Project Flamenco

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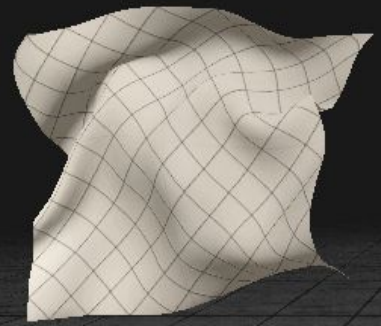

Follow Along!

Github Repo: http://bit.ly/project_flamenco

Run the Live Demo: http://bit.ly/azura_cloth_build_241

Objective

Implement a Position-Based Dynamics (PBD) cloth simulation algorithm on the GPU using predictive constraints – a technique introduced at GDC 2018 by EA's Frostbite team.

Currently, this runs on the Frostbite Engine but no game has shipped with this tech so far. Anthem may be the first.

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Project Features

- (CPU) core PBD algorithm for comparison
- (GPU) core PBD algorithm
- Jacobi-style constraint solver using D3D12 compute shaders

- Basic distance constraint
- Isometric bending constraint
- Long Range Attachment (LRA) Constraint

- Environment collision SDF constraints
- Self-collision constraints using predictive contact constraints
- Acceleration structure using spatial hash grid

- Cloth mesh discretization
- GLTF 2.0 Mesh Support
- Rendering pipeline

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Project Architecture

- Built on Azura Engine: Custom Rendering Engine
  - Currently supports D3D12 and Vulkan APIs
- Built to be Platform and API Agnostic
- Uses open sourced NVIDIA Slang shaders for cross compilation
  - Azura has reported about 5 bugs while using Slang
- Automated Builds on Appveyor

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(GPU) Core PBD Algorithm

30 x 30 at ~280 fps

$k_{distance} = 0.3$

$k_{bending} = 0.3$

30 x 30 at ~280 fps

$k_{distance} = 0.8$

$k_{bending} = 0.8$

100 x 100 at ~330 fps

$k_{distance} = 0.99$

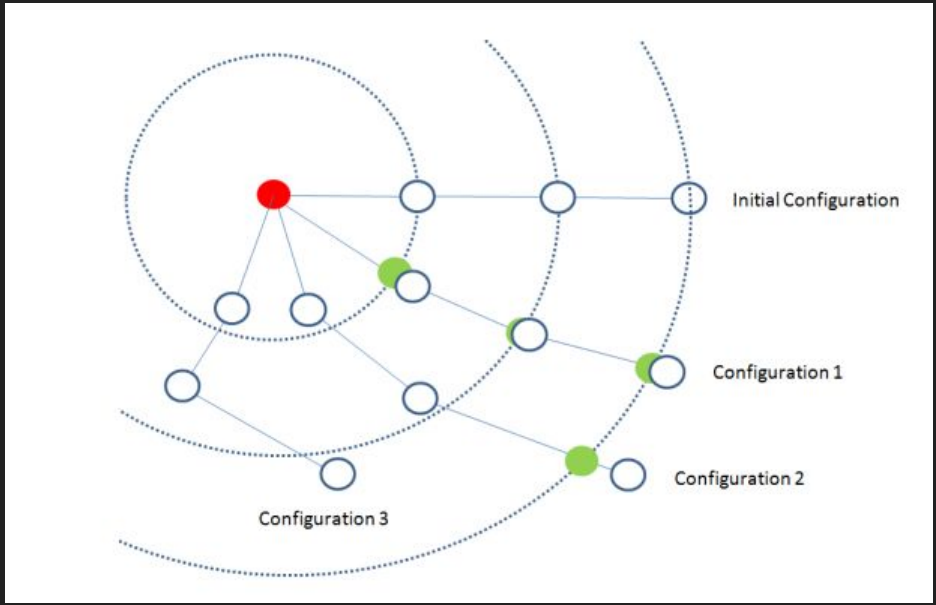
$k_{bending} = 0.7$

300 x 300 at ~330 fps

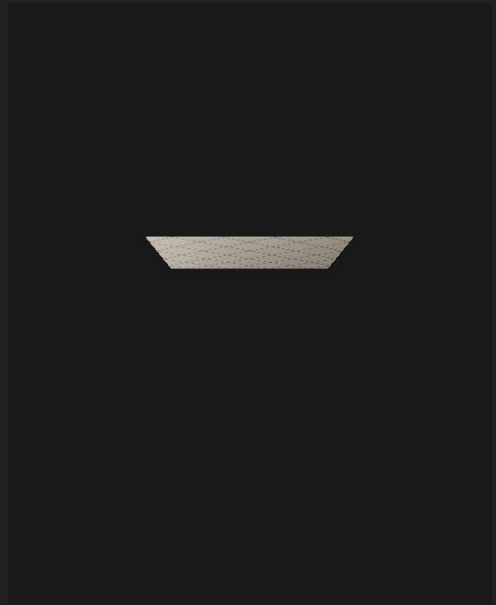
$k_{distance} = 0.99$

$k_{bending} = 0.7$

Long Range Attachment Constraint



Source: Position-Based Simulation Methods in Computer Graphics (Pg 15)

