From 2D Sketching to 3D Printing: A Deep Learning Approach for 3D Mesh Generation with 2D Sketches

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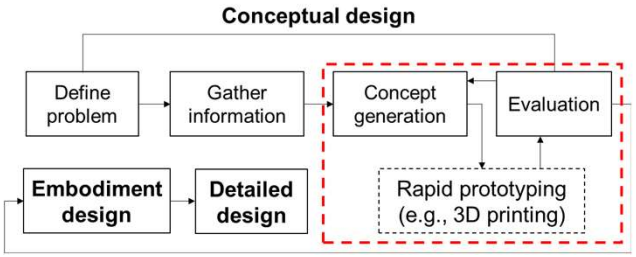
Background

- 2D Sketching (e.g., sketch of product silhouette) is usually used for design idea generation and design concept brainstorming
- 3D CAD models are built for visualization, engineering analysis, and rapid prototyping
- A large number of iterations could happen in an engineering design cycle between concept generation and evaluation (3D printing might also be used)
- Can we expediate the 2D-to-3D design cycle?
- Can we provide a better decision support for design concept generation by directly connecting 2D ideation to 3D prototyping?

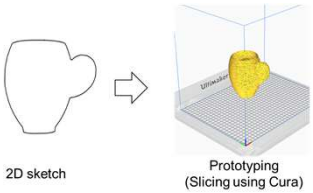


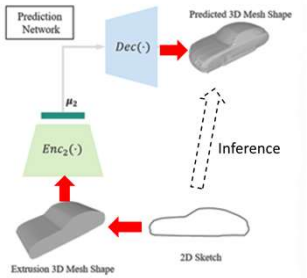
Research Objective

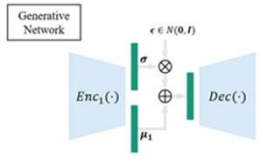
- To develop a deep learning approach to predicting 3D mesh models from 2D sketches, and meanwhile, to support generative design novel of shapes for fast iteration between design ideation and design prototyping.

Research Approach

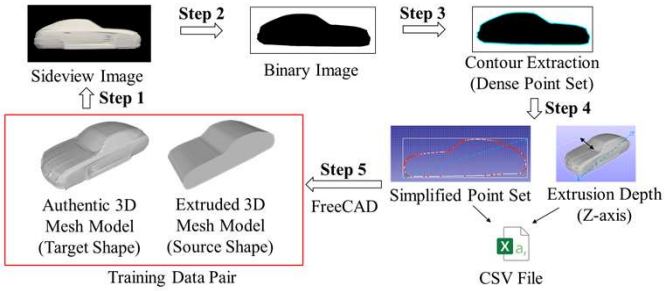
Predicting the 3D model that can be printed from 2D sketches drawn by a user





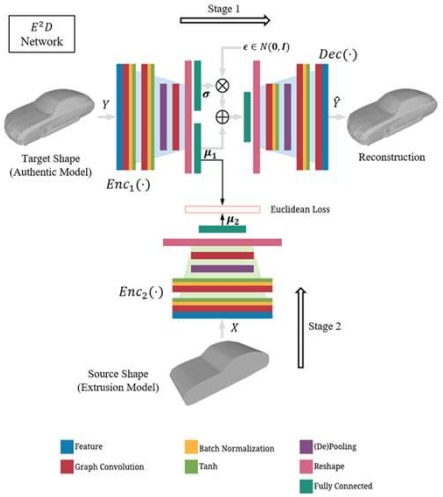


Application modules: prediction network and generative network



Training data preparation

- 1240 car models [1]
- Source shape (S_s) and target shape (S_t) form data pairs $\{S_s^i, S_t^i\}_{i=1}^{N=1240}$

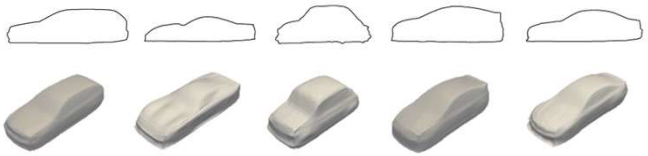


Training module: E^2D network based on a target embedding variational autoencoder network architecture

- E^2D network (two encoder-one-decoder network) by concatenating Encoder 2 to a MeshVAE (Encoder 1 + Decoder) [2]

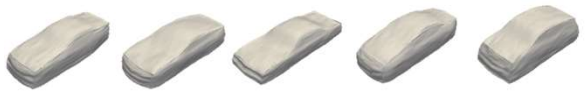
Results

- Prediction Network



- **Generative Network: shape interpolation**

- **Generative Network: random generation**



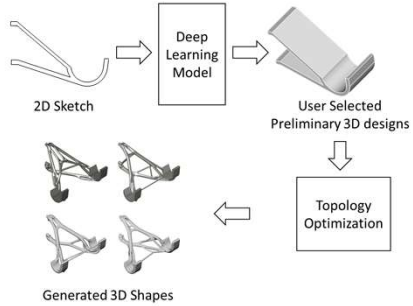
Conclusion and Future Work

Conclusion

- **Predictive module**: simple contour sketches to authentic 3D shapes
- **Generative module**: a large number of novel 3D shapes
- The generated shapes are in **polygon mesh** with high surface details which can be used for **downstream evaluation or prototyping using 3D printing**

Future work

- A **user interface** to allow human-computer interaction including input of 2D sketches and modification of generated 3D shapes
- **Integrate deep generative model with topology optimization** to facilitate the generation of designs with optimized engineering performance



Conceptual integrated deep generative model with topology optimization

Acknowledgments

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References

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2. Yuan, Y.-J., Lai, Y.-K., Yang, J., Duan, Q., Fu, H., and Gao, L., 2020. "Mesh variational autoencoders with edge contraction pooling". In Proceedings of the IEEE/CVF Conference on Computer Vision and Pat-tern Recognition Workshops, pp. 274–275.