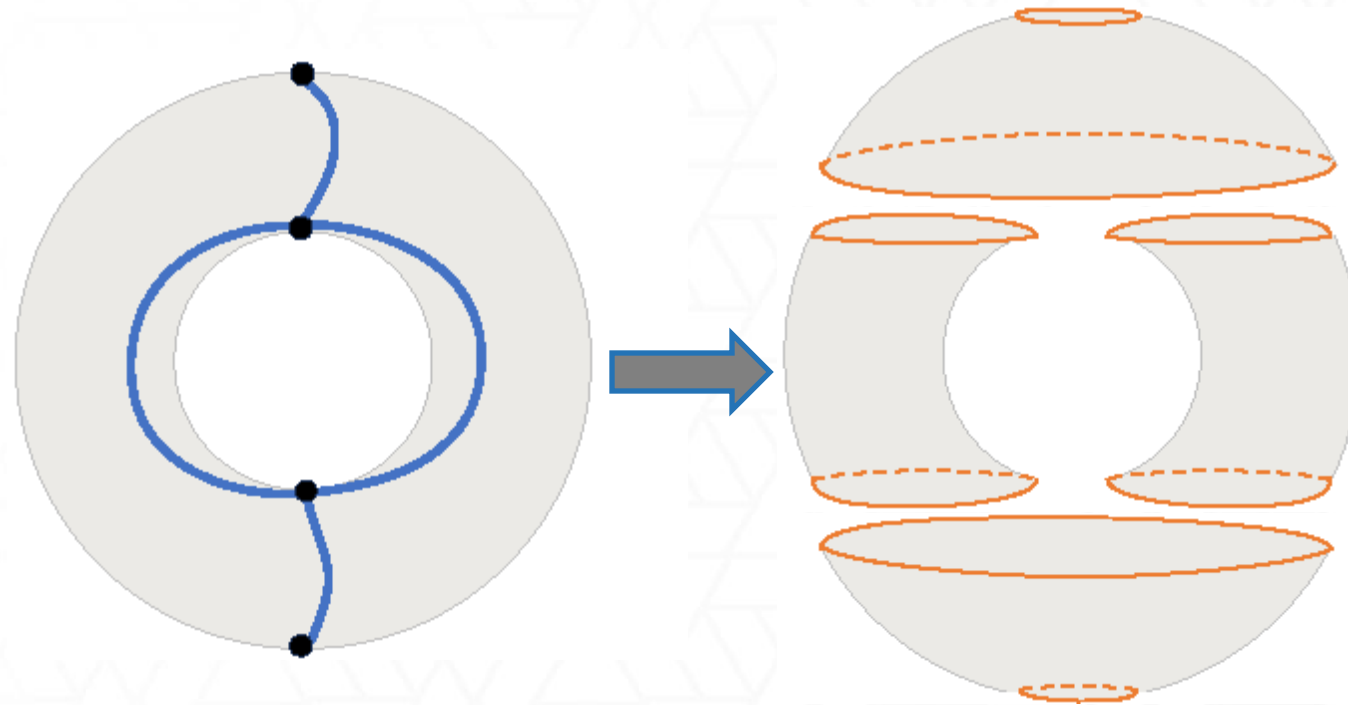
# Gradient-Aware Shortest Path (GASP)

