Titre

Access the slides

https://shorturl.at/flHOY

Mesh Deformation

Introduction to the problem

Mesh Deformation

Step by step animation of a triangle mesh bending

Mesh Deformation

Highlight of bad triangle quality

2 solutions

Global remeshing

Local remeshing

Global remeshing
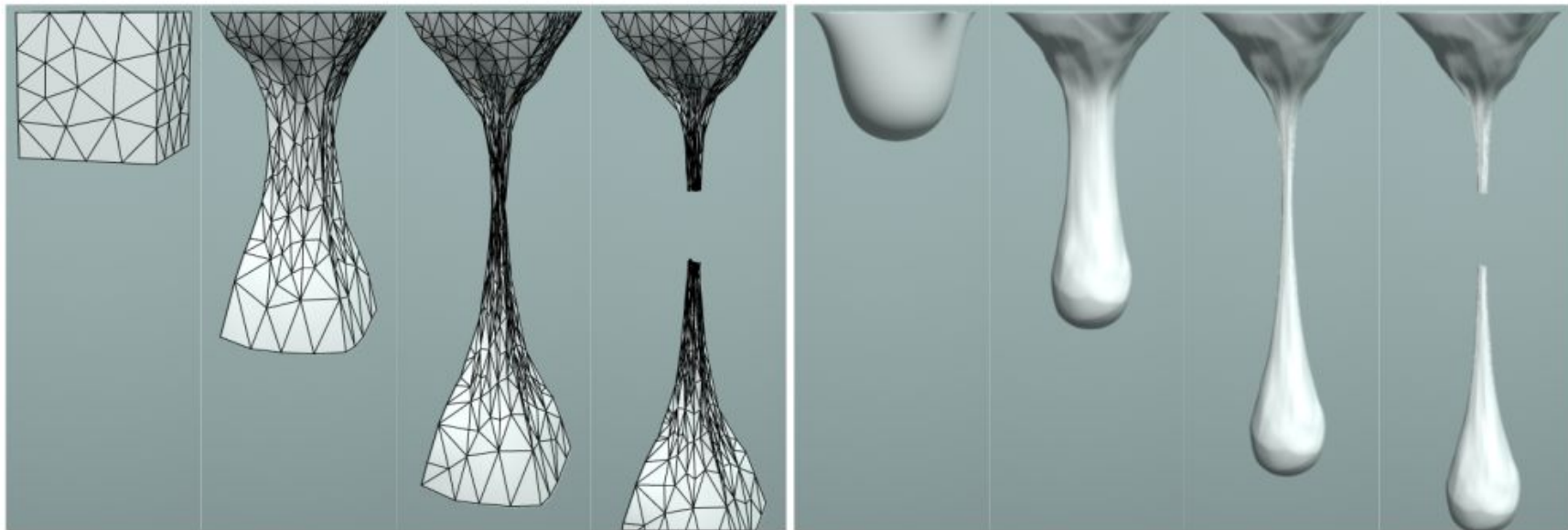
Bad mesh -> good mesh

Local remeshing

Bad mesh -> find bad elements (highlight on image) -> good mesh

Dynamic Local Remeshing for Elastoplastic Simulation
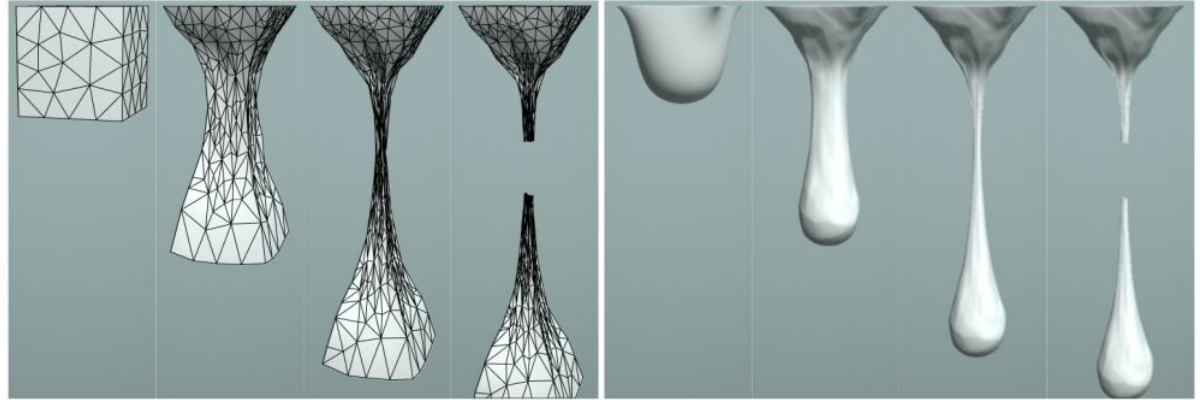
Martin Wicke   Daniel Ritchie   Bryan M. Klingner*   Sebastian Burke   Jonathan R. Shewchuk   James F. O'Brien

University of California, Berkeley and *Graphwalking Associates

Dynamic Local Remeshing for Elastoplastic Simulation

- Local remeshing solution
- Hill climbing method
- Iterative passes

2D vs 3D meshes

Triangle mesh (surface)

Tetrahedral mesh (surface)

2D vs 3D meshes

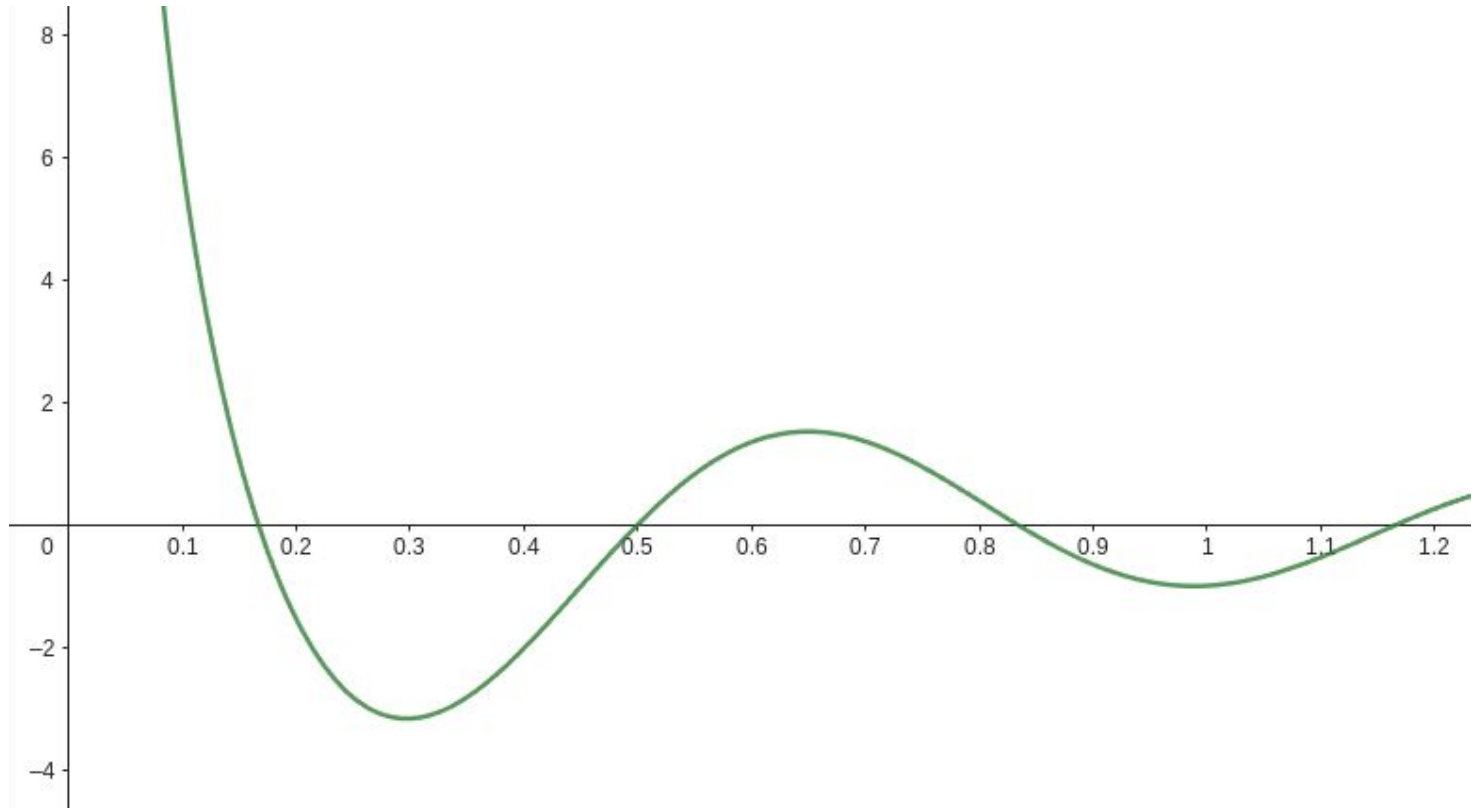Triangle mesh (inside cut)

