Verification of shape generation AI for practical Hood models

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Overview

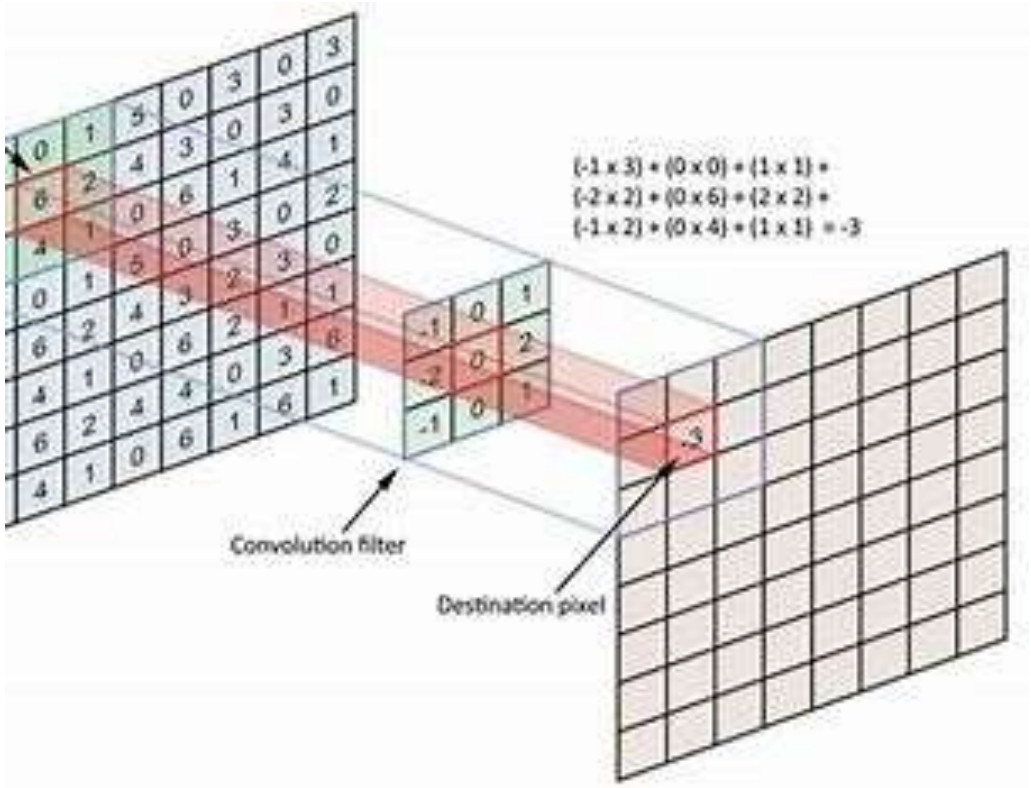
- Using a dataset of 10,000 hood frame models provided by Honda Europe, we evaluated the feasibility of a self-reconstruction model. This model encodes the original shape into a feature vector using an encoder and then reconstructs the shape with a decoder.
- We first tested a simple 2D convolutional model (page 4) and a ResNet-based model (page 7). However, both models produced insufficient reconstructions of the shapes (pages 6 and 9).
- Next, we evaluated a Variational Autoencoder (VAE) model (page 10). The VAE successfully produced accurate reconstructions of the shapes (page 12). Additionally, it was possible to recreate surface shapes from the reconstructed point cloud data (page 13).
- Furthermore, we combined the feature vectors of two different shapes to generate new shapes. Although the VAE output consisted of point clouds, we successfully created new shapes, including surface generation from the point clouds (pages 14 and 15).

Hood shape dataset used

- We used the hood shape dataset from the following paper provided by Honda Europe.
- Number of hood skin shape types: 109
- Number of shape data included in one shape type: around 100
- Total number of shape data: 10,500

- Reference paper and URL:
  - CarHoods10k: An Industry-Grade Data Set for Representation Learning and Design Optimization in Engineering Applications
  - https://ieeexplore.ieee.org/document/9696004

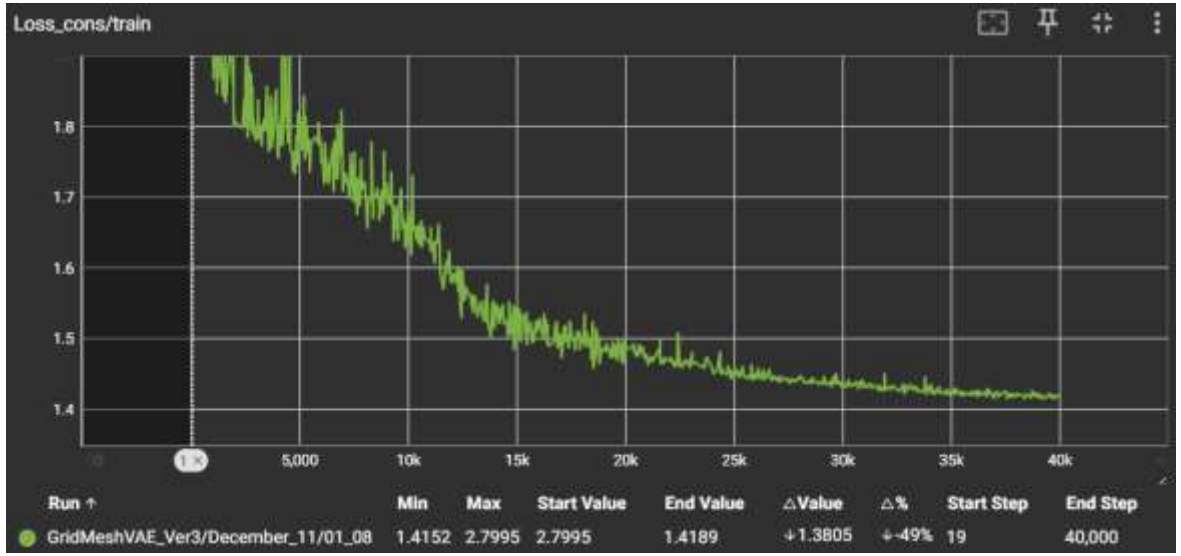
Verification 1: 2dConv+ConvTranspose2d model



