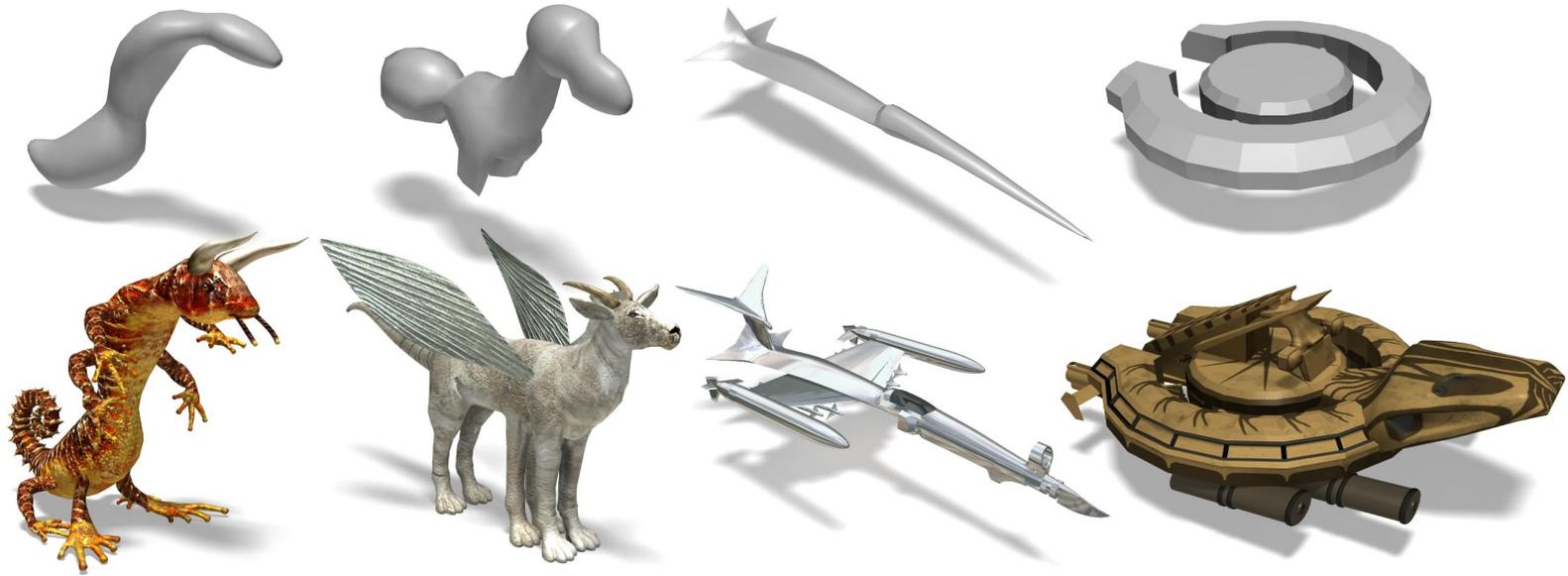


Data-Driven Suggestions for Creativity Support in 3D Modeling



Siddhartha Chaudhuri
Vladlen Koltun

Stanford University

Basic Idea

Automatically suggest ways in which the user can extend a basic shape, to stimulate creative exploration