Tetrahedral mesh

Hill climbing

https://www.english-heritage.org.uk/siteassets/home/visit/places-to-visit/silbury-hill/silbury-hill-hero.jpg

Hill climbing

https://en.wikipedia.org/wiki/File:Everest_North_Face_toward_Base_Camp_Tibet_Luca_Galuzzi_2006_edit_1.jpg

Hill climbing - Local optimum

Quality measure

Image of highlighted bad elements
on mesh from slide before

$$6\sqrt{2}V\frac{\ell_{harm}}{\ell_{rms}^4}$$

Quality measure

Image of tetrahedron to highlight lengths

$$\ell_{harm} = \frac{n}{\sum_{i=1}^{n} \frac{1}{e_i}}, \, e \in E$$

Quality measure

Image of tetrahedron to
highlight lengths

$$\ell_{rms} = \sqrt{\frac{\sum_{i=1}^{n} e_i^2}{n}}, e \in E$$

Iterative passes

Flowchart going bad elements -> topo pass -> contra pass -> insert pass -> smoothing pass

Topological pass

Show different types of flips

Contraction pass

Show tet and contract each

Insertion pass

Flowchart dig hole -> add point -> fill cavity

Smoothing pass

Discuss smoothing

23

World and material space

Martin Wicke, Daniel Ritchie, Bryan M. Klingner, Sebastian Burke, Jonathan R. Shewchuk, and James F. O'Brien. Dynamic local remeshing for elastoplastic simulation. ACM Trans. Graph., 29(4), jul 2010.
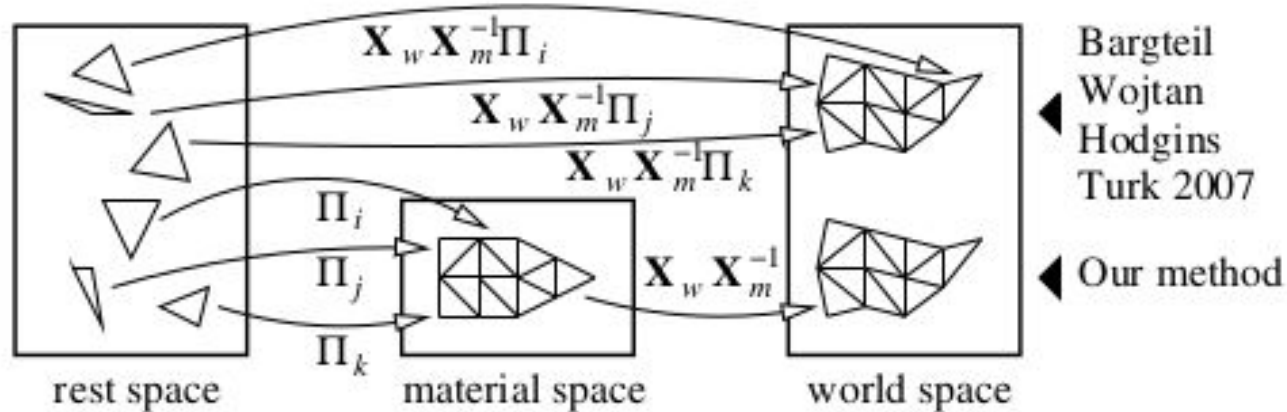
My Implementation

- 2D and 3D
- World mesh

Quality Evaluation

$$6\sqrt{2}V\frac{\ell_{harm}}{\ell_{rms}^4}$$

Quality Evaluation

$$6\sqrt{2}V\frac{\ell_{harm}}{\ell_{rms}^4} \longrightarrow 4\sqrt{3}A\frac{1}{\sum_{i=1}^{3}l_i^2}$$

Lori Freitag, Mark Jones, and Paul Plassmann. A parallel algorithm for mesh smoothing. SIAM Journal on Scientific Computing , 20(6):2023–2040, 1999

Quality Evaluation

$$4\sqrt{3}A \frac{1}{\sum_{i=1}^{3} l_i^2}$$

Image of triangle losing quality

Lori Freitag, Mark Jones, and Paul Plassmann. A parallel algorithm for mesh smoothing. SIAM Journal on Scientific Computing , 20(6):2023–2040, 1999

Topological pass

Show edge flip

Contraction pass

Show triangle and contract each edge

Insertion pass

Flowchart dig hole -> add point -> fill cavity

Smoothing pass

Show point going to center of hexagon

Quality Evaluation

Dirichlet energy

$$E_{dirichlet}(t) = \|\mathcal{J}_t\|^2 + \|\mathcal{J}_t^{-1}\|^2 - 6$$

Show tet losing quality

Topological pass

Edge and face removal algorithms

Insertion pass

Digging cavity

Explain galaxy approach (center of chebyshev)