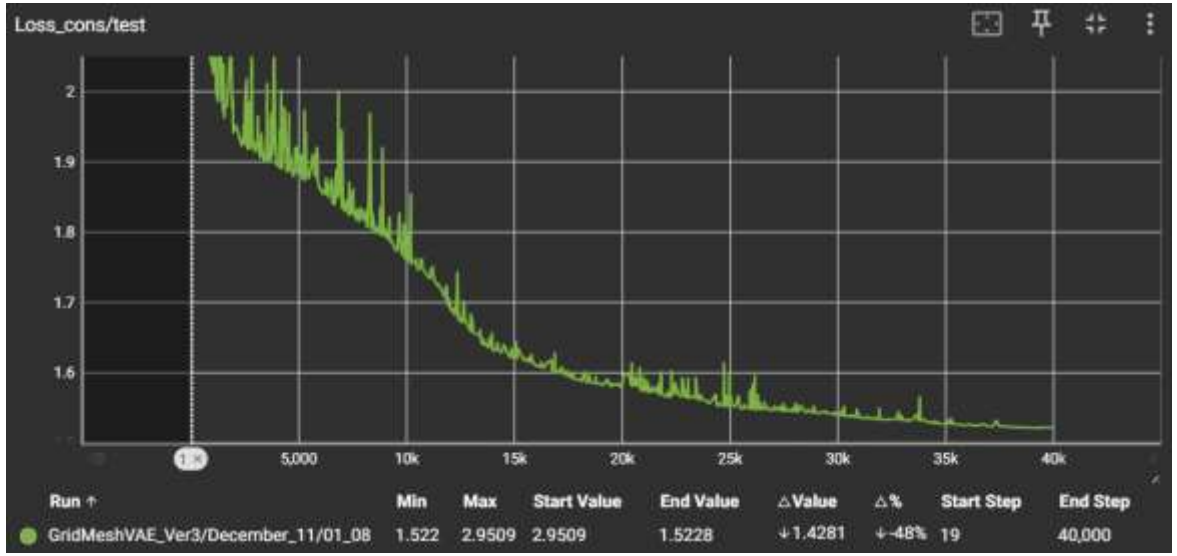
- Encoder
  - 2dConv -> ReLU (x4)
  - Linear –> Linear
- Decoder
  - ConvTranspose2d -> ReLU (x4)

Loss function convergence history

Training data



Validation Data

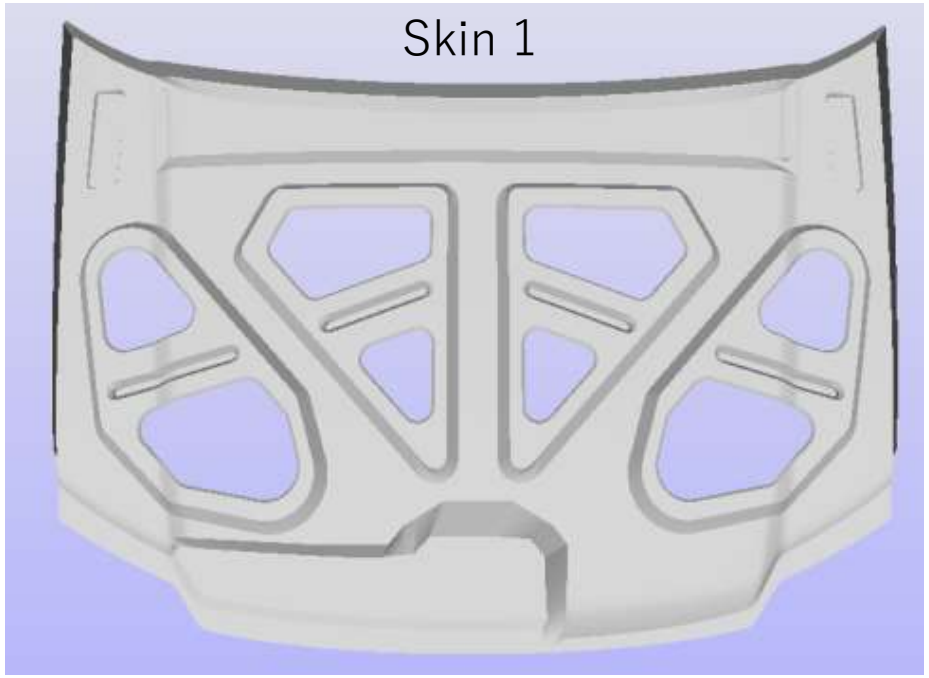


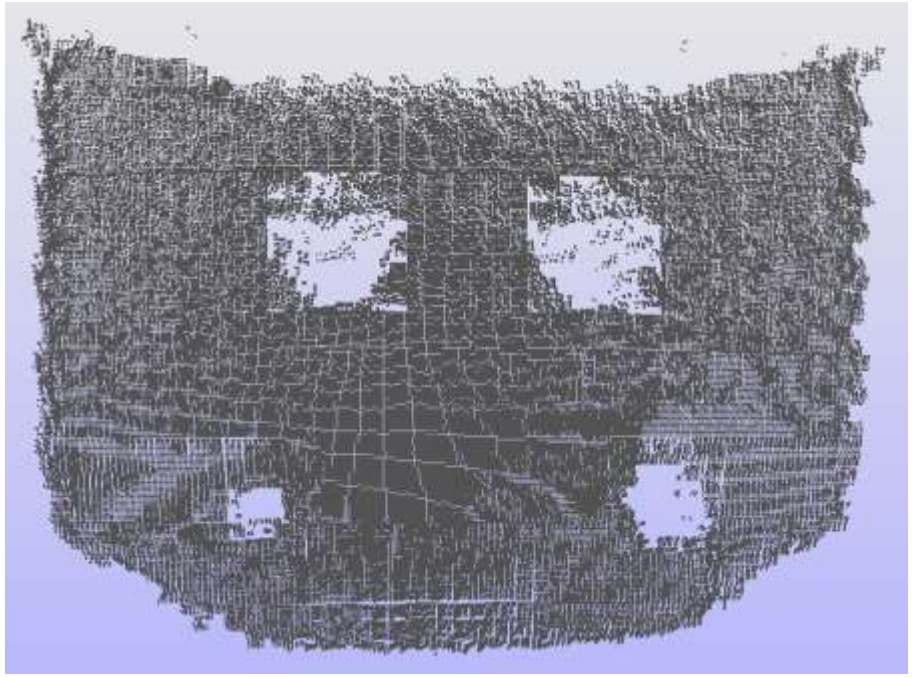
Verification results:

Left: Original shape
Right: Reproduced shape.