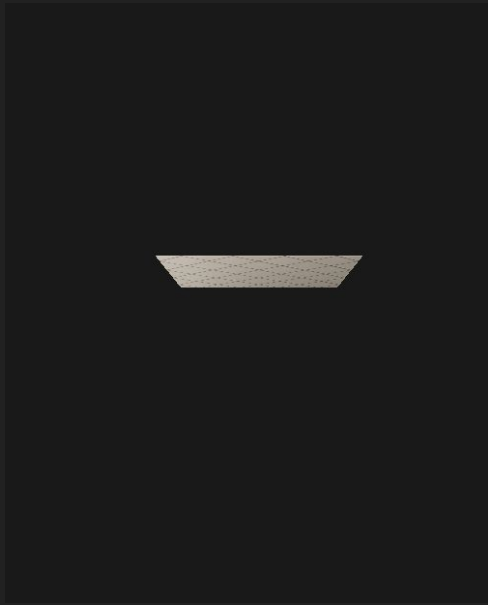


No LR Constraint

100 x 100

$k_{distance} = 0.99$

$k_{bending} = 0.7$



With LR Constraint

100 x 100

$k_{distance} = 0.6$

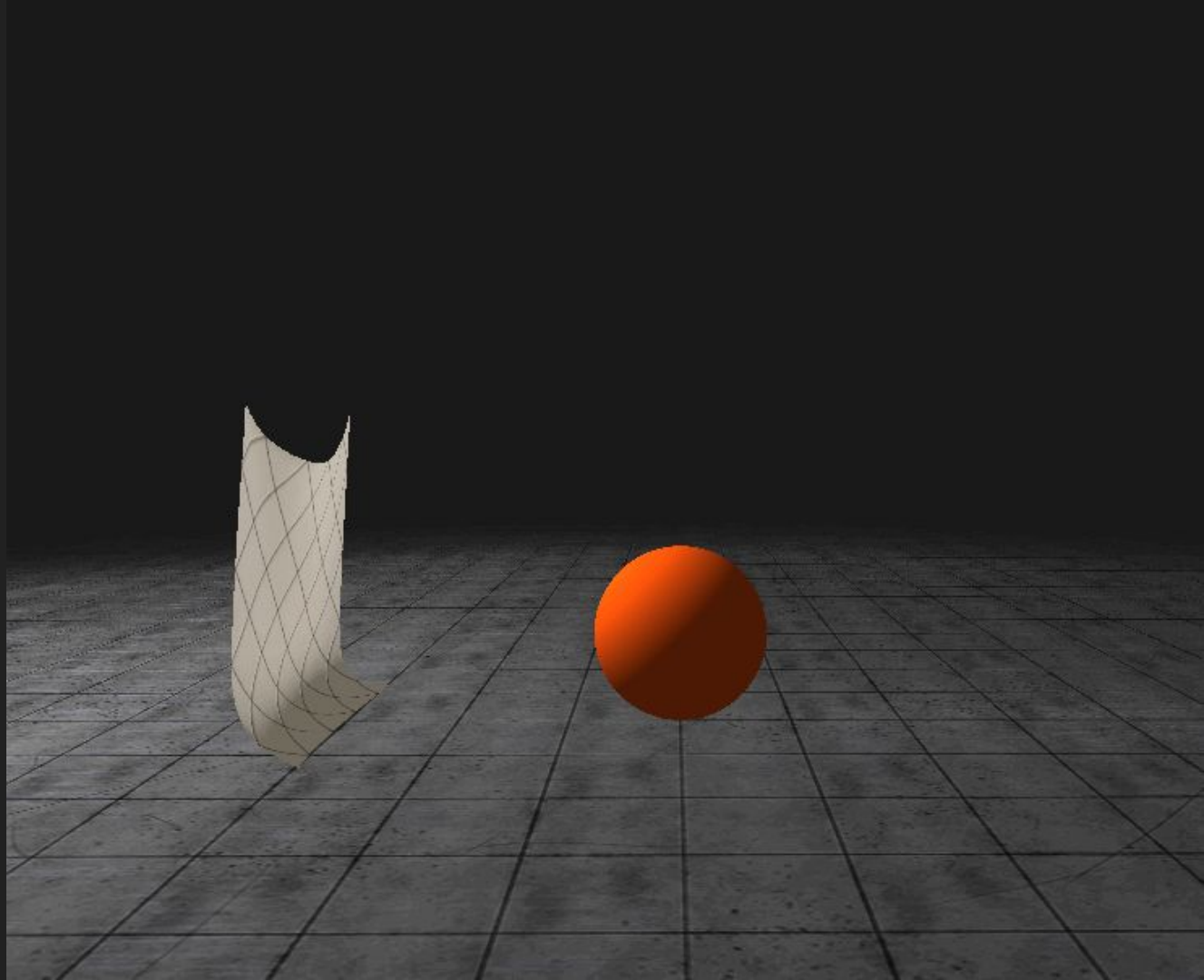
$k_{bending} = 0.4$

$k_{long\ range} = 0.8$

LRA + Anchors

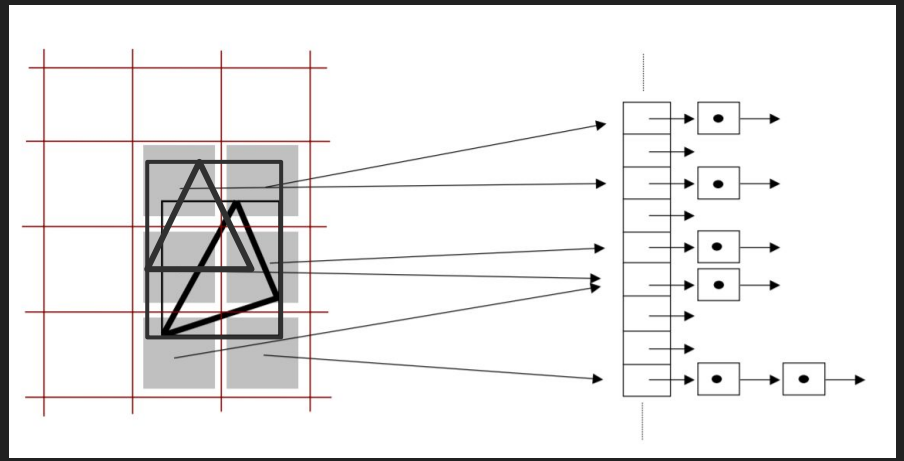
Environment Collision Constraints

- SDF Based Collisions
  - Sphere Collisions
  - Plane Collisions