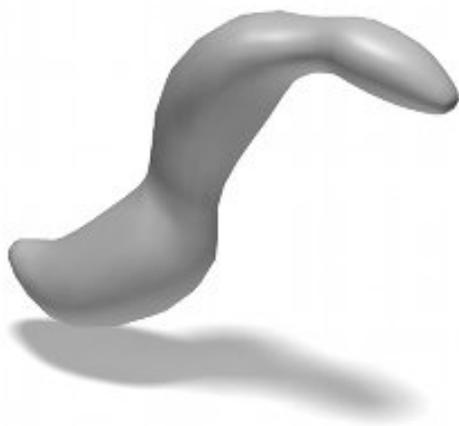
Overview



Overview



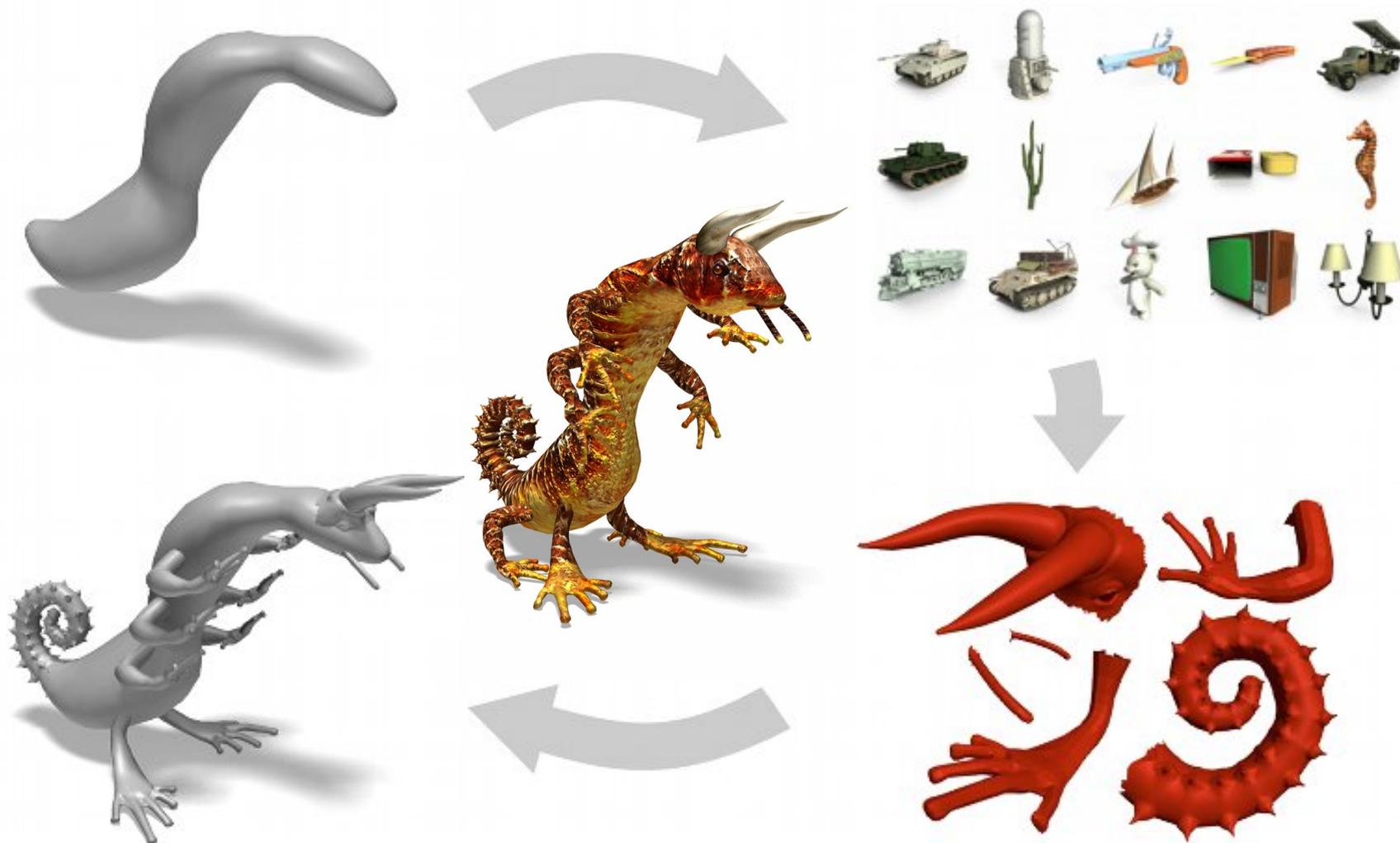
Overview



Overview



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Data-Driven Suggestions

- Support **creative discovery** in 3D modeling
 - Customized examples and alternatives stimulate creativity [*Boden '90, Finke et al. '92, Marsh '96, Weisberg '06, ...*]