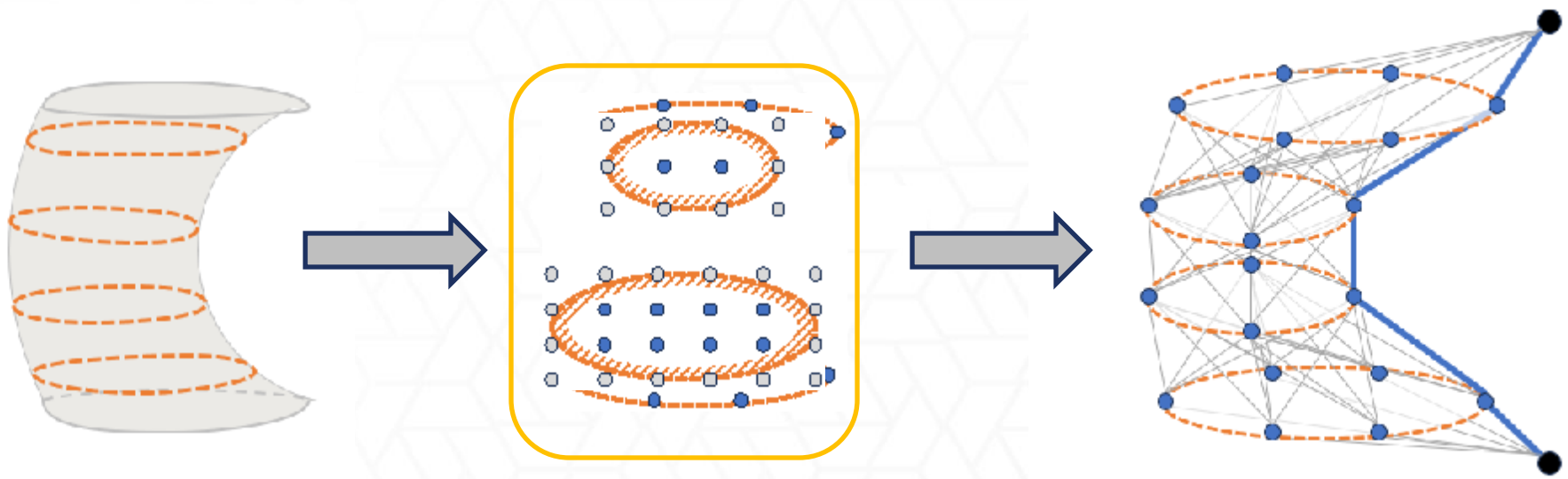
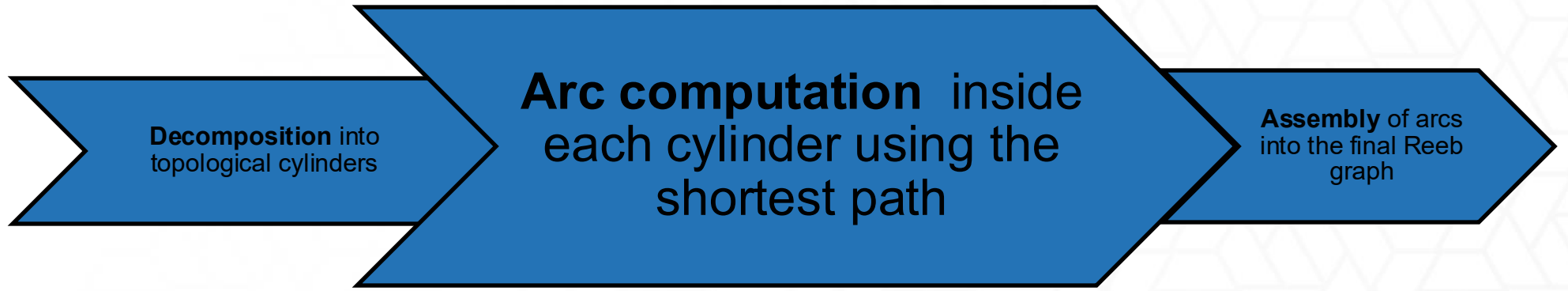