- Executed in Compute Shader

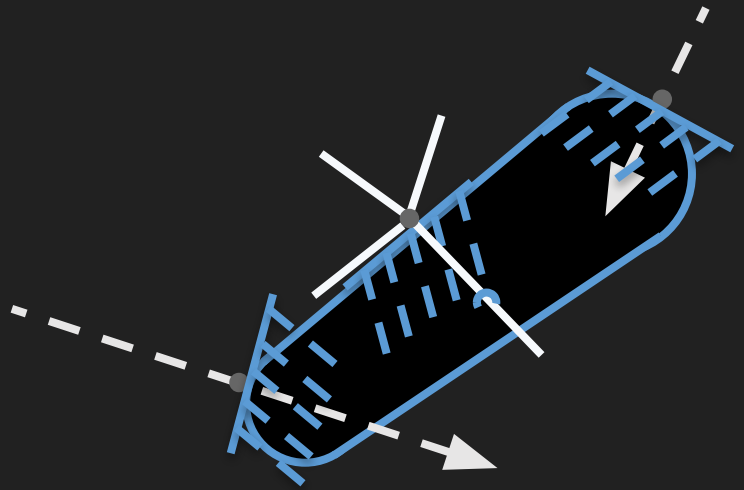


Self-Collisions using Predictive Constraints

- Introduced at GDC 2018 - *Self Collisions with Predictive Contacts*, Chris Lewin, EA Frostbite Team
- Accelerated with *Optimized Spatial Hashing for Collision Detection of Deformable Objects*, Teschner et al, ETH Zurich



Source: Optimized Spatial Hashing for Collision Detection of Deformable Objects (Pg 3)