Insertion pass

Filling cavity and second topological pass

Smoothing pass

Reuse center of chebyshev

World and material space

Flowchart illustrating remeshing validity check with material space

Experiments

- 2D
  - Stretch
  - Compress
- 3D
  - Spin
  - Stretch

Experiments

- **2D**
  - Stretch
  - Compress
- 3D
  - Spin
  - Stretch

2D Stretch

Animation of experiment

2D Compress

Animation of experiment

Results

Results

Quality min=0.1

Quality min=0.2

Results

Quality min=0.1

Quality min=0.2

Quality min=0.3

Quality min=0.4

Quality min=0.5

Quality min=0.55
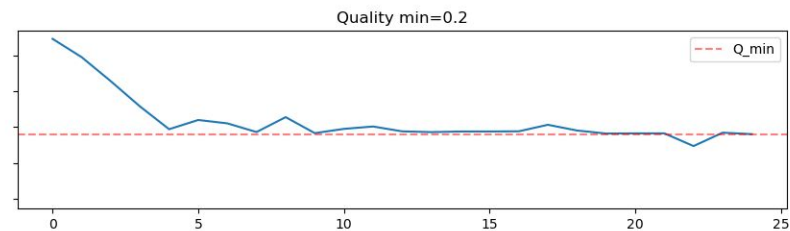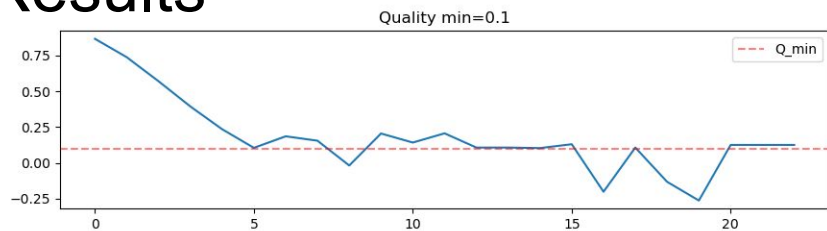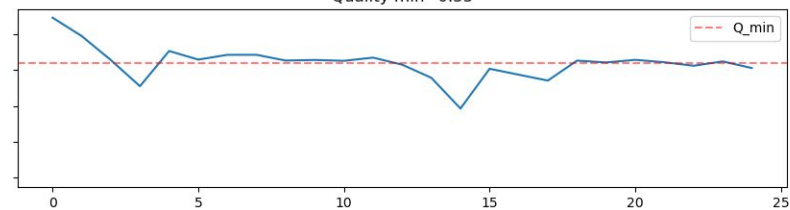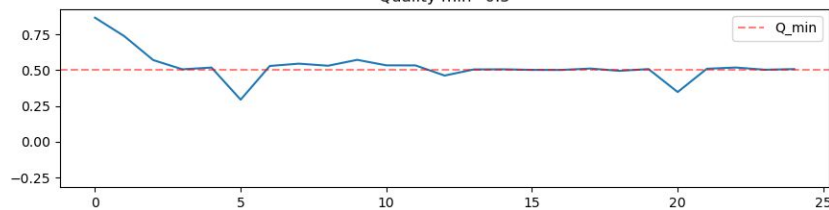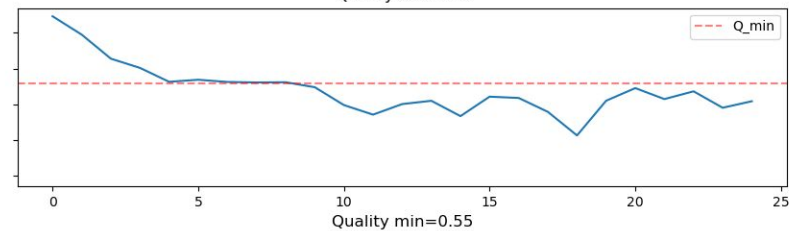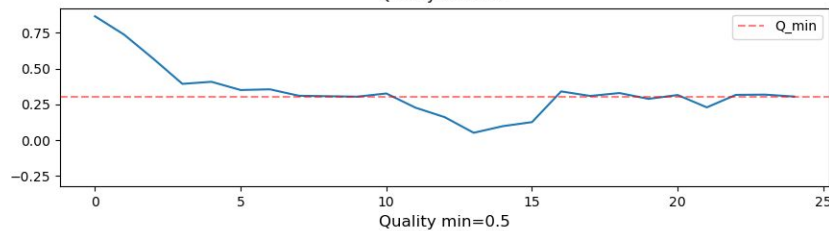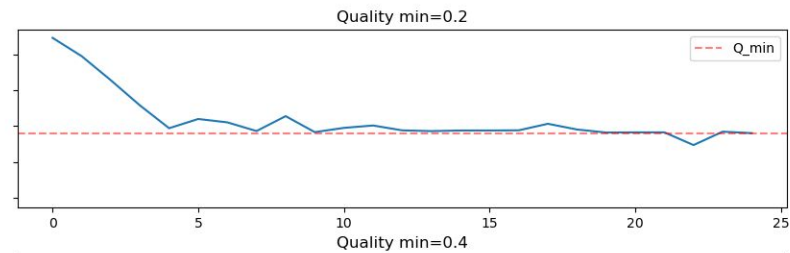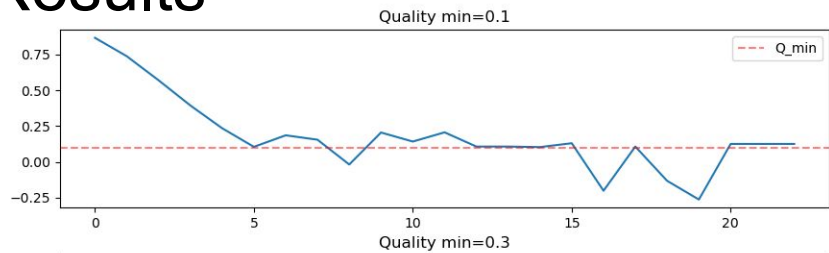
Results
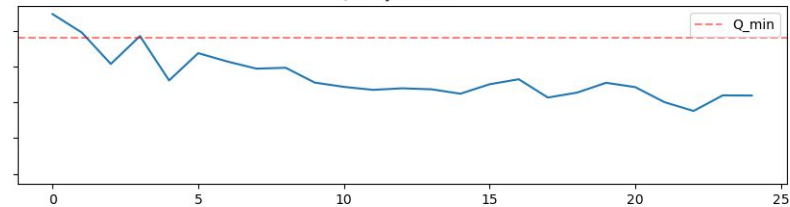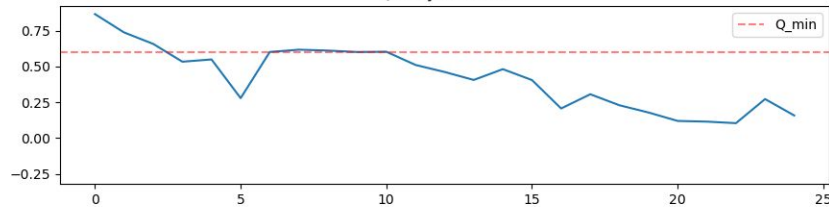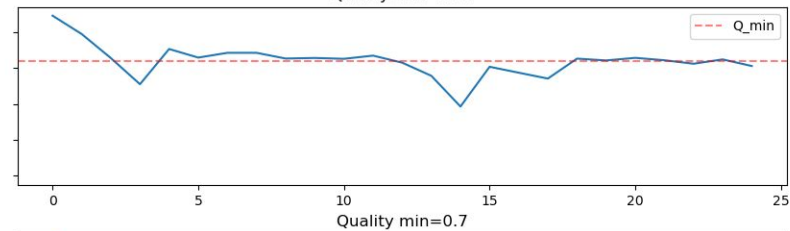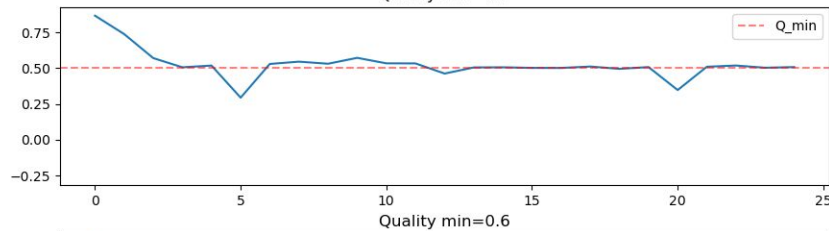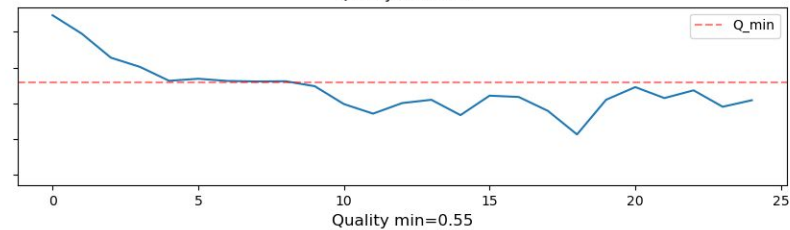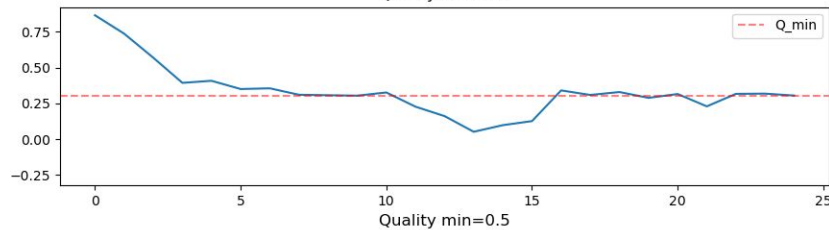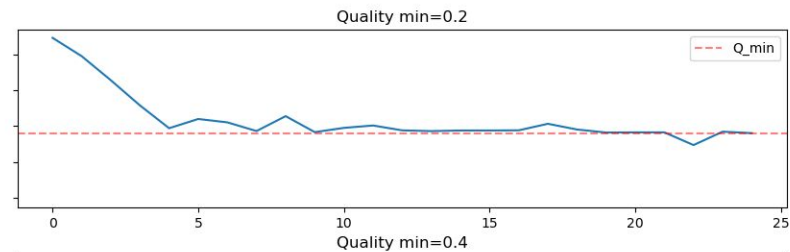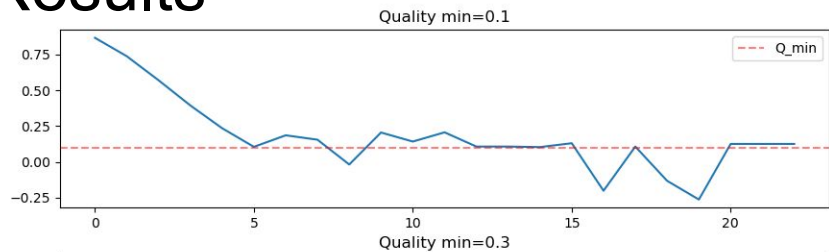
Experiments

- 2D
  - Stretch
  - Compress
  - Find optimal quality threshold
- **3D**
  - Spin
  - Stretch

3D Spin

Show animation of experiment

3D Spin

- Optimal quality
- Timestep angle
- Severity of deformation
- World mesh influence

Quality
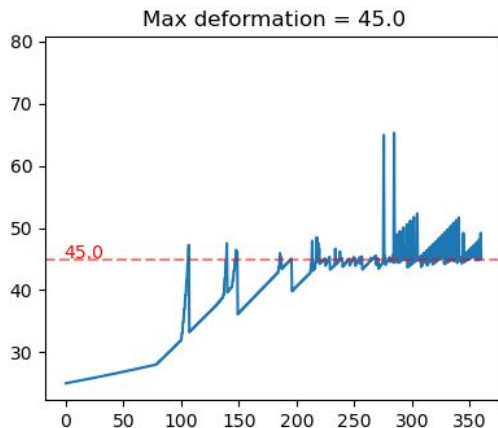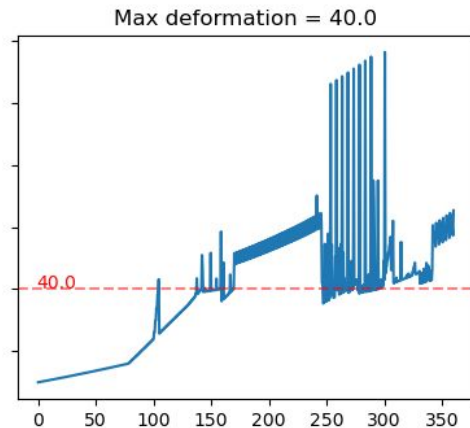--- Maximal deformation