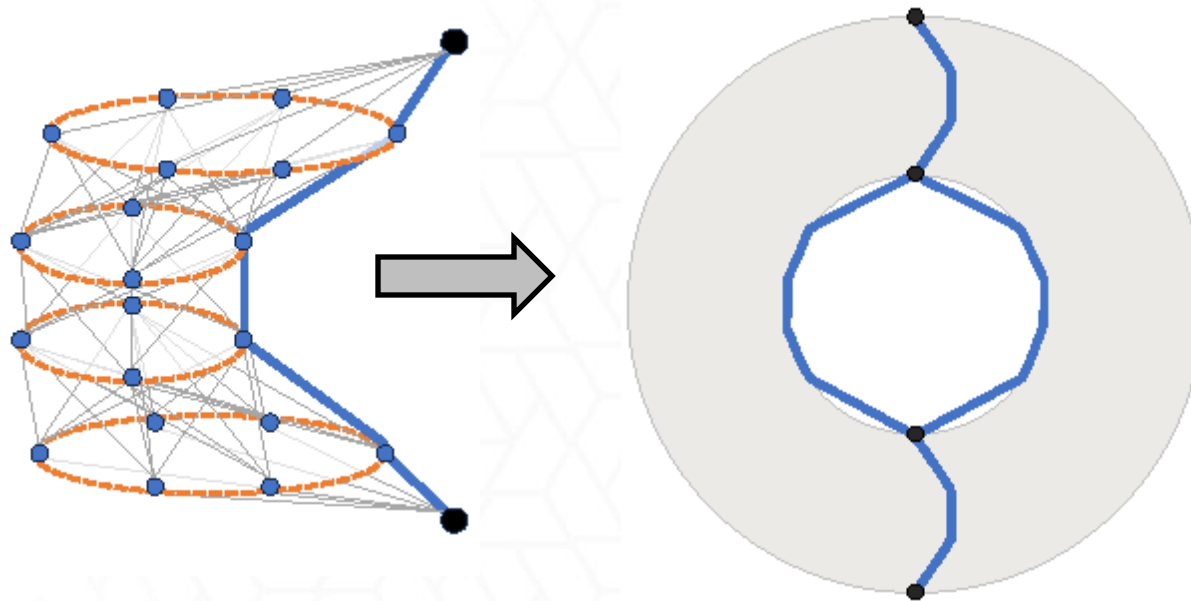
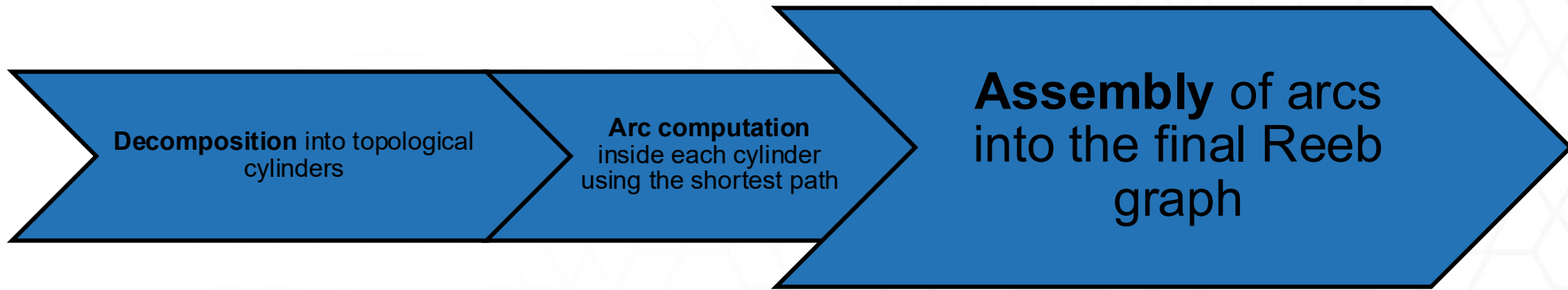
**Decomposition** into topological cylinders

**Arc computation** inside each cylinder using the shortest path

**Assembly** of arcs into the final Reeb graph



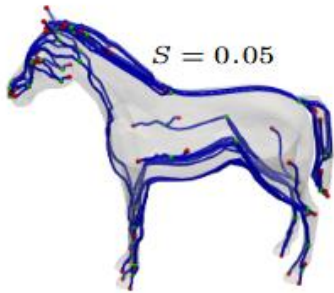




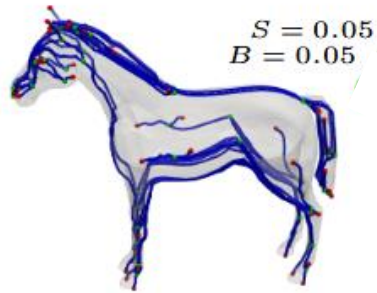
# Evaluation

- › **Baseline:** Geometric Barycenter (GB; TTK implementation)
- › **Data:** 30 triangle meshes (e.g., duck, fish, rabbit, horse)
- › **Metrics:**
  - › Arcs confined to the model
  - › Arc compactness (length)
  - › Alignment with gradient
  - › Smoothness (not discussed; see paper)