Source: Self Collision with Predictive Contacts

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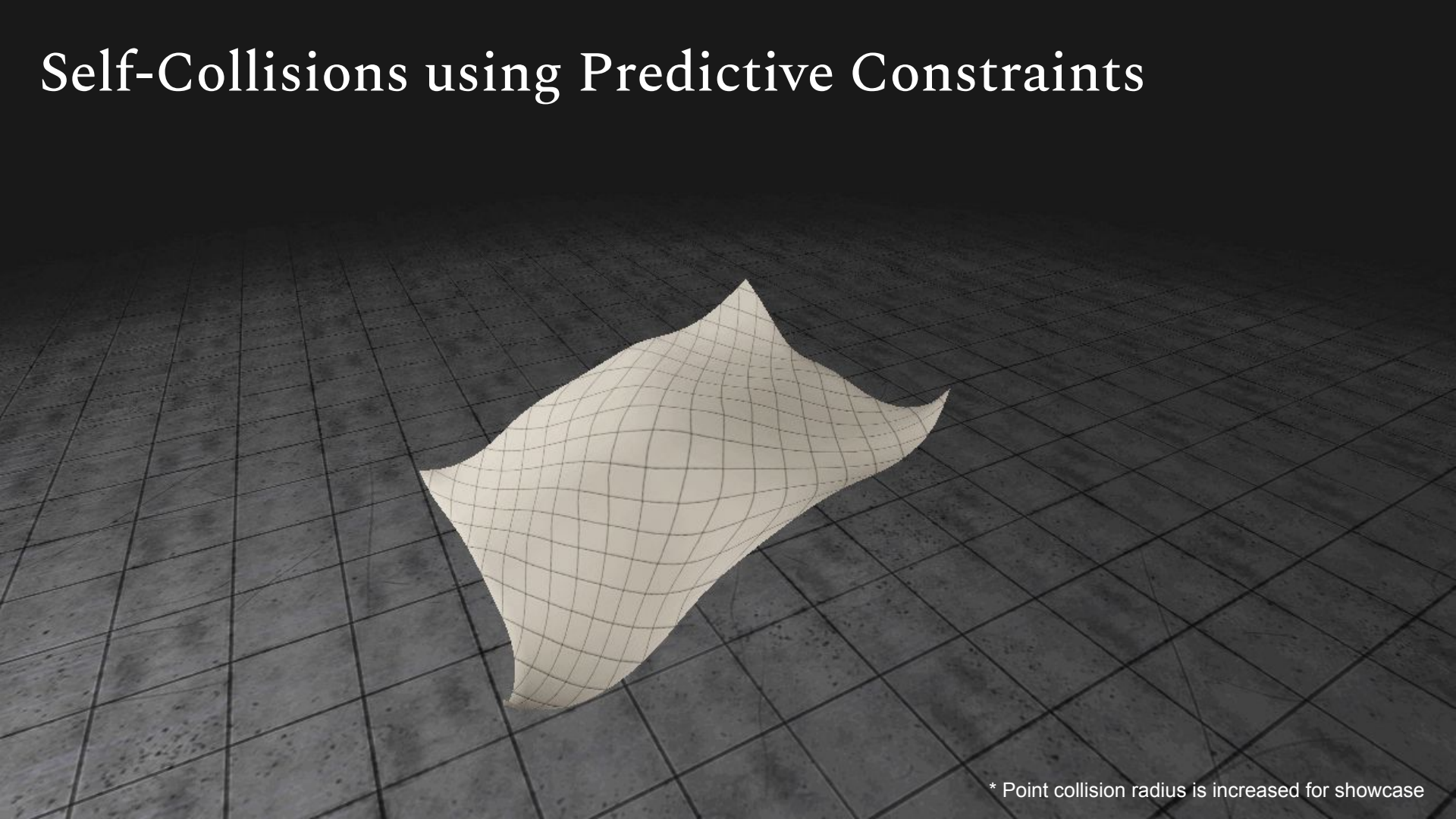
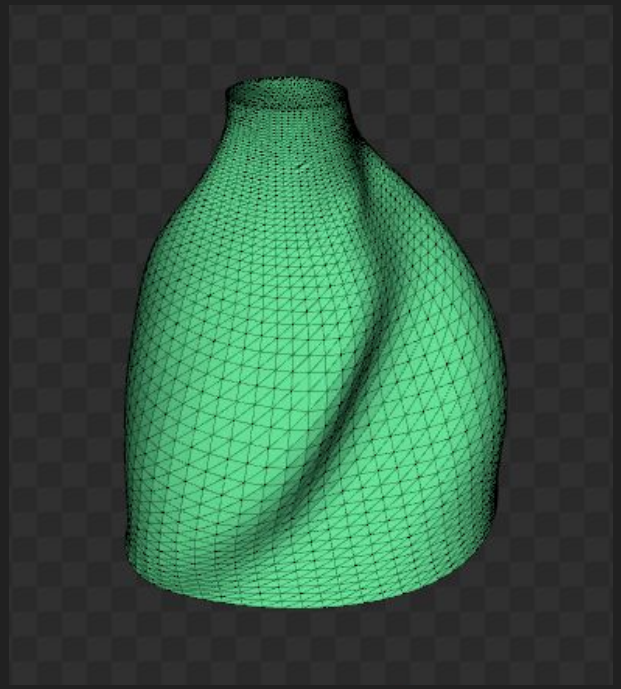
Self-Collisions using Predictive Constraints



* Point collision radius is increased for showcase

GLTF 2.0 Mesh Support



- **8192 Triangles**
- **4160 Vertices**
- **8256 Edges**
- **~ 24,576 Constraints in parallel**