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 - Unexpected yet valuable suggestions

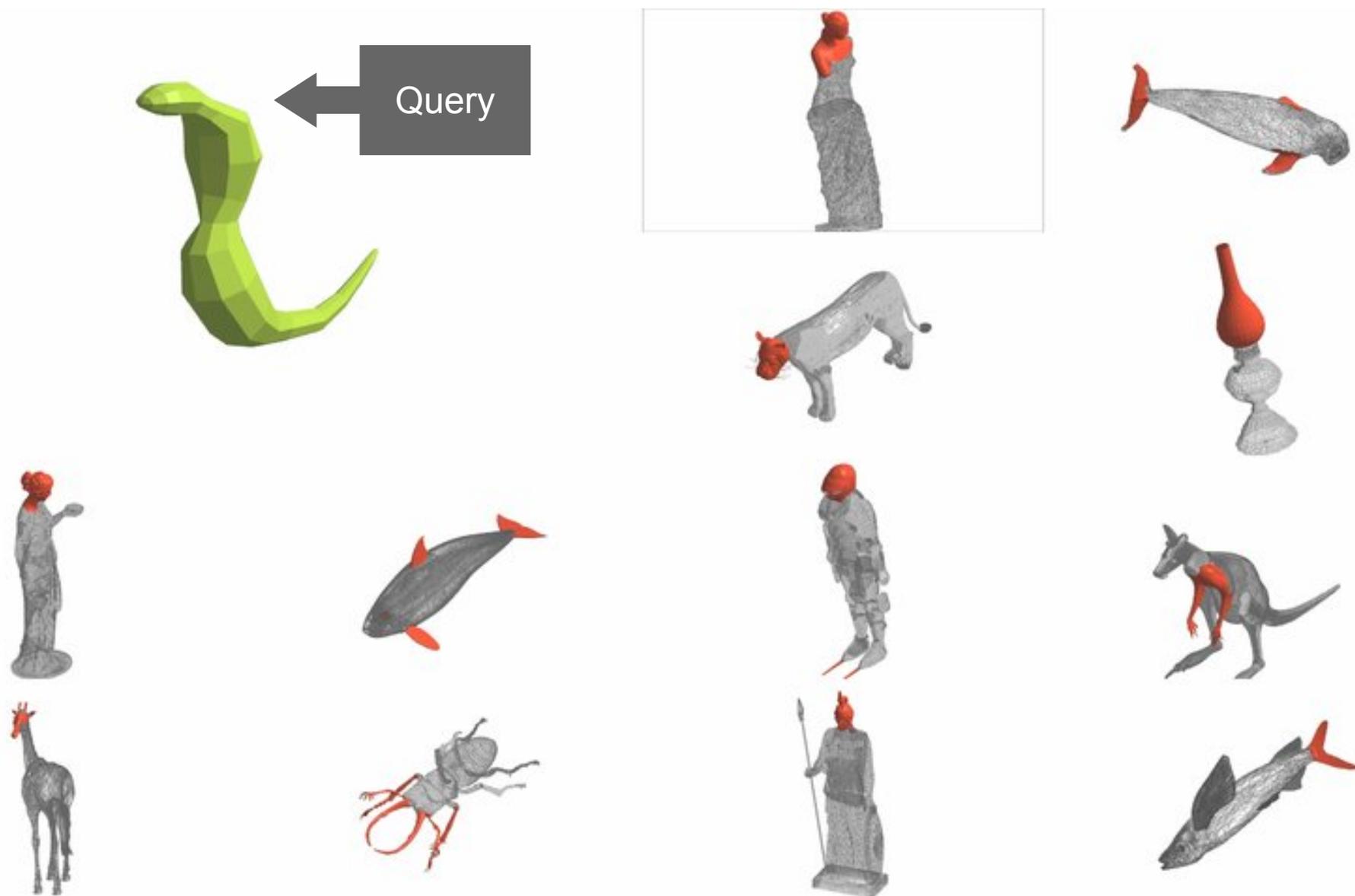
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- Entirely **unsupervised**
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 - Unexpected yet valuable suggestions
- **Meaningful and compatible**, because they are drawn from complete prior models

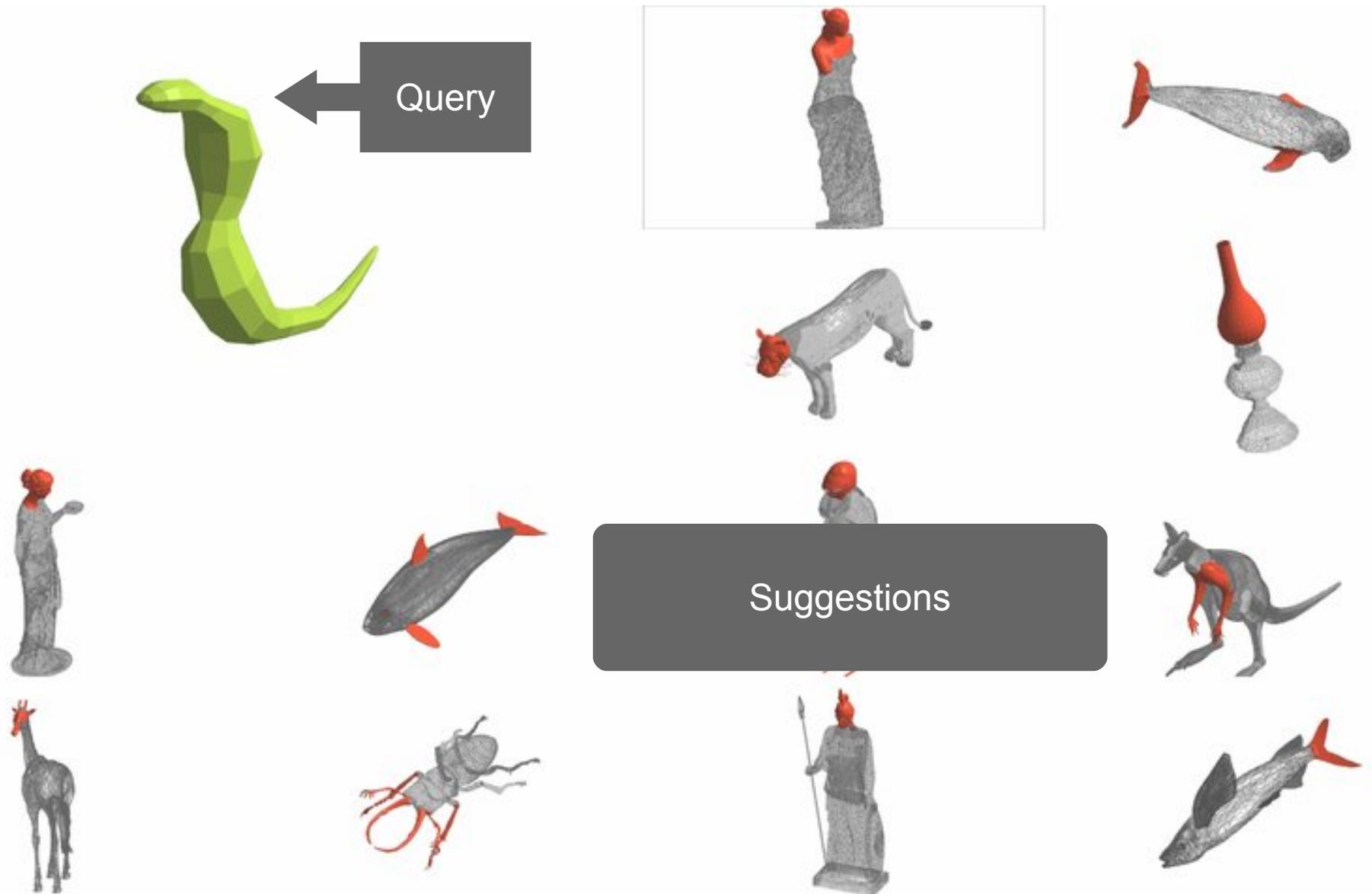
InspireMe



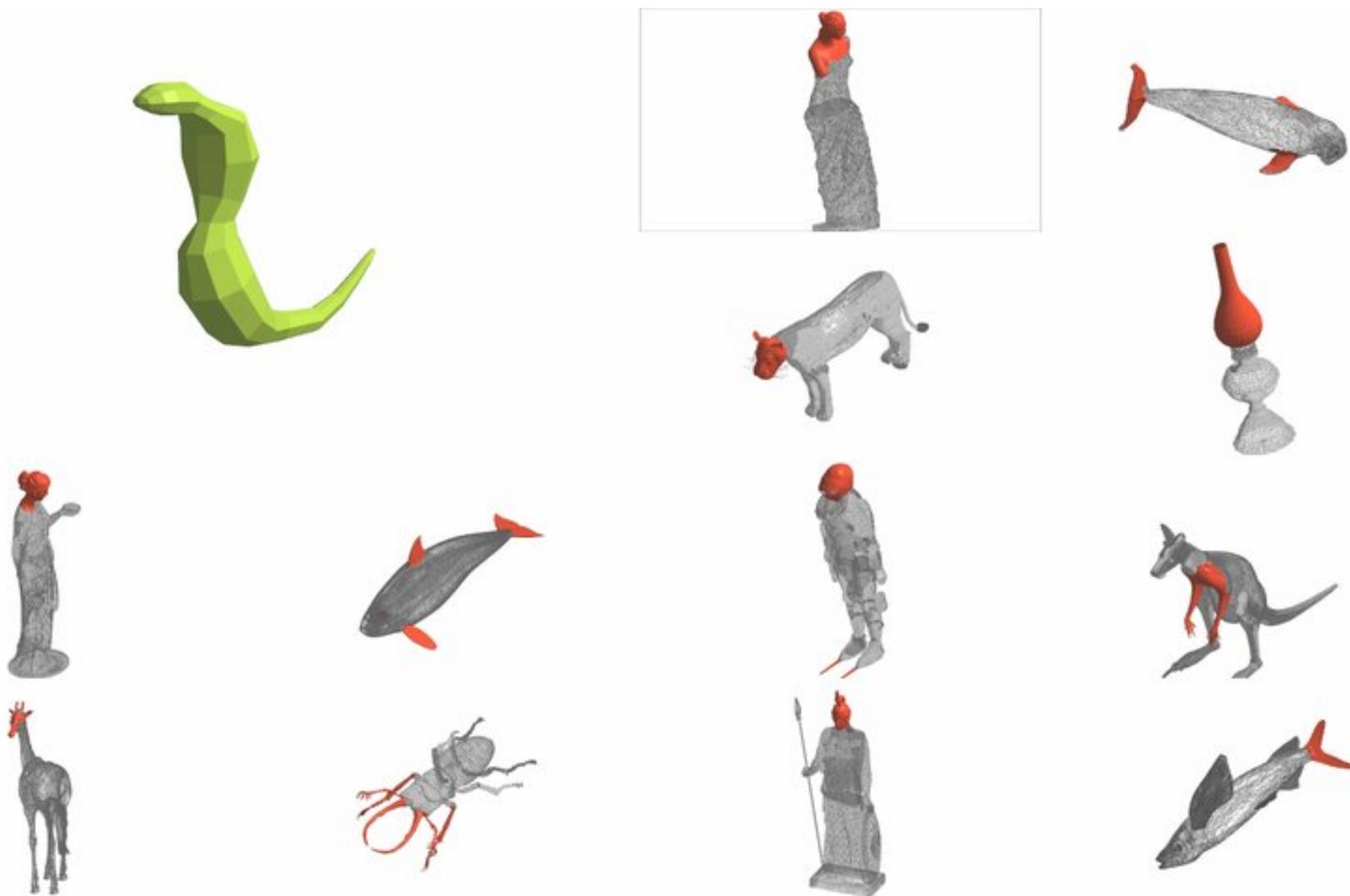
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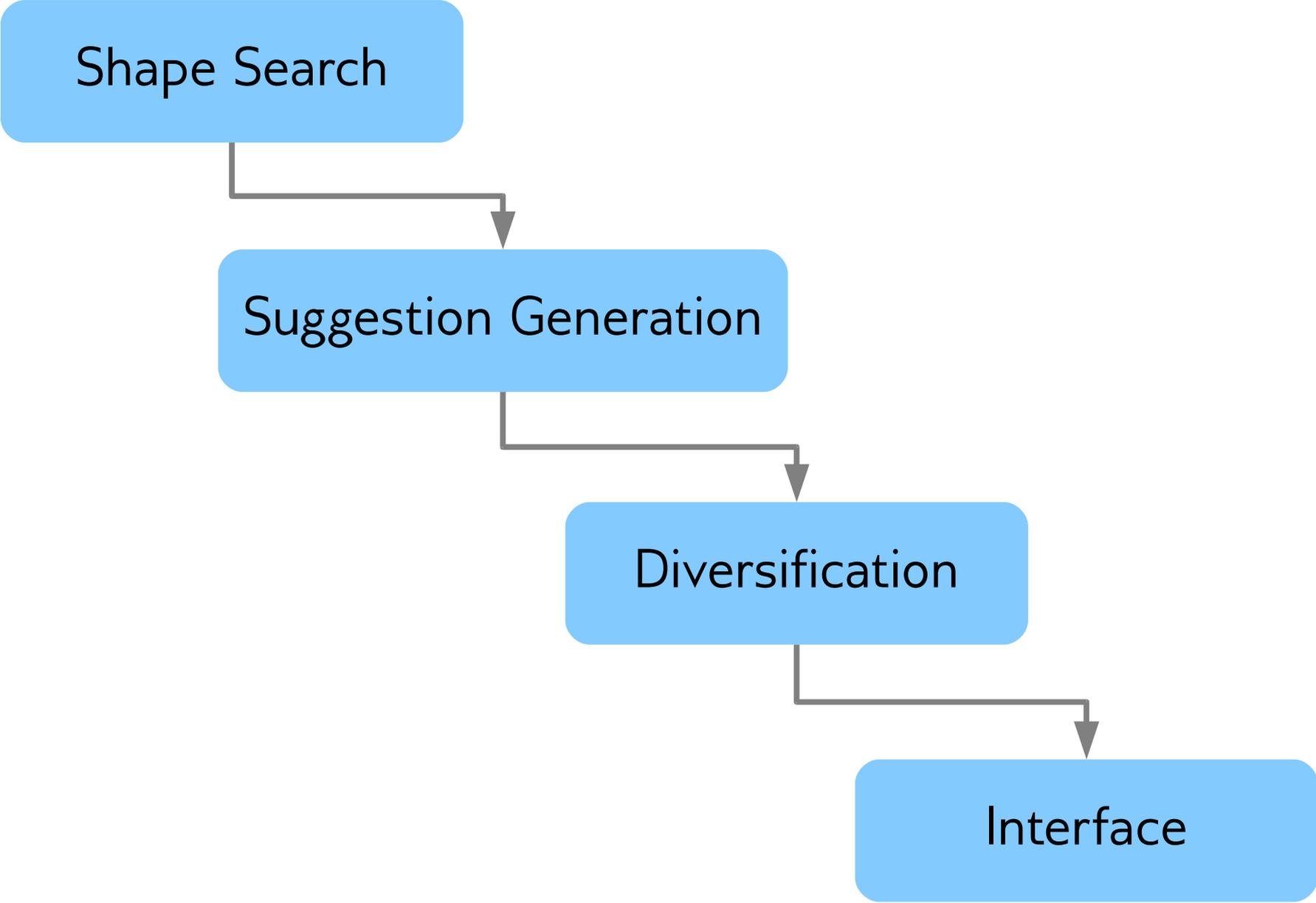