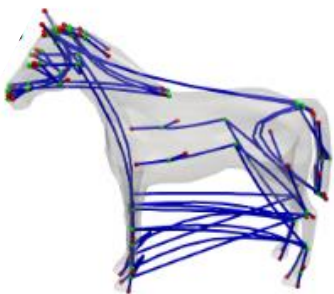
# Property 1: Boundary Confinement



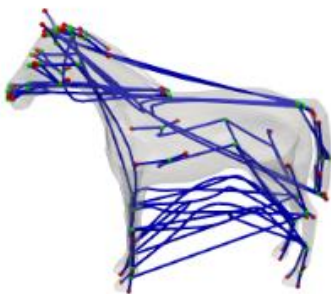
(a) GASP Boundary



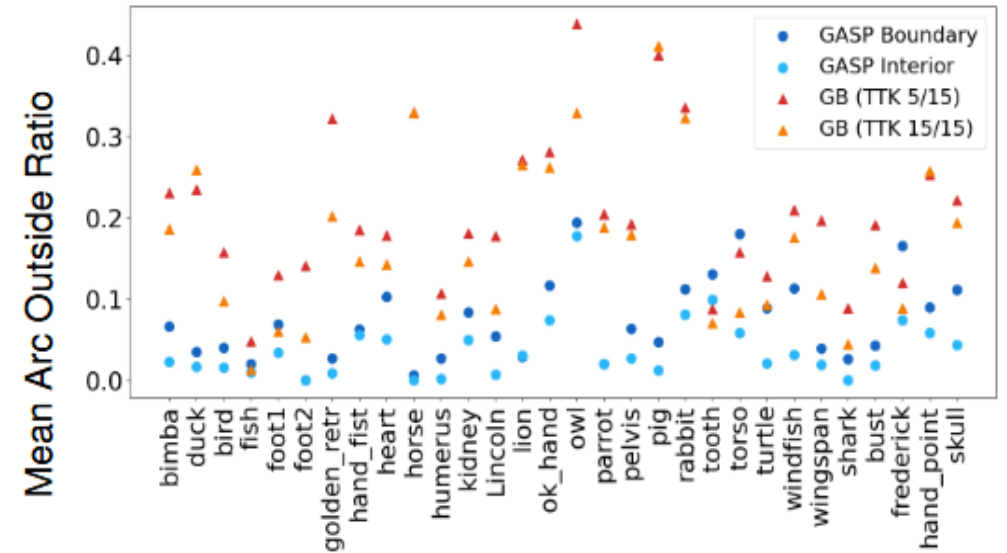
(b) GASP Interior



(c) GB (TTK 5/15)



(d) GB (TTK 15/15)



(a) Comparison of GASP and GB ( $x$  function)

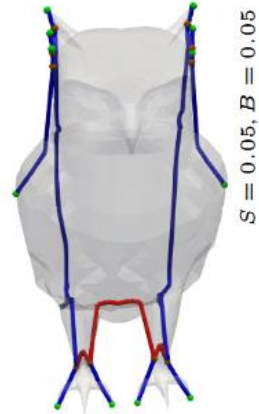
# Property 2: Compactness



owl  
 $x$  function



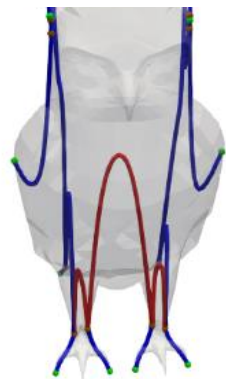
(a) GASP Boundary



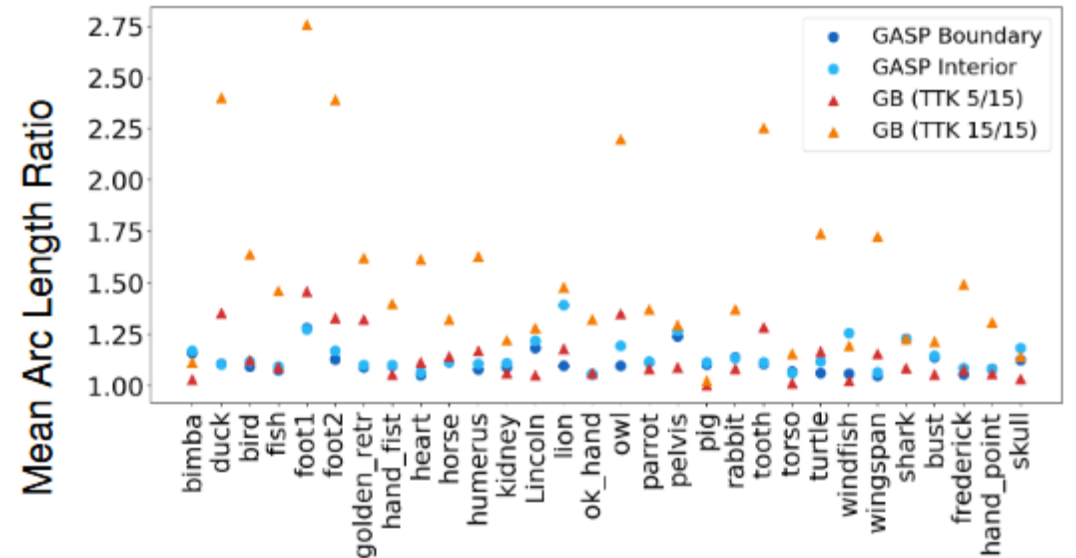
(b) GASP Interior



(c) GB (TTK 5/15)