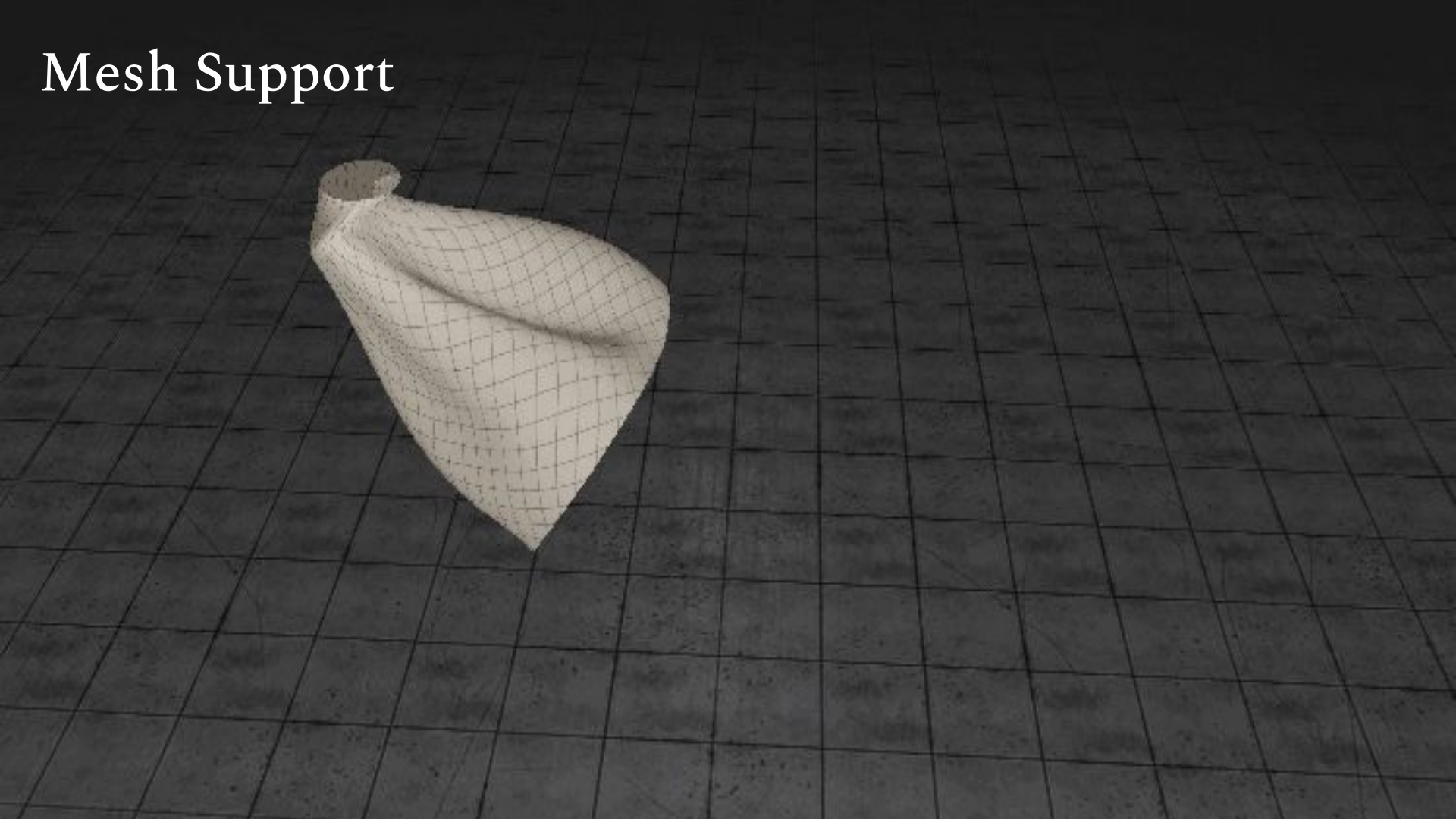
$k_{distance} = 0.6$

$k_{bending} = 0.1$

$k_{distance} = 0.9$

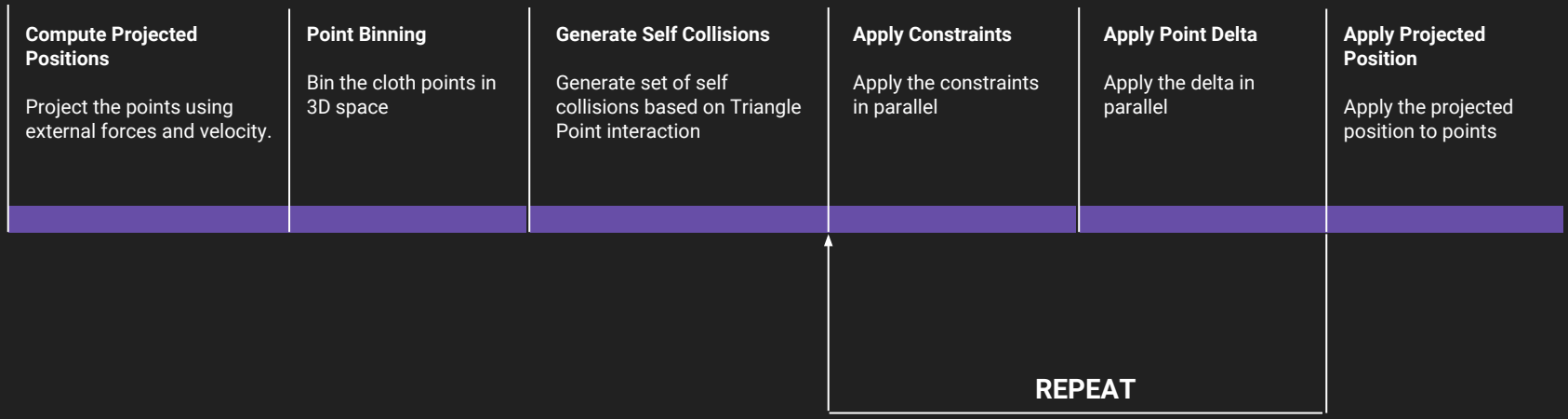
$k_{bending} = 0.6$

Mesh Support