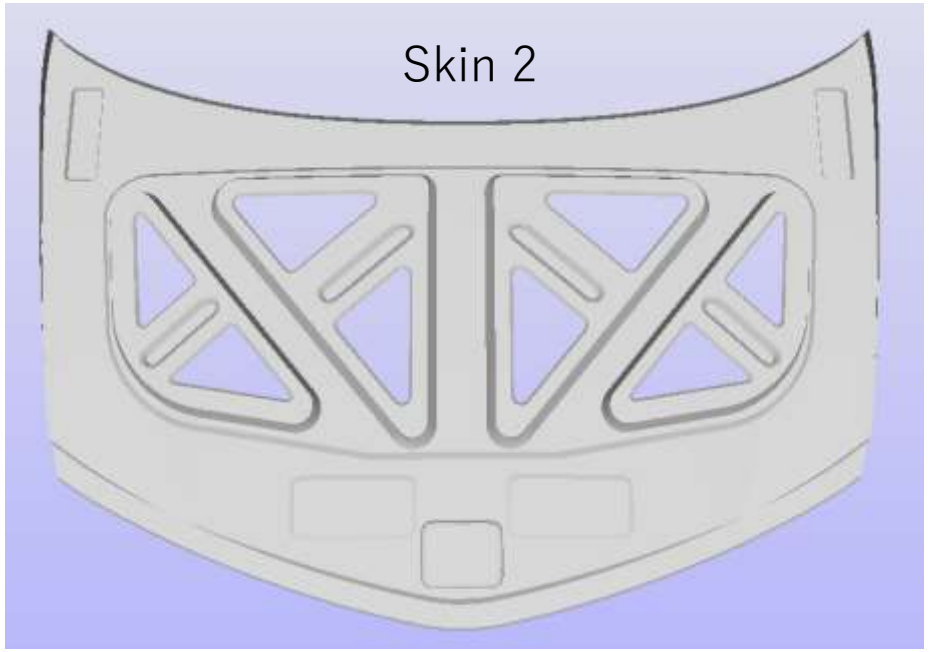
The shape reproduction is insufficient.

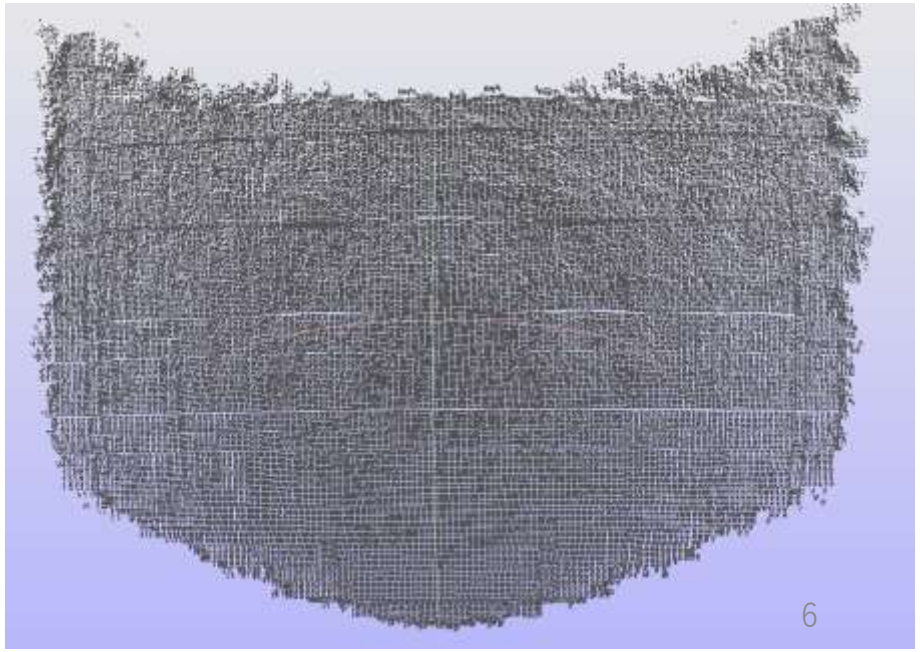
Skin 1





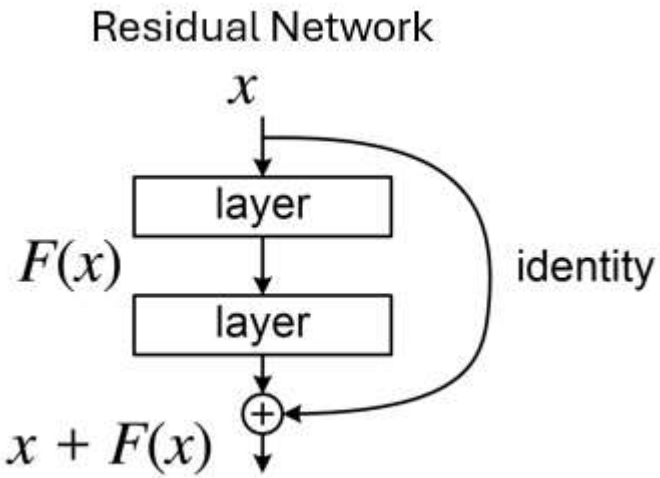
Skin 2





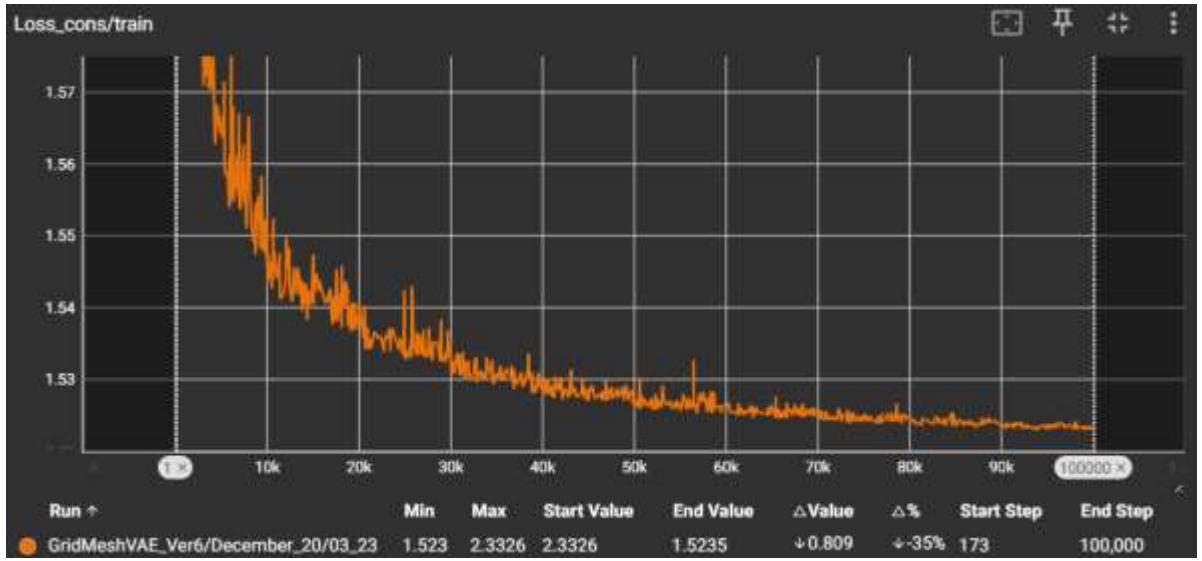
Verification 2: Using ResNet

- Several studies have suggested that ResNet is well-suited for deep networks in tasks such as image processing and depth prediction. Based on this, I incorporated ResNet into the final encoder network.
- Encoder
- 2dConv -> ReLU (x4)
- Linear –> Linear
- ResNet
- Decoder
- ConvTranspose2d -> ReLU (x4)