3D Spin

- **Optimal quality**
  - Timestep angle
  - Severity of deformation
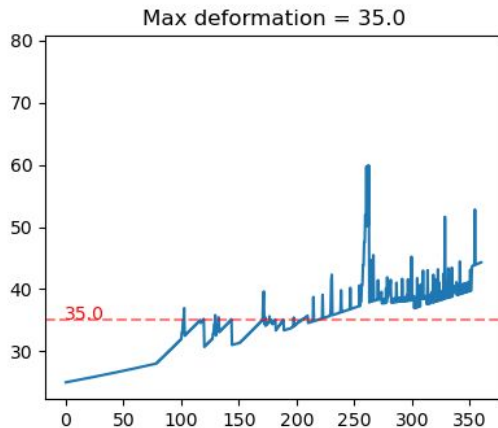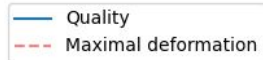 - World mesh influence

3D Spin

- **Optimal quality**
  - Timestep angle
  - Severity of deformation
  - World mesh influence

Deformation of worse element

Quality
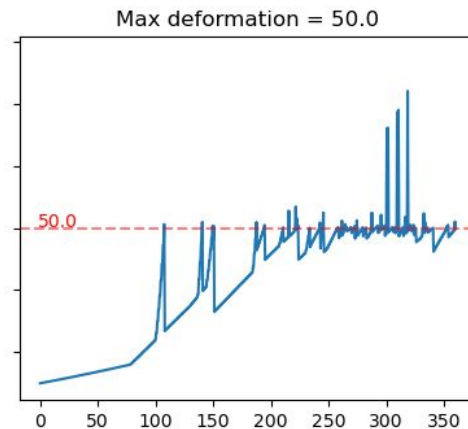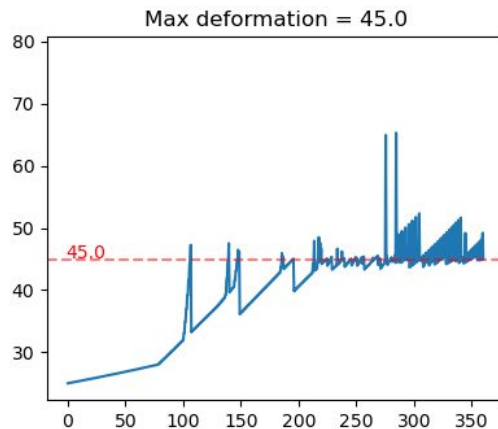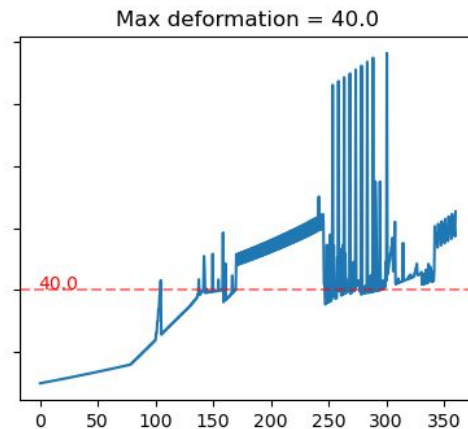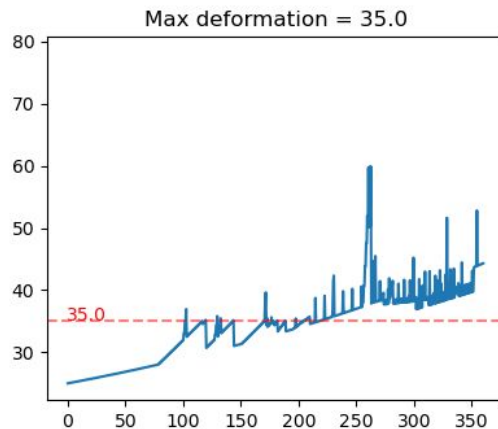Maximal deformation

Max deformation = 35.0

35.0

3D Spin

- **Optimal quality**
- Timestep angle
- Severity of deformation
- World mesh influence

Quality
Maximal deformation

Max deformation = 35.0

Max deformation = 40.0

3D Spin

- **Optimal quality**
- Timestep angle
- Severity of deformation
- World mesh influence

Deformation of worse element

— Quality
- - - Maximal deformation

Max deformation = 35.0

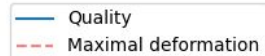Max deformation = 40.0

Max deformation = 45.0
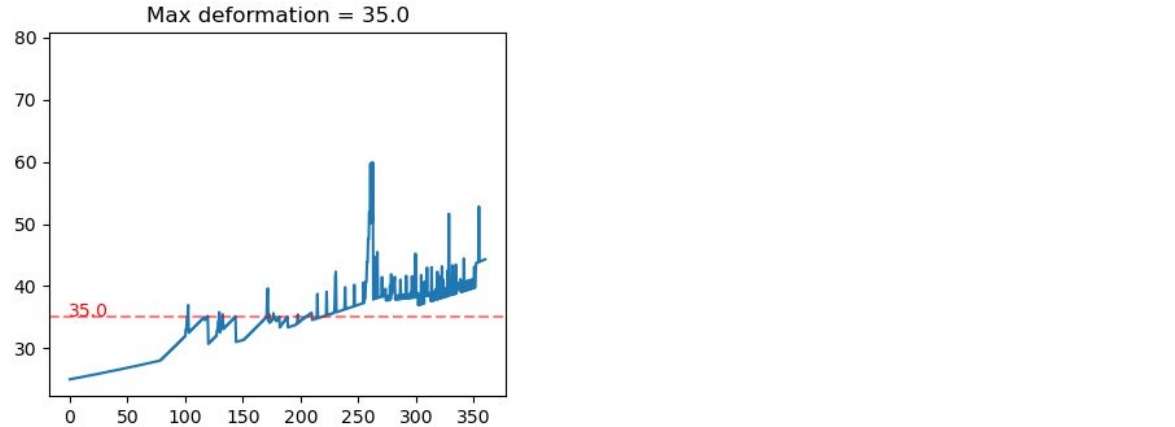
3D Spin

- **Optimal quality**
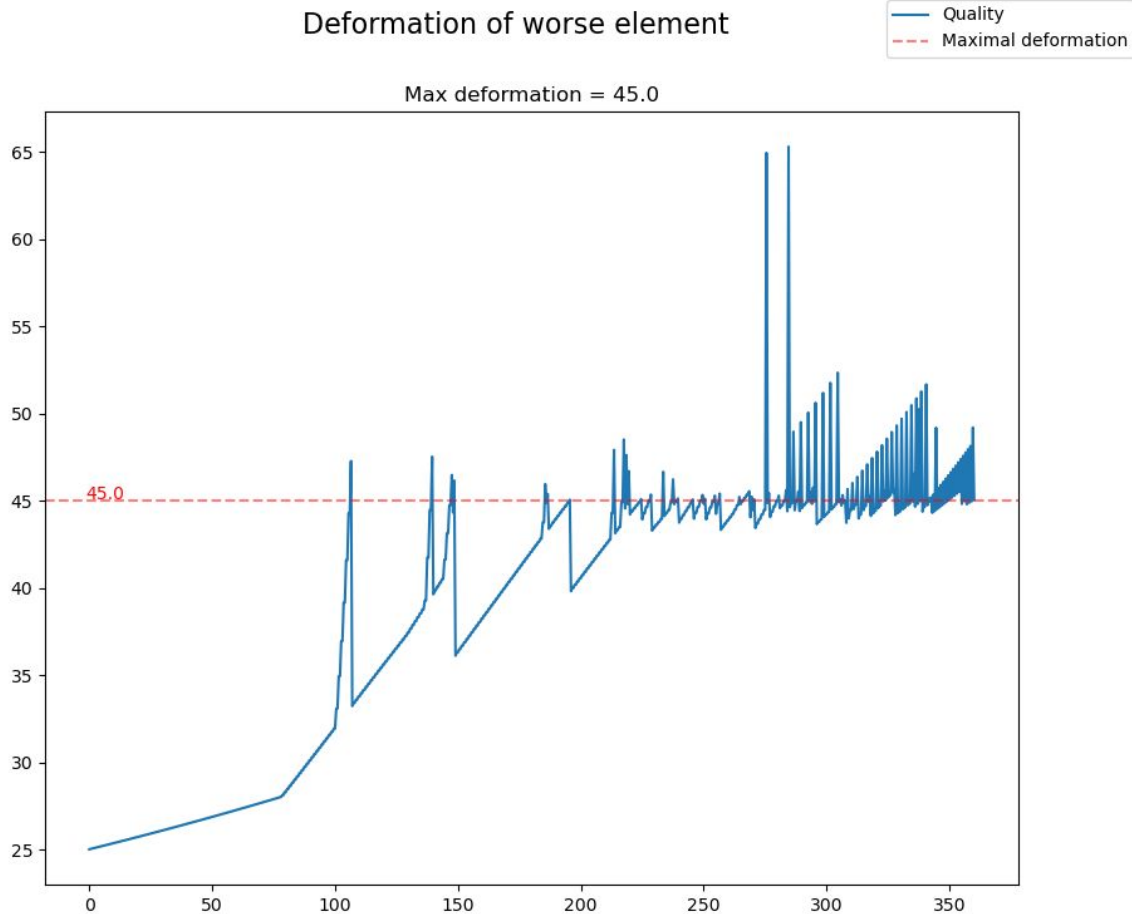- Timestep angle
- Severity of deformation
- World mesh influence