Pipeline Breakdown

Jacobi Solver Compute Passes



Compute Pass

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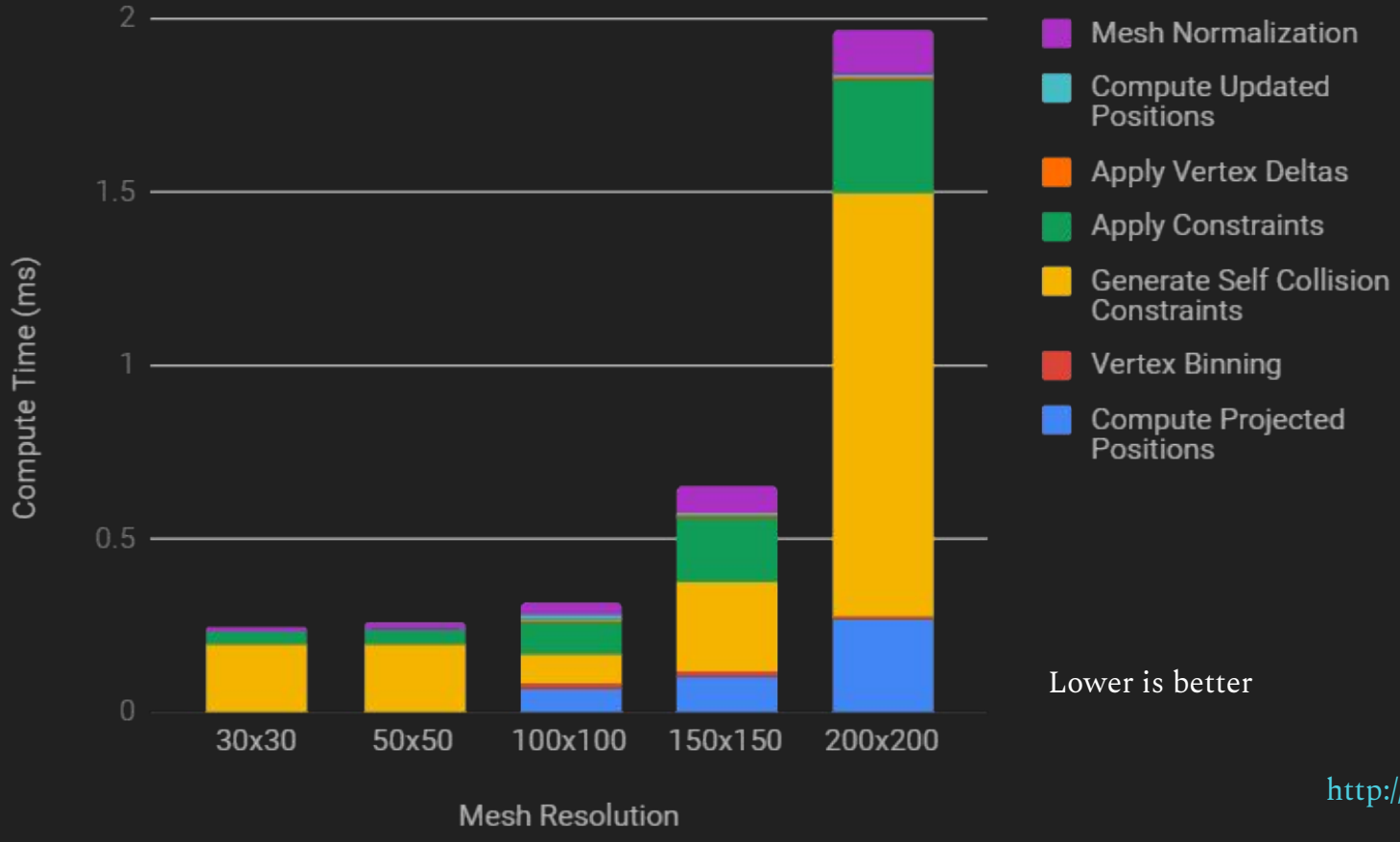
Compute Time Breakdown