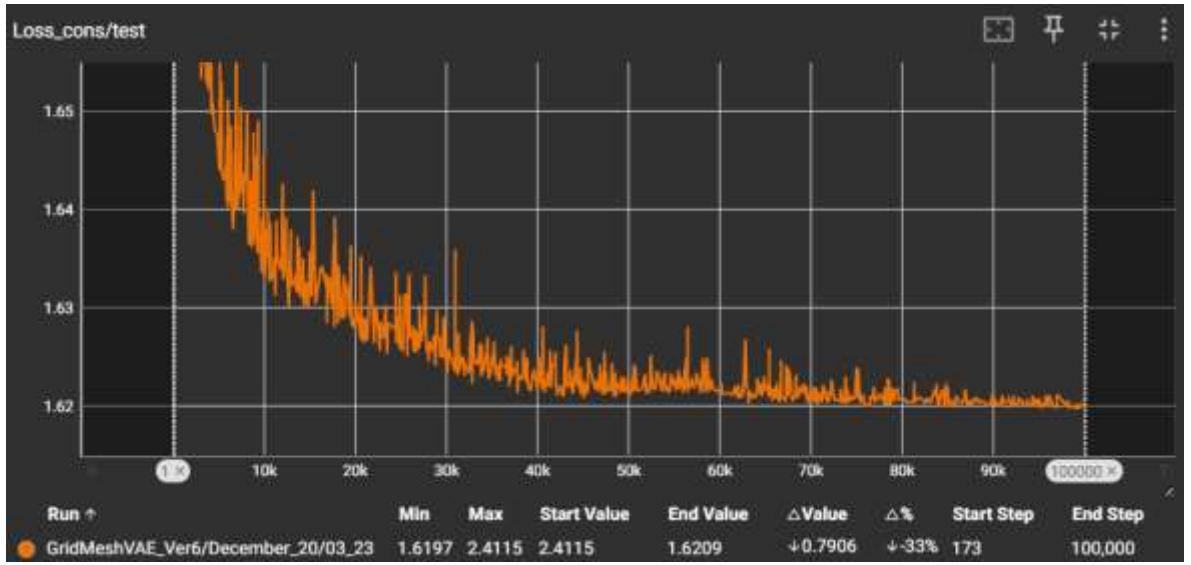


Loss function convergence history

Training data

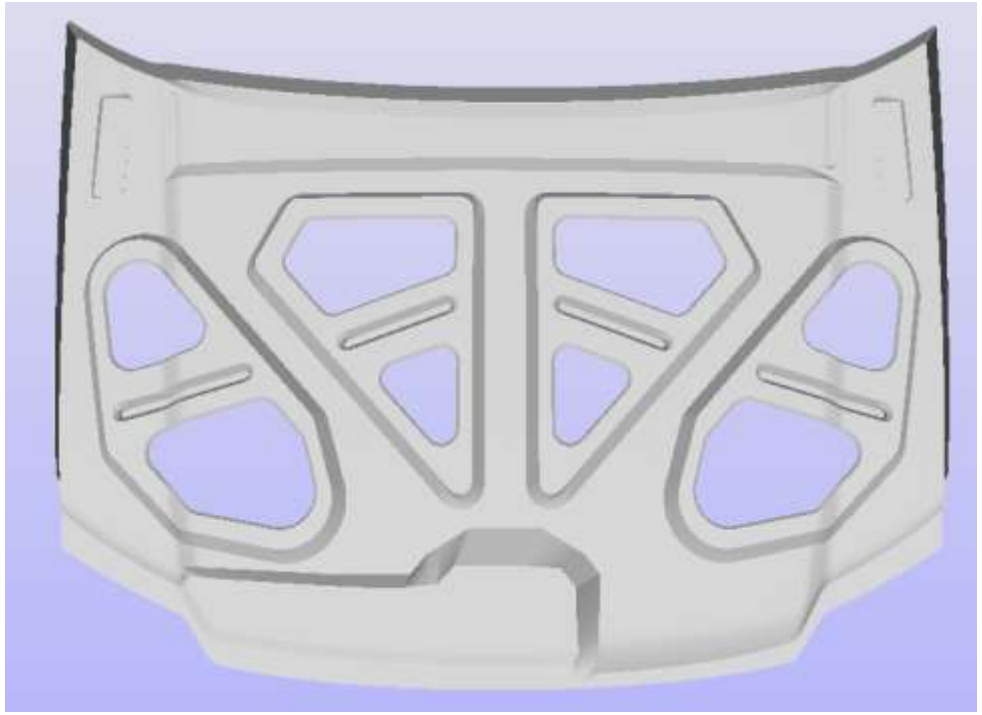


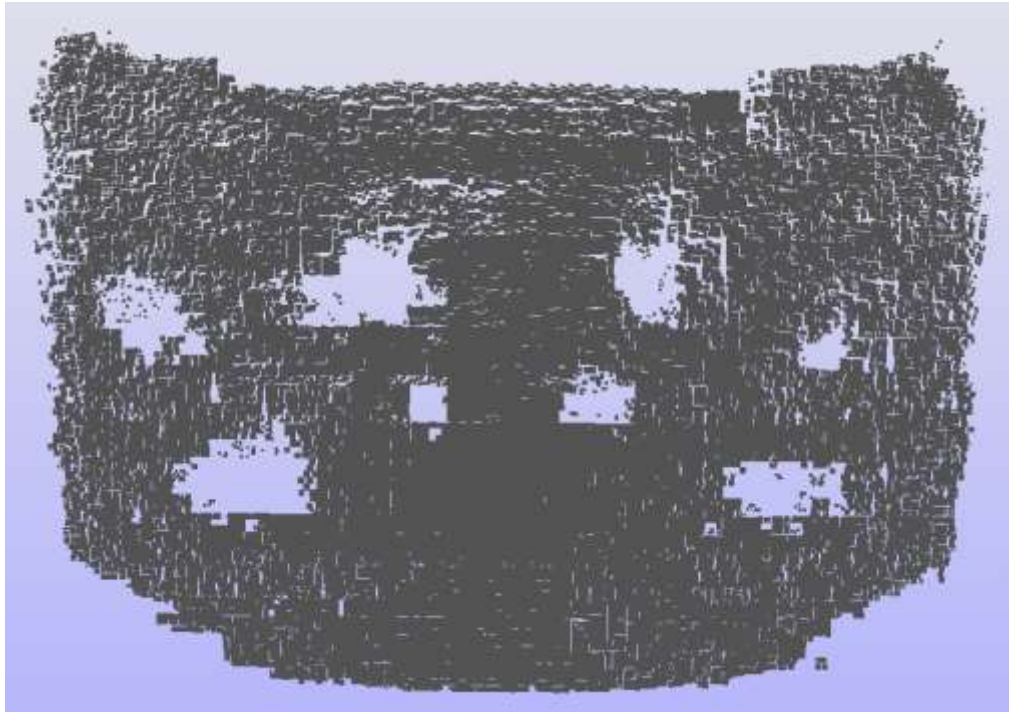
Validation Data



Verification results
Left: Original shape Right: Reproduced shape

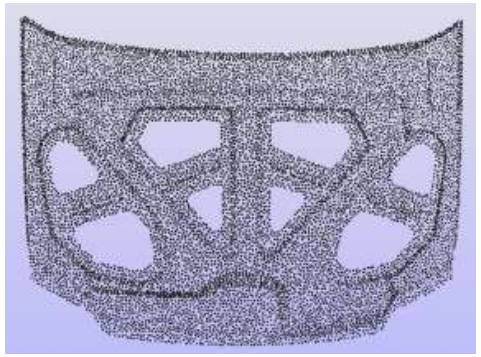
Skin 1



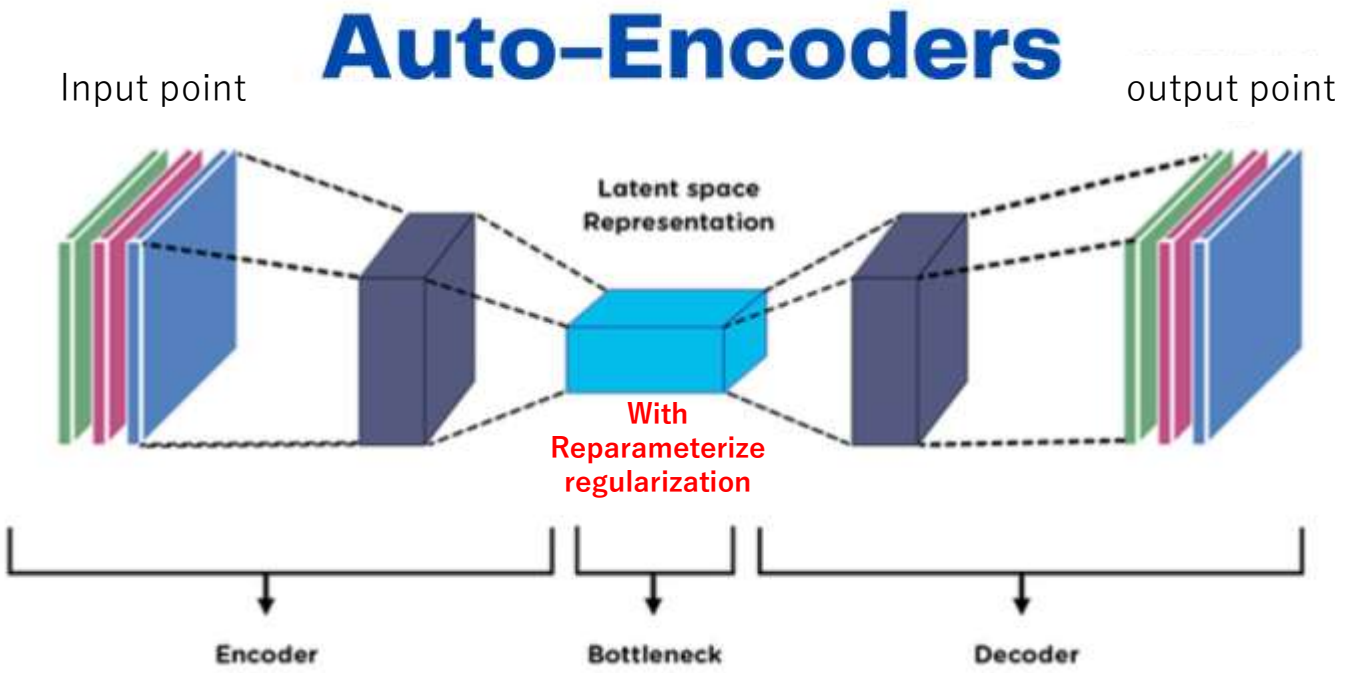


再現形状は不十分であった

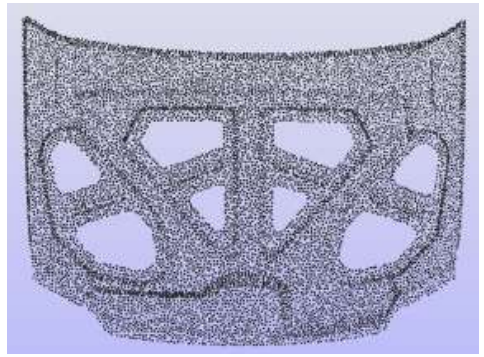