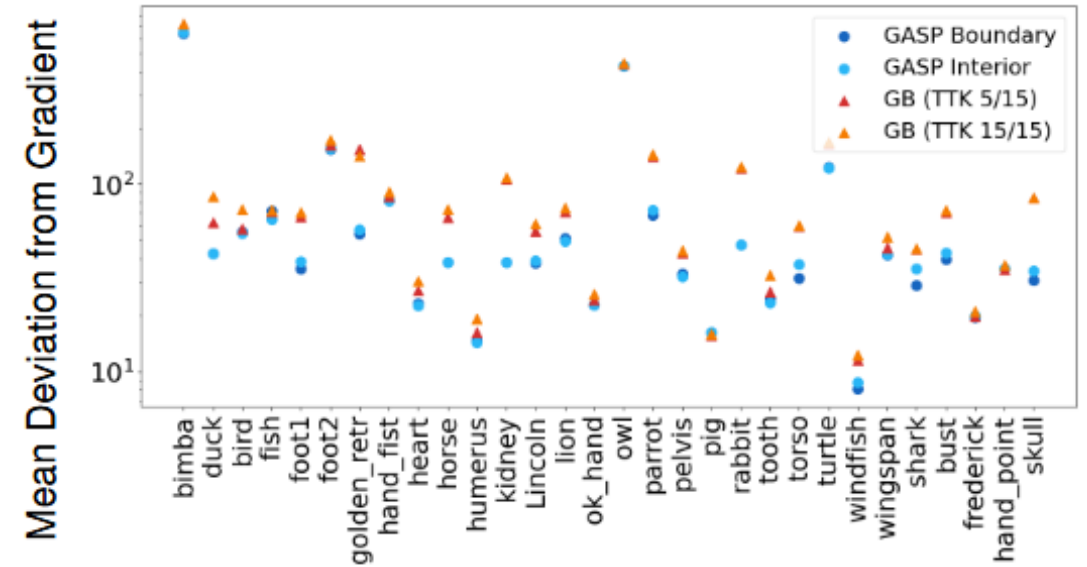
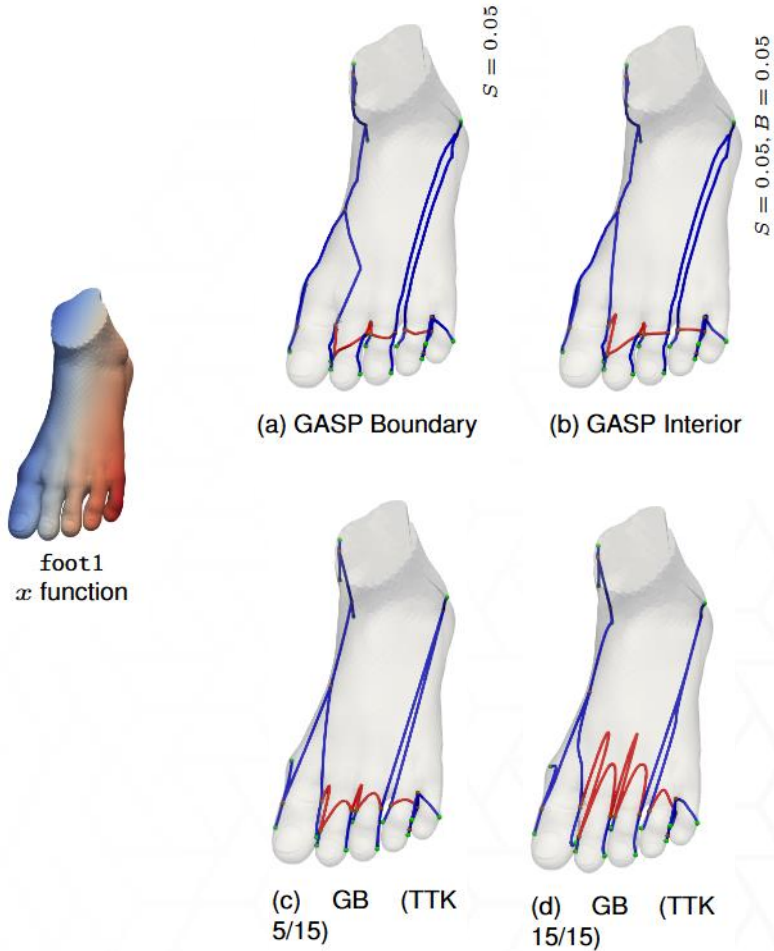