Lower is better

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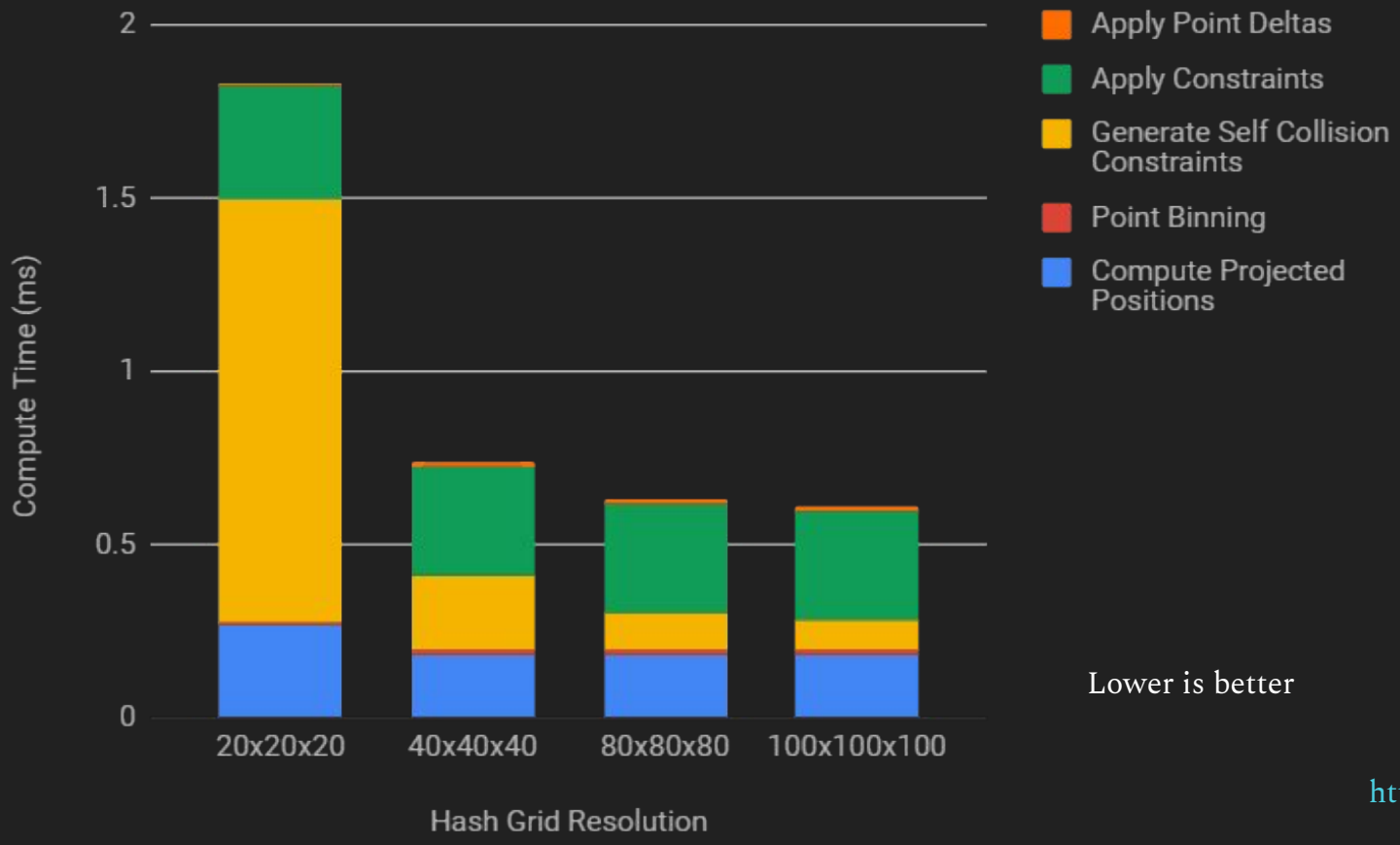
Hash Grid Acceleration