Verification 3: Verification using a VAE (Variational Auto-Encoder) model



Input point

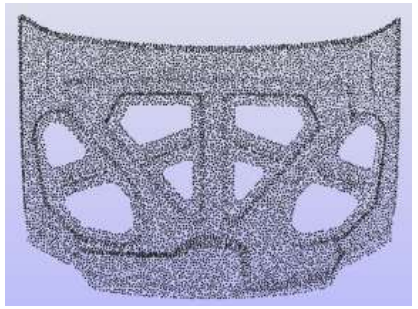


output point

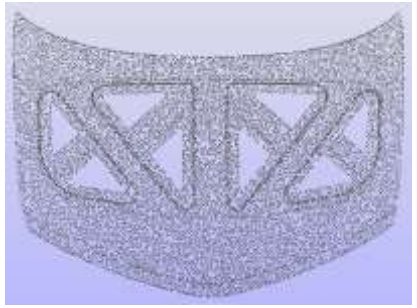


Training Data

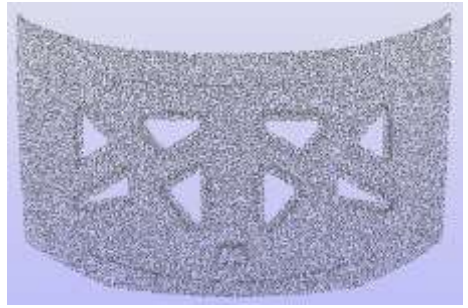
- Five skin types are extracted and used:
  - Skin 1: 100 data
  - Skin 2: 100 data
  - Skin 3: 91 data
  - Skin 4: 99 data
  - Skin 5: 99 data