Deformation of worse element

3D Spin

- **Optimal quality**
- Timestep angle
- Severity of deformation
- World mesh influence

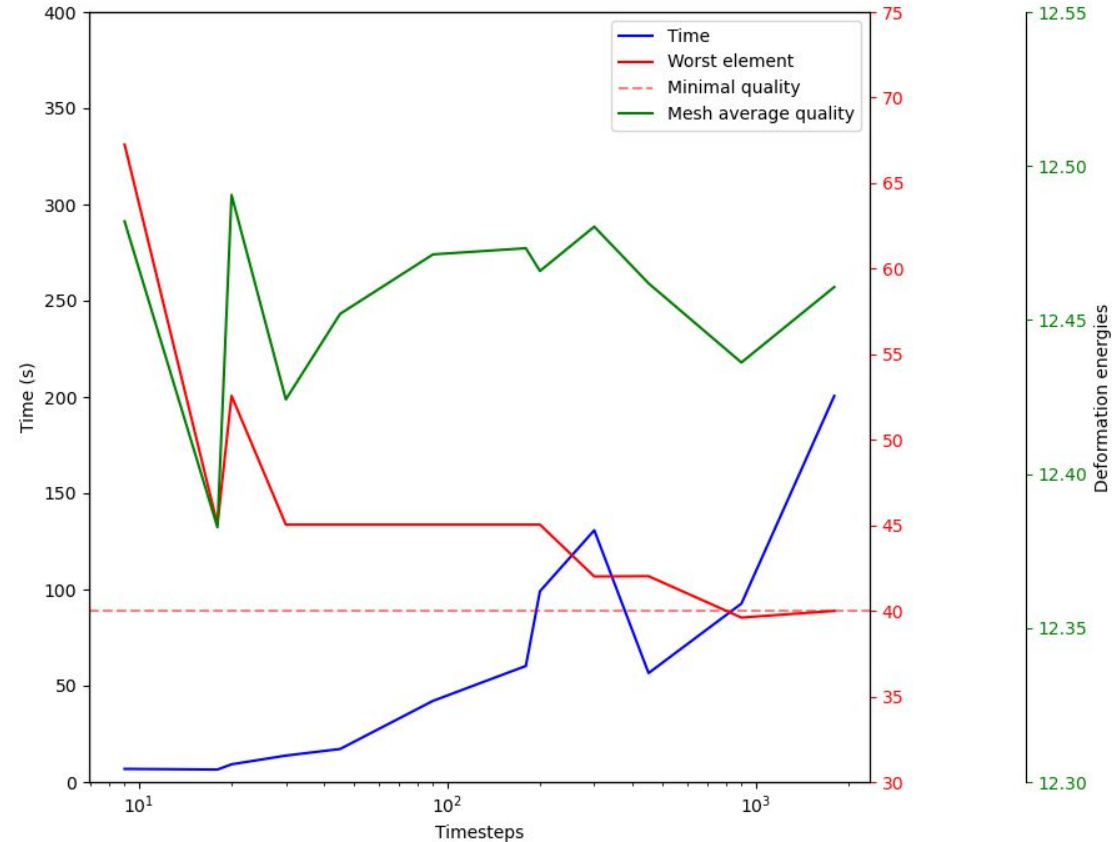Deformation of worse element

Max deformation = 45.0

3D Spin

- Optimal quality
- **Timestep angle**
- Severity of deformation
- World mesh influence

Angle to time with max deformation = 40
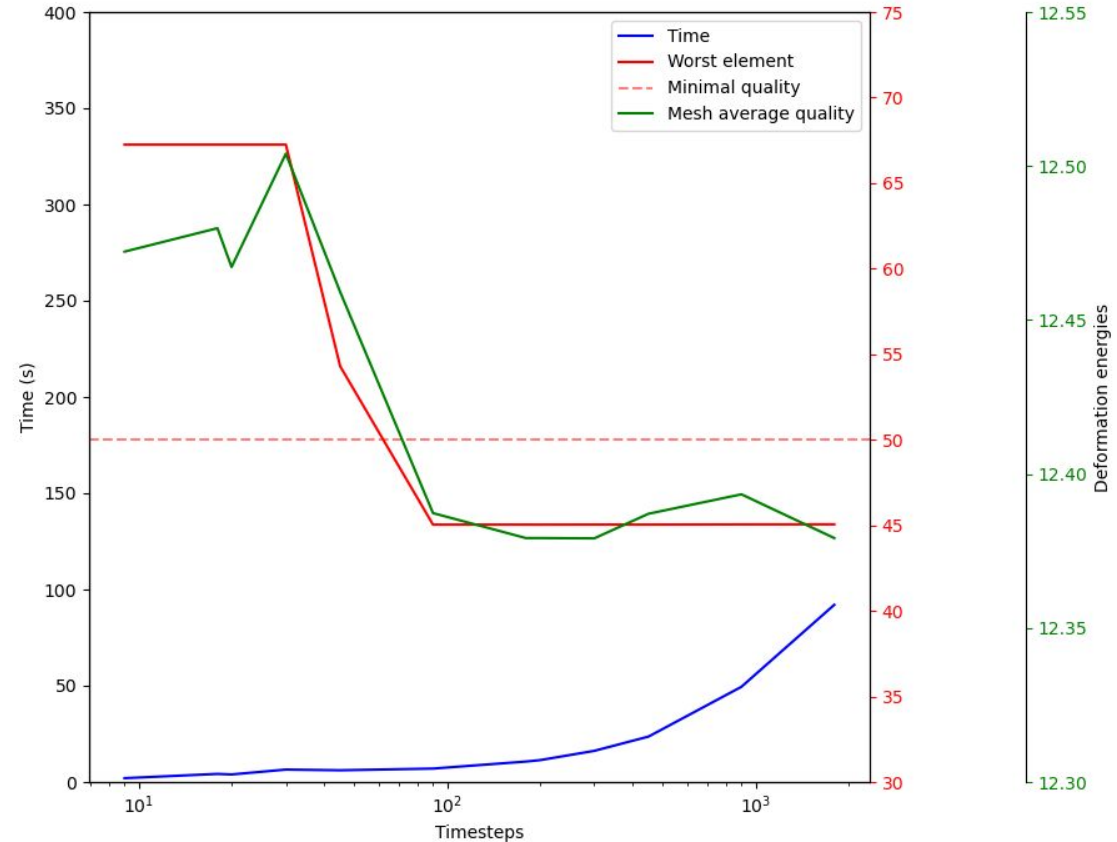
Rotation = 180°

3D Spin

- Optimal quality
- **Timestep angle**
- Severity of deformation
- World mesh influence