(d) GB (TTK 15/15)



(a) Comparison of GASP and GB ( $x$  function)

# Property 3: Gradient Alignment



(a) Comparison of GASP and GB (x function)

# Conclusion

- › GASP produces more faithful Reeb graph visualizations by ensuring:
  - › Boundary confinement
  - › Compactness
  - › Gradient awareness
- › Takeaway: *Important to ensure that the visualization of topological data structures is reflective of its underlying data*

# Thanks for your attention

GASP: Gradient-Aware Shortest Path Algorithm for  
Boundary-Confined 2-Manifold Reeb Graph Visualization

**Source Code:** <https://github.com/shape-vis/gasp>

**Contact:** sefat.rahman@utah.edu,  
athawaletm@ornl.gov,  
paul.rosen@utah.edu

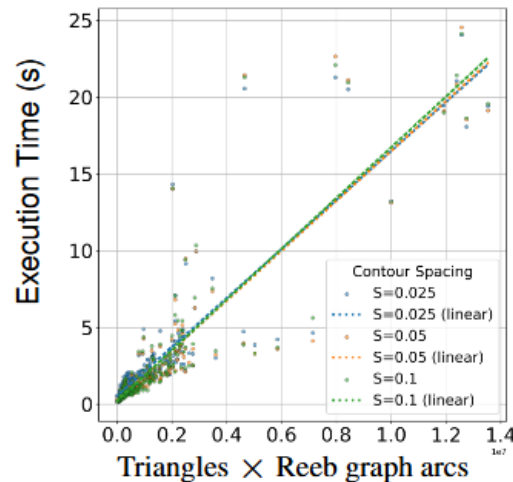


# Limitations

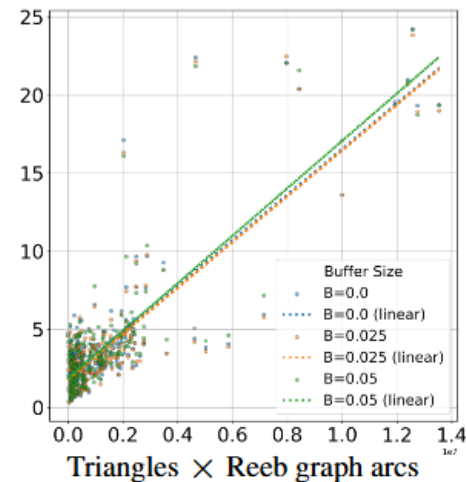
- Interior approach assumes contours are approximately planar.
- May produce low-quality arcs for non-planar contours.
- Implemented in Python → slower than C++ counterparts.

# Performance

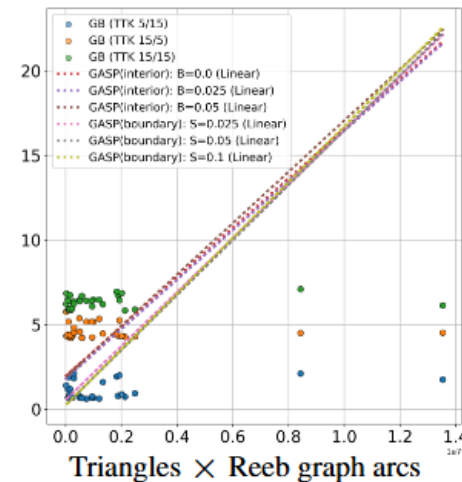
- › GASP scales linearly with the **number of triangles**  $\times$  **Reeb graph arcs**.
- › Average complexity:  $\Theta(T \log t)$
- › Slightly slower than C++ TTK (implemented in Python).
- › Good trade-off between quality and performance.



(a) GASP Boundary



(b) GASP Interior



(c) GB (TTK)