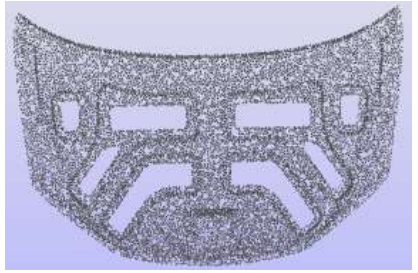
Skin 1



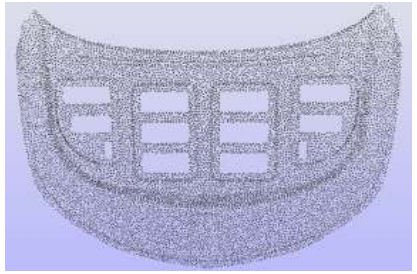
Skin 2



Skin 3



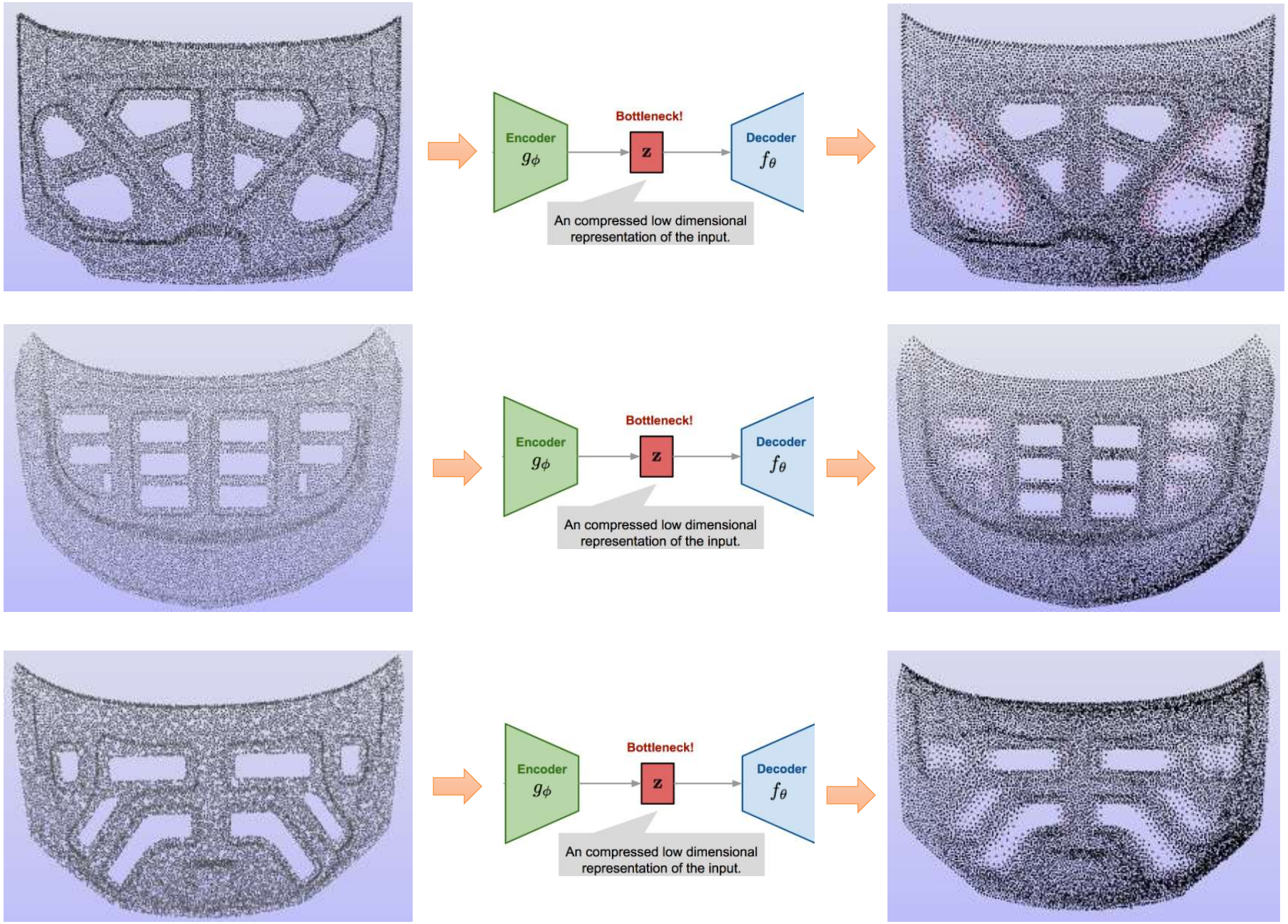
Skin 4



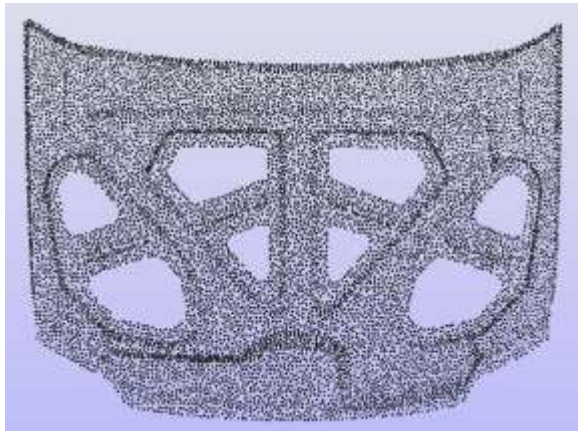
Skin 5

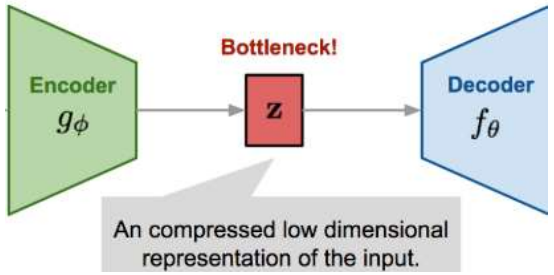
Shape reconstruction results:

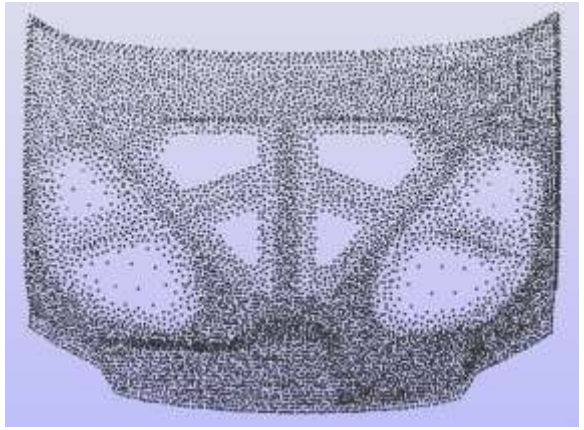
The original shape and the reproduced shape match well.