Angle to time with max deformation = 50
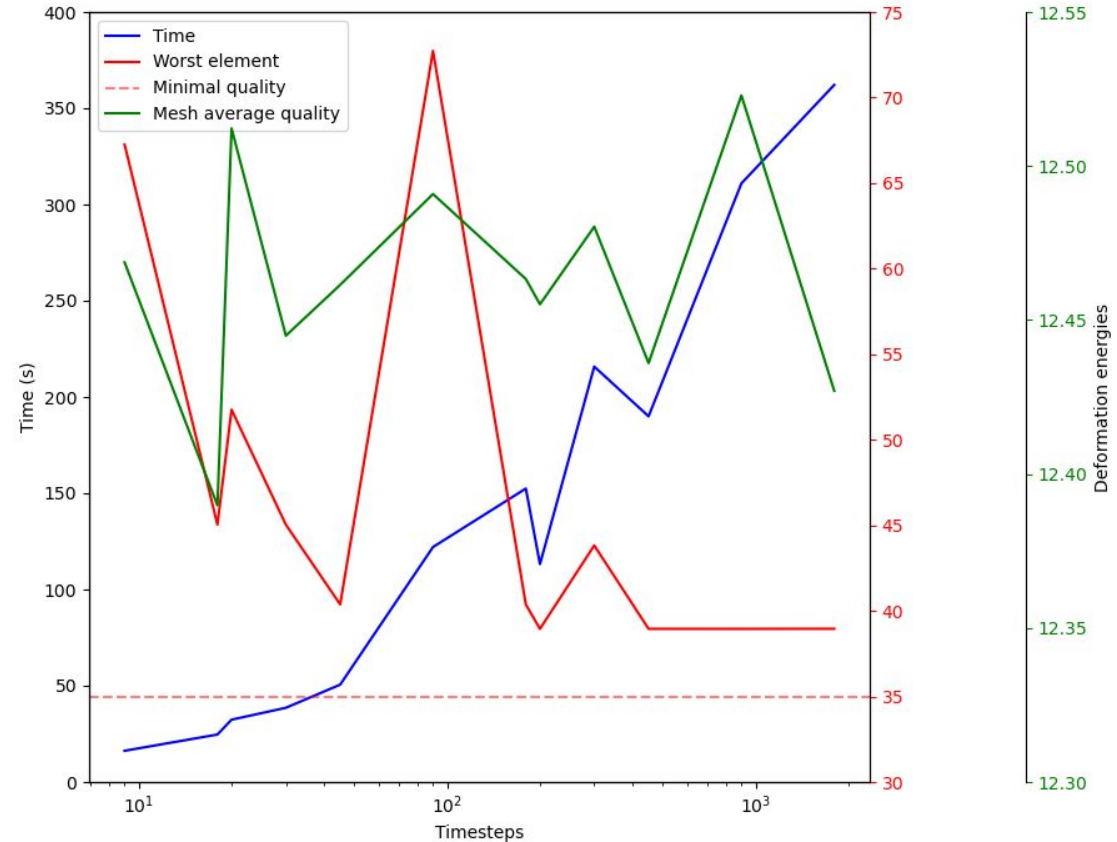
Rotation = 180°

3D Spin

- Optimal quality
- **Timestep angle**
- Severity of deformation
- World mesh influence

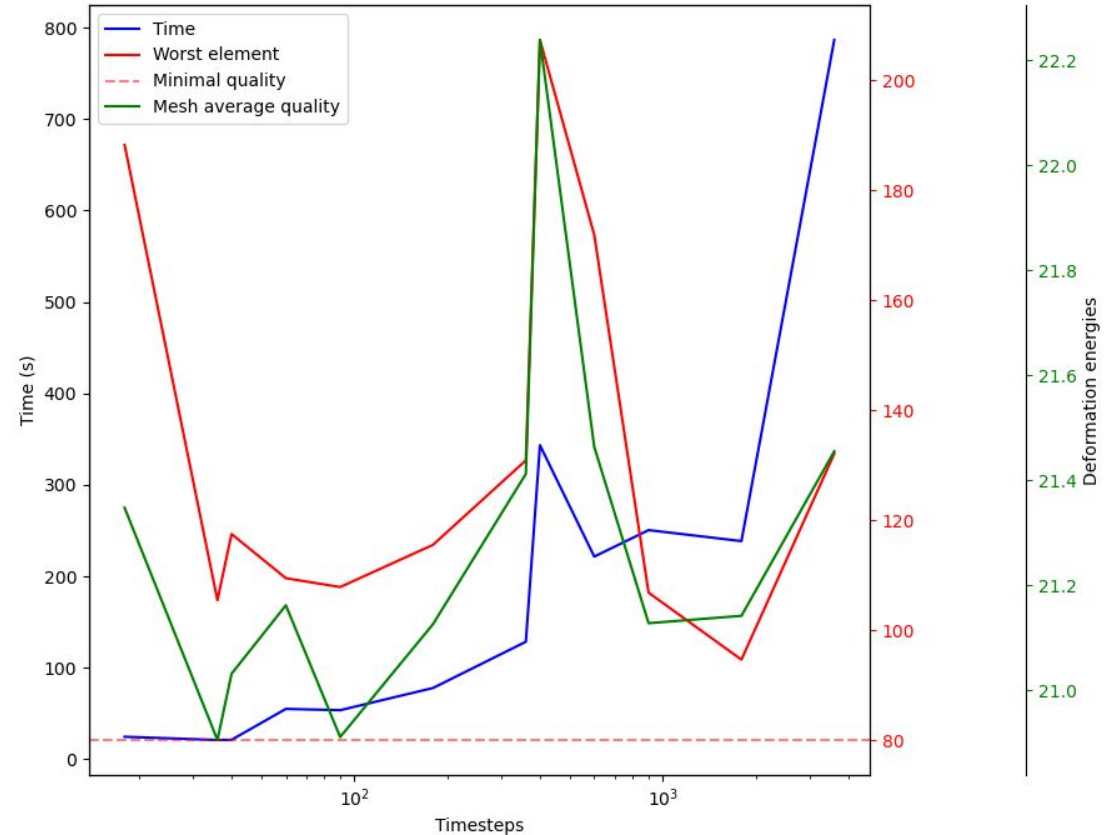
Angle to time with max deformation = 35

Rotation = 180°

3D Spin

- Optimal quality
- **Timestep angle**
- Severity of deformation
- World mesh influence