Lower is better

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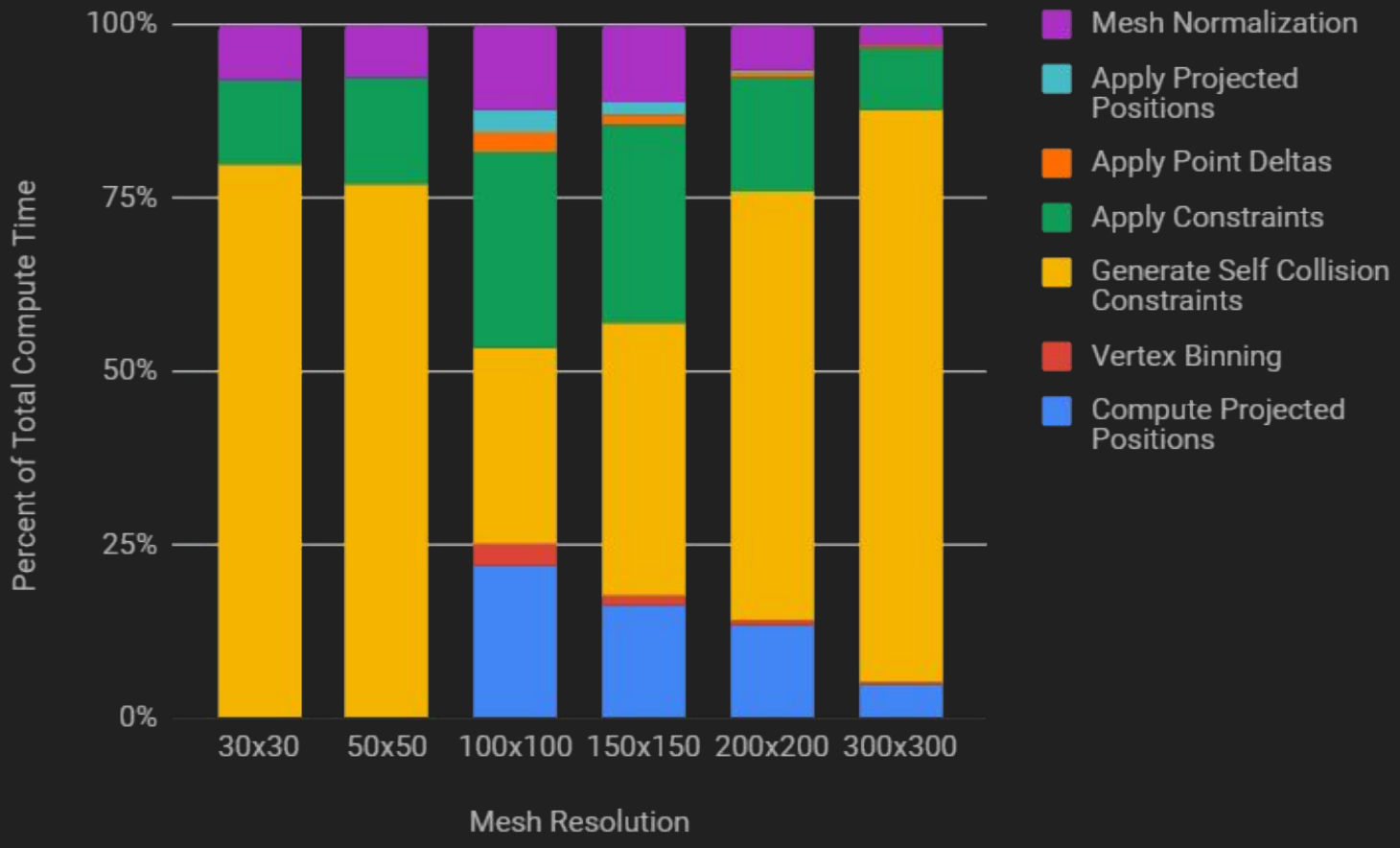
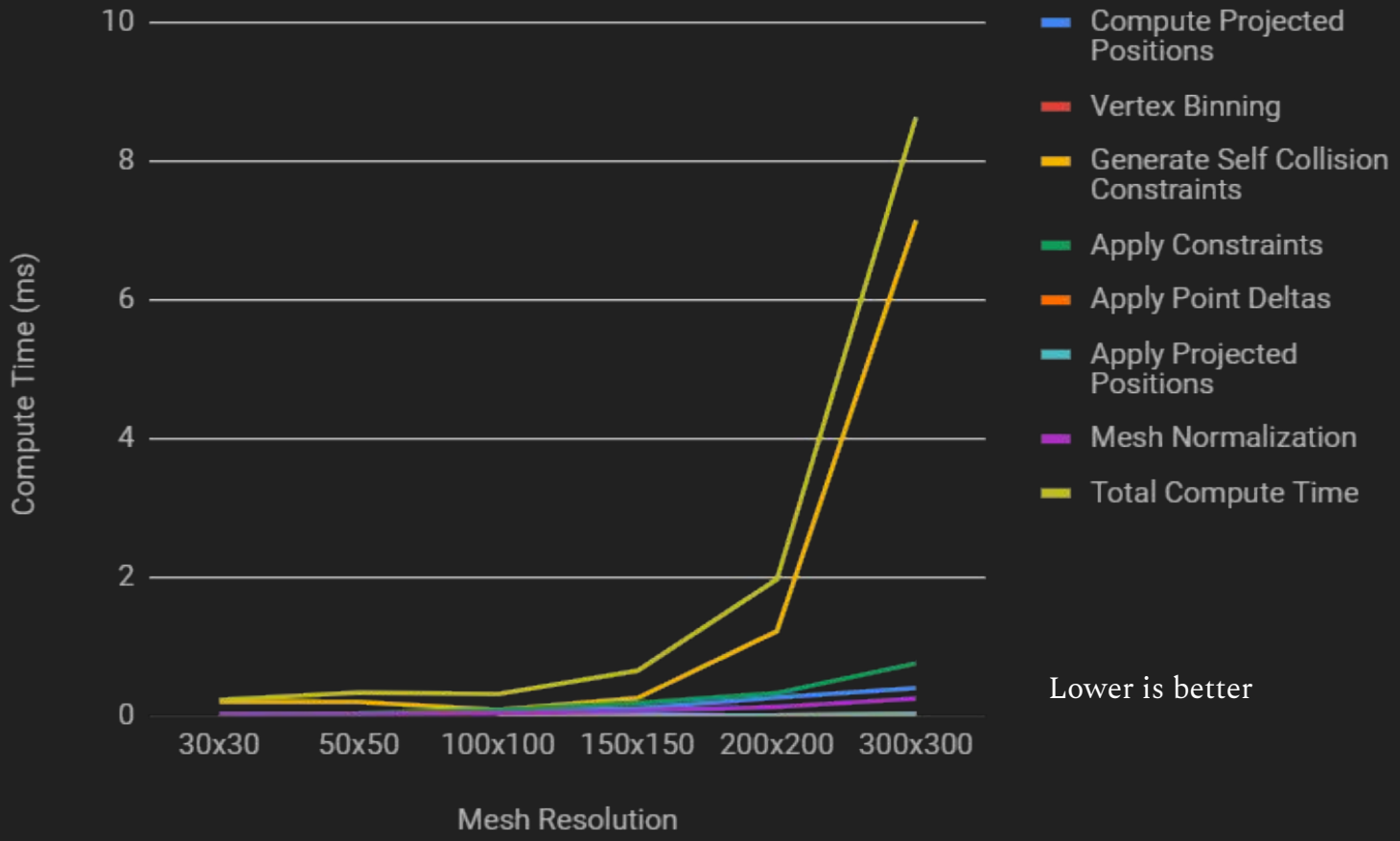
Thank You

Performance Breakdown



Performance Breakdown



Lower is better