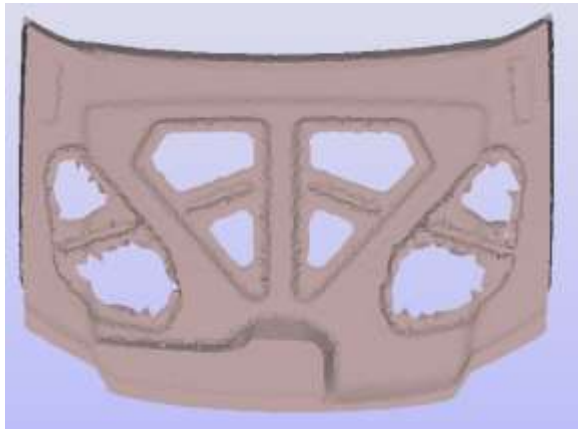


Surface Mesh Reconstruction from Point Clouds using Ball Pivoting Method

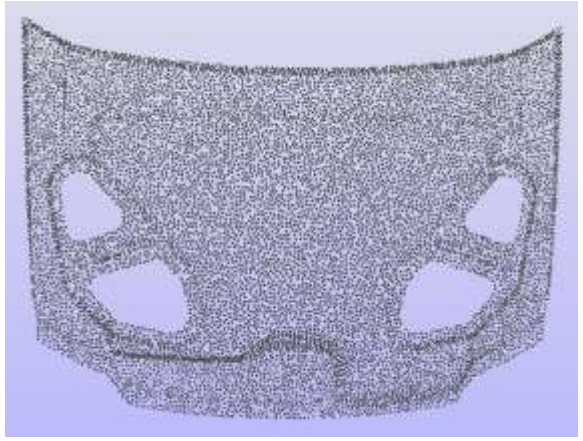


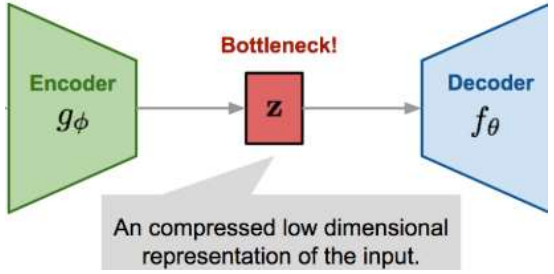


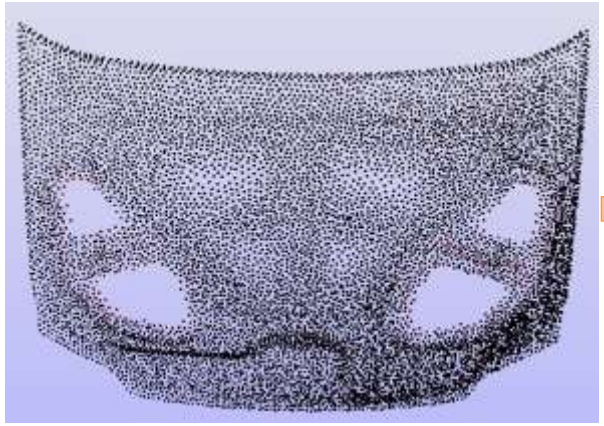


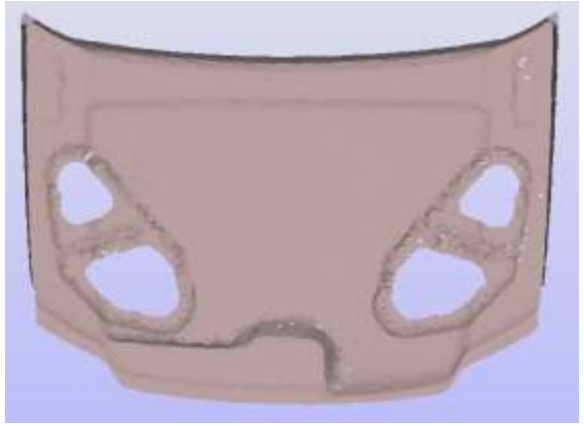


64 Latent Space

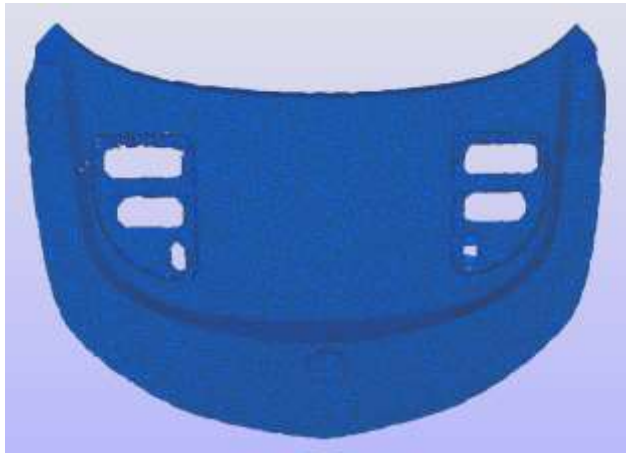




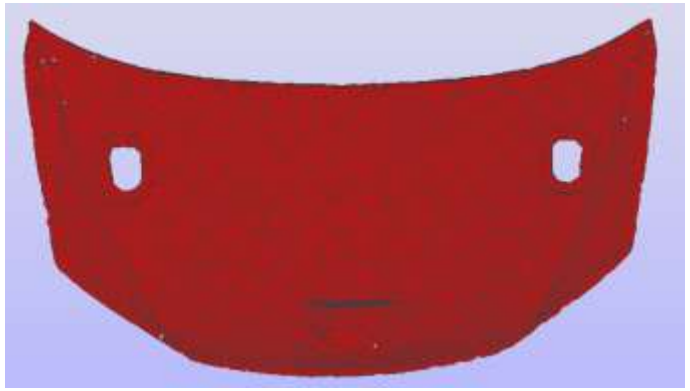