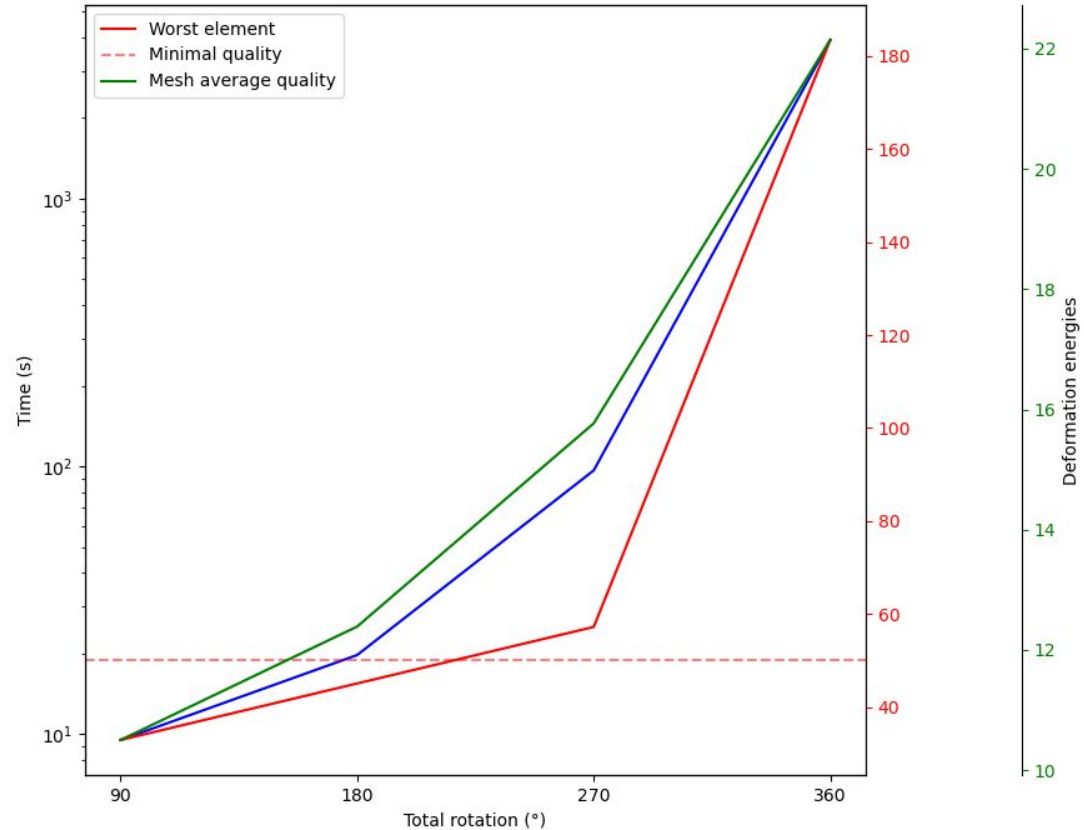
Angle to time with max deformation = 80

Rotation = 360°

3D Spin

- Optimal quality
- Timestep angle
- **Severity of deformation**
- World mesh influence
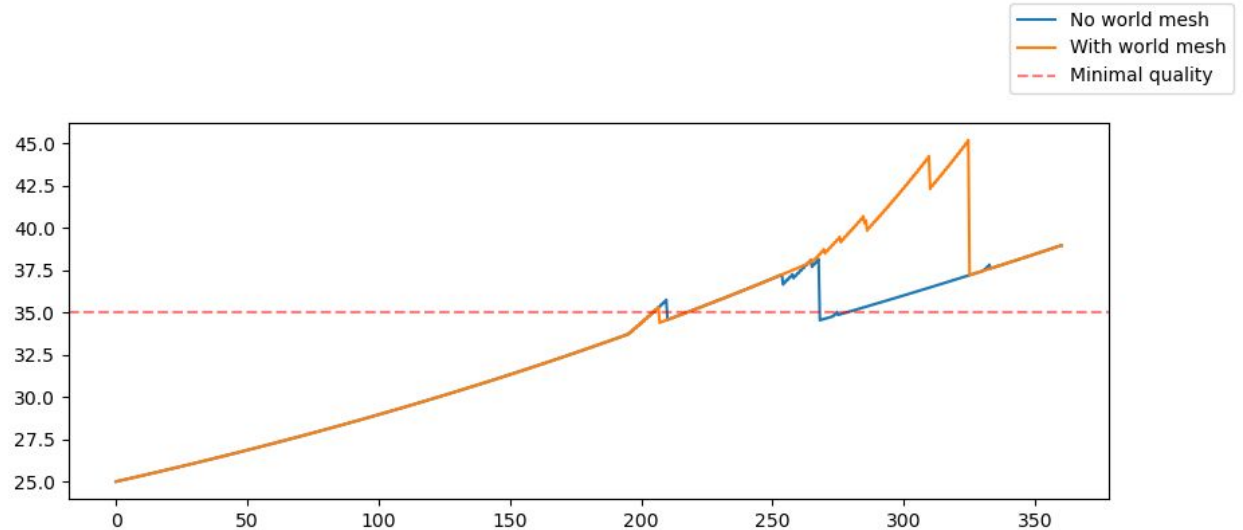

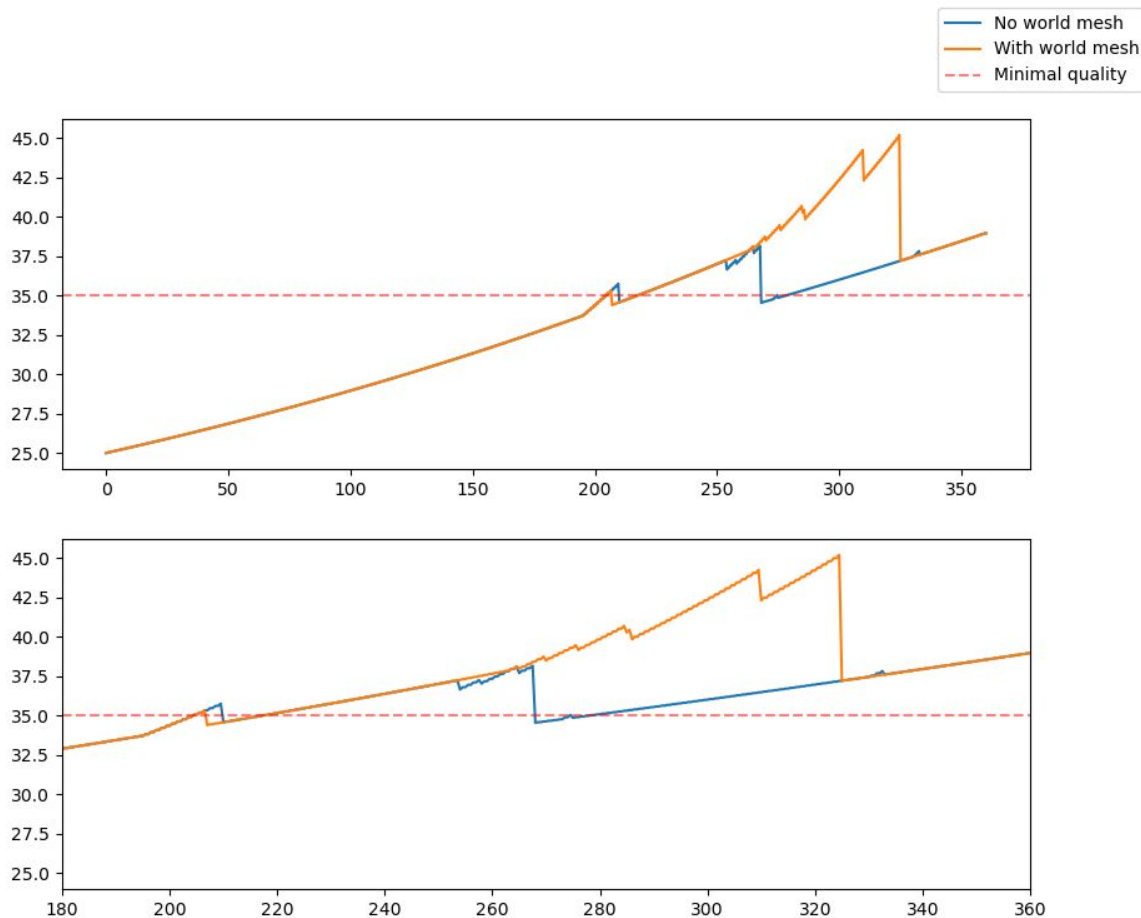
Time to turn with max deformation = 50

3D Spin

- Optimal quality
- Timestep angle
- Severity of deformation
- **World mesh influence**

3D Spin

- Optimal quality
- Timestep angle
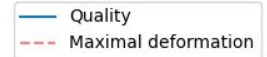- Severity of deformation
- **World mesh influence**

3D Stretch
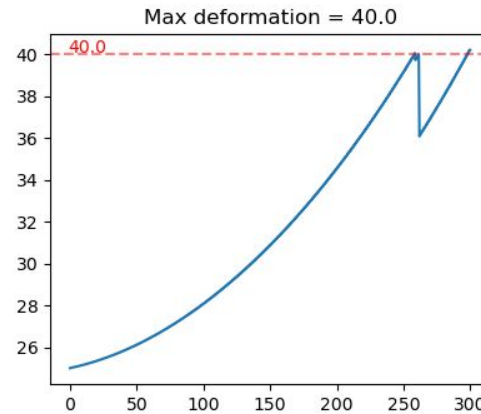
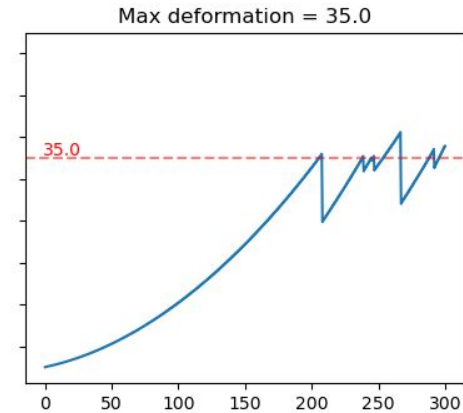Show animation of experiment

3D Stretch

- Quality experiment
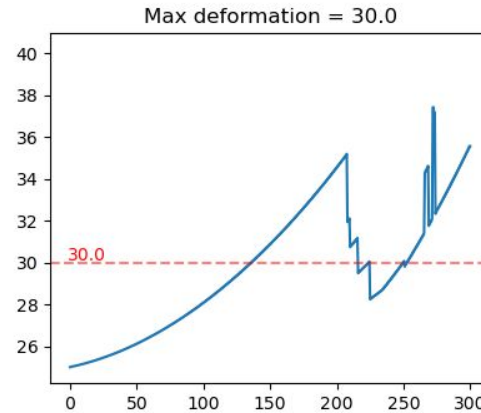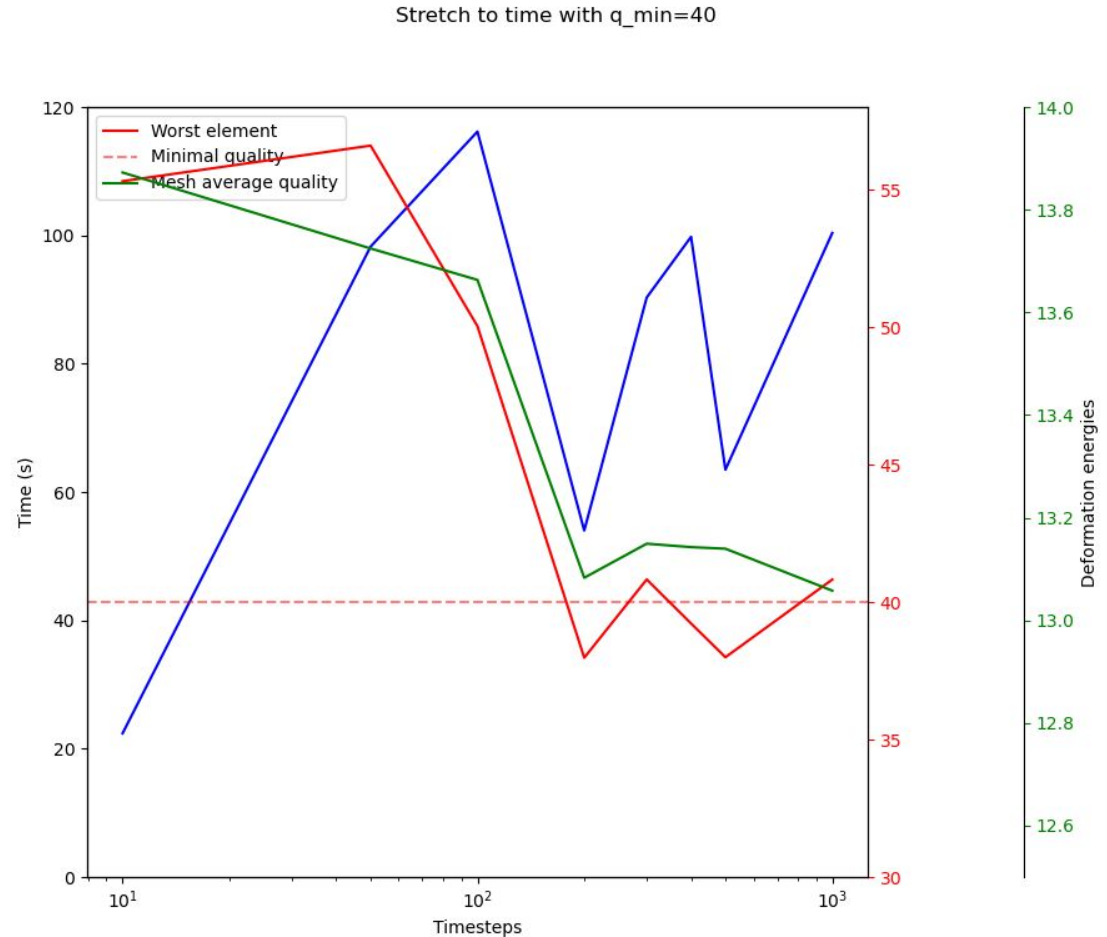- Stretch experiment
- Length experiment

