3D MESH WATERMARKING

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1. WATERMARKING

Data is getting more and more valuable. 3D models are very commonly used in for example:

- Virtual Reality and Augmented reality
- Films and games
- Architecture & Product design

Therefore, there is high need for ownership detection. An approach to do so is called watermarking, which:

- allows for ownership detection
- embeds secret data, which can later be extracted again
- should be robust against attempts to remove the watermark
- should leave the usability of the data high

2. 3D WATERMARKING

Applying watermarking to 3D models is specifically difficult, because:

- the order of the data is not consistent
- most abrupt changes to the data visually impair the model

The aim of this research is to improve an existing watermarking algorithm, feature vertex localisation [1] to be more robust against mesh simplification attacks.

3. MESH SIMPLIFICATION

Mesh simplification:

- Keeps the shape of the 3D model
- Removes data (vertices and edges) from the model
- could be an attempt to remove a watermark

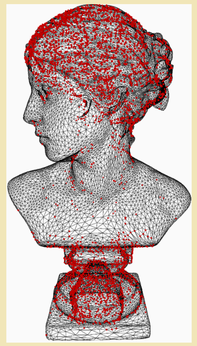
Example meshes can be seen on the top-right, with their simplified version next to it.

4. FEATURE VERTEX SELECTION

The watermarking process:

- Select features of a mesh
- Embed the watermark using a spherical domain
- Spherical domain has a new **origin point**

An example of feature vertices on a mesh is shown here.



5. ORIGIN POINTS

The two approaches are:

- Centre of mass; the average point of all vertices
- Centre of volume, the 2D centre of the outline of a model

Examples origin points are seen to the right

6. RESULTS

The volume centre approach has 86.2% accuracy against mesh simplification attacks. This is an improvement of 22.4% over the mass centre approach.
The approach was more accurate in other experiments as well.

6. FUTURE WORK

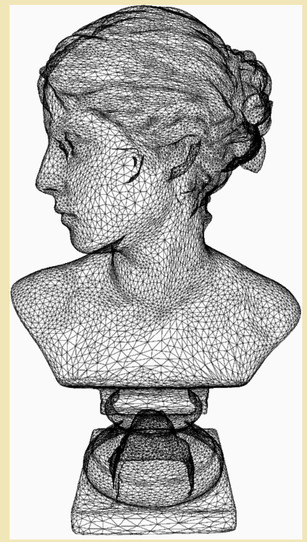
To improve this work further, research could be done toward multi-dimensional volume centre approaches. Further experimentation, for example against non-uniform mesh-simplification, would also improve and build on this work.

7. CONCLUSION

In conclusion, using a volume centre
With further work, it could be determined if this approach improves on the watermarking of a 3D mesh object, because of the smaller effect a mesh simplification attack has on the origin point.

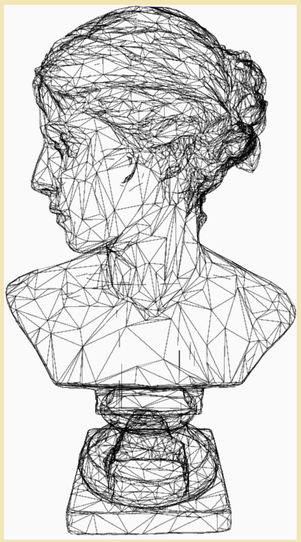
Original sculpture and its simplified version

1 (a) A mesh of a sculpture



1 (b) A mesh of a sculpture, shown as a wireframe

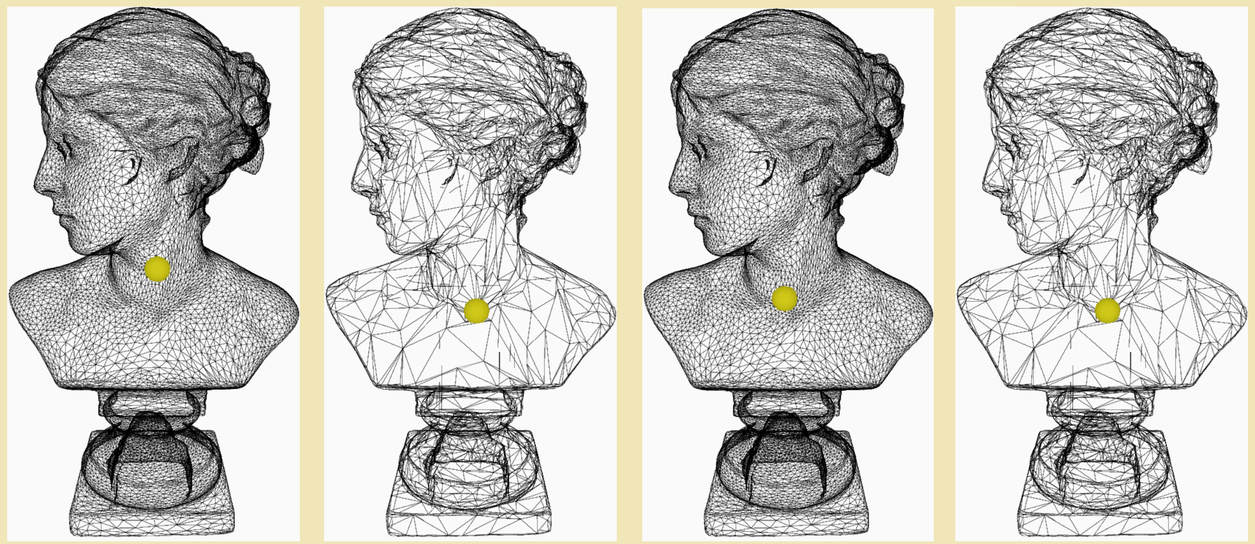
2 (a) A simplified mesh of a sculpture



2 (a) A simplified mesh of a sculpture, shown as a wireframe

Sculptures, origin calculated with *centre of* ***mass***

Sculptures, origin calculated with *centre of* ***volume***



86.2%
Average accuracy against mesh simplification attacks

22.4%
Average improvement in accuracy with volume centre

Related literature
[1] Jing Liu et al. “A Watermarking Method for 3D Models Based on Feature Vertex Localization”. In: IEEE Access 6 (2018), pp. 56122–56134. DOI: 10 . 1109 / ACCESS 2018. 2872783. URL:https://doi.org/10.1109/ACCESS.2018.2872783.