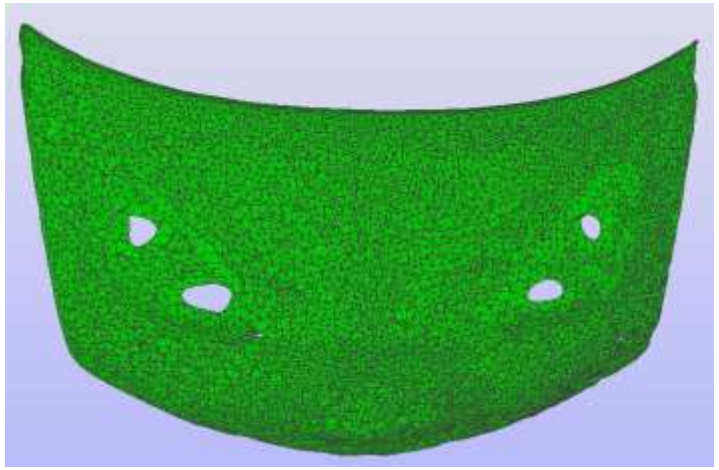
Shape synthesis result 1



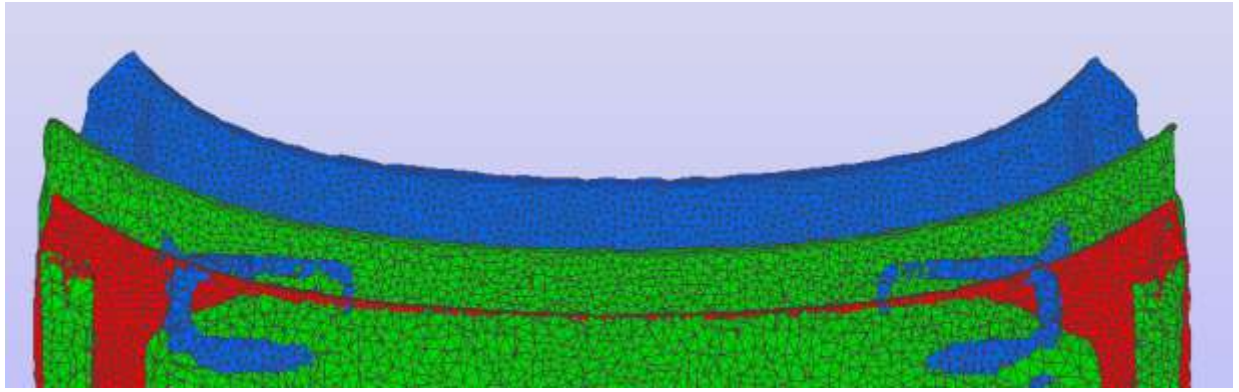
Skin 4 – Geometry 64



Skin 5 – Geometry 64

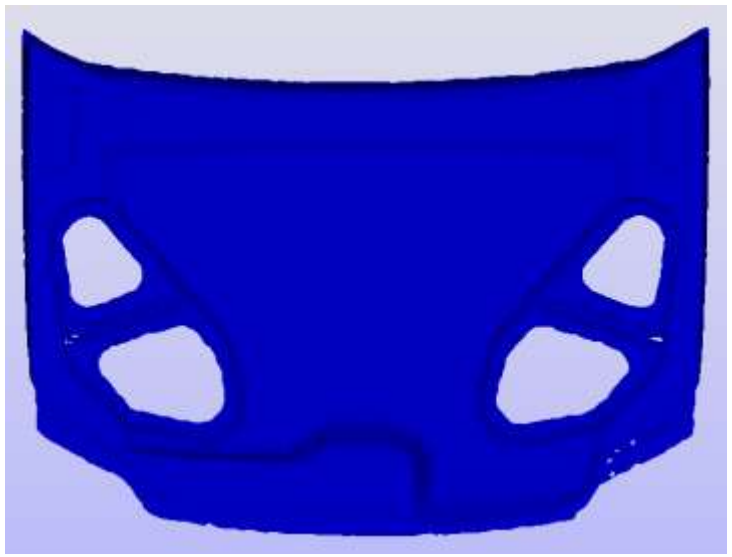


Shape synthesis result

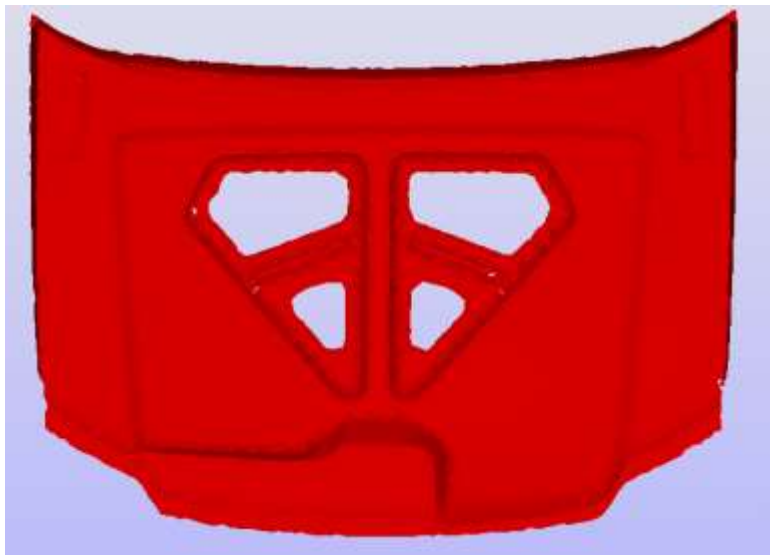


Size Comparison

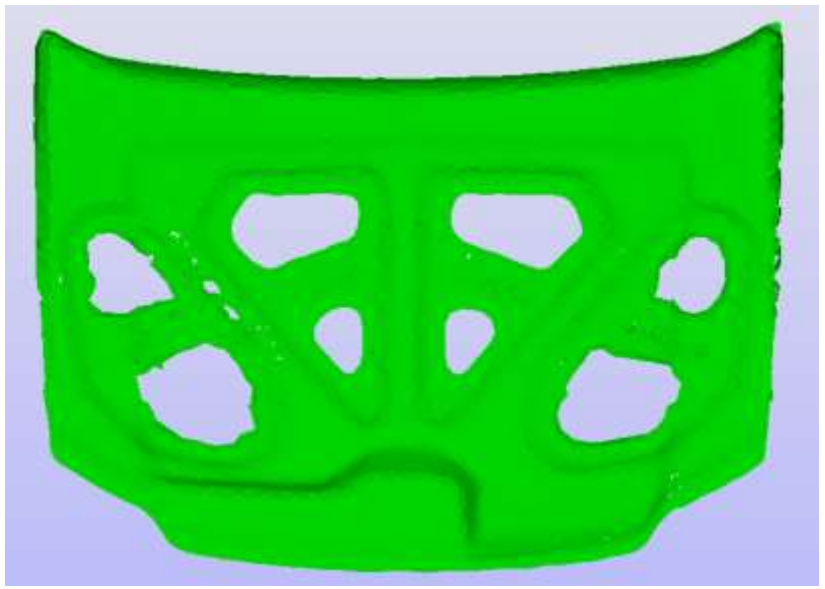
Shape synthesis result 2



Skin 1 – Geometry 44



Skin 1 – Geometry 64



Shape synthesis result

End