3D Stretch

- **Quality experiment**
  - Stretch experiment
  - Length experiment

Deformation of worse element

3D Stretch

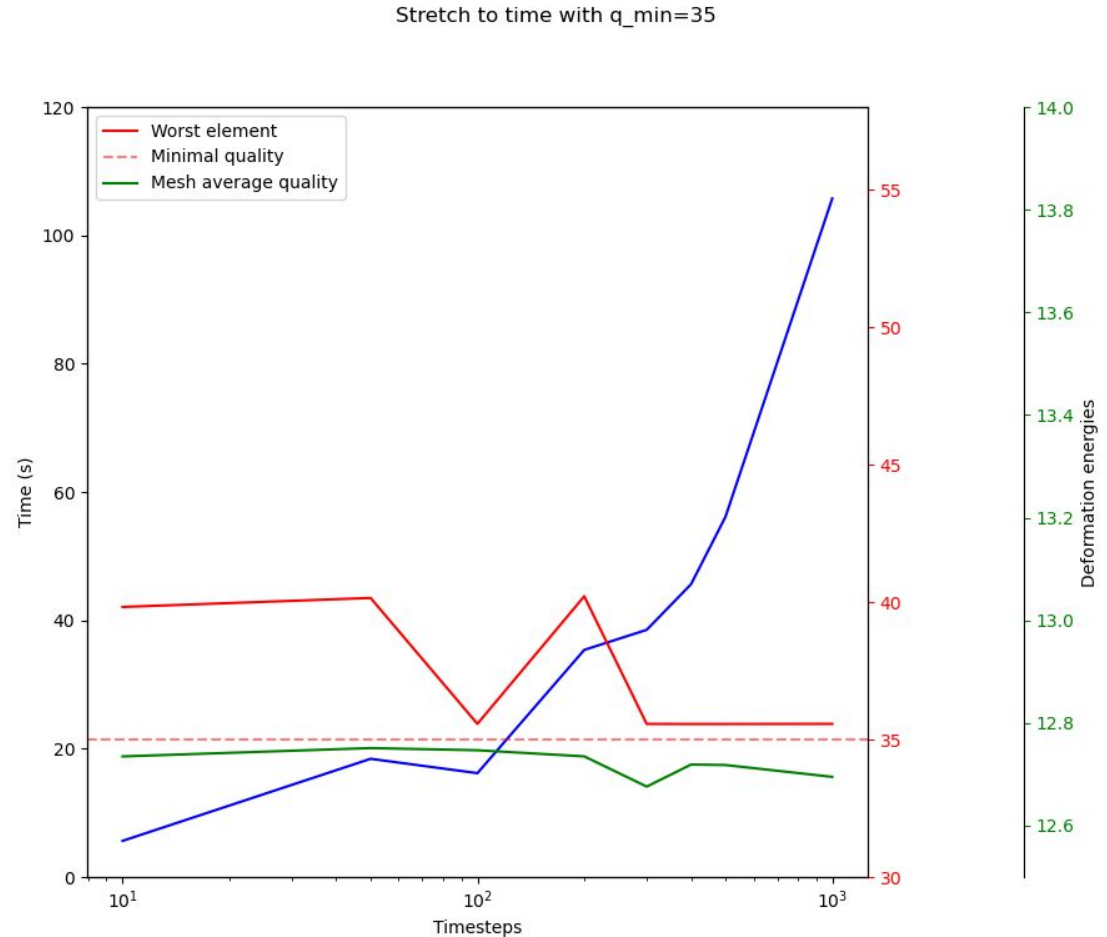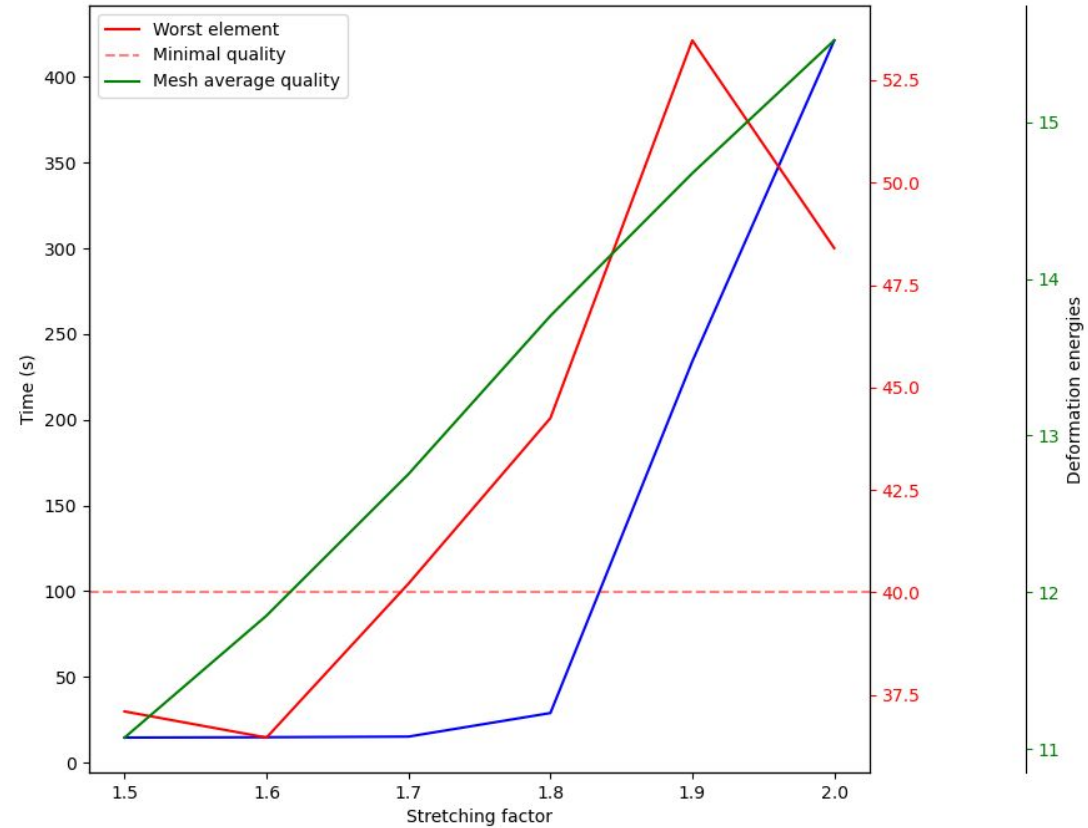- Quality experiment
- **Stretch experiment**
- Length experiment

Stretch to time with q_min=40

3D Stretch

- Quality experiment
- **Stretch experiment**
- Length experiment

Stretch to time with q_min=35

3D Stretch

- Quality experiment
- Stretch experiment

- **Length
  experiment**

Limitations

- Performances
- Bigger deformations

Conclusion

- Local remeshing
- Hill climbing method with successive passes
- Material and world spaces
- Experimented through stretching, spinning (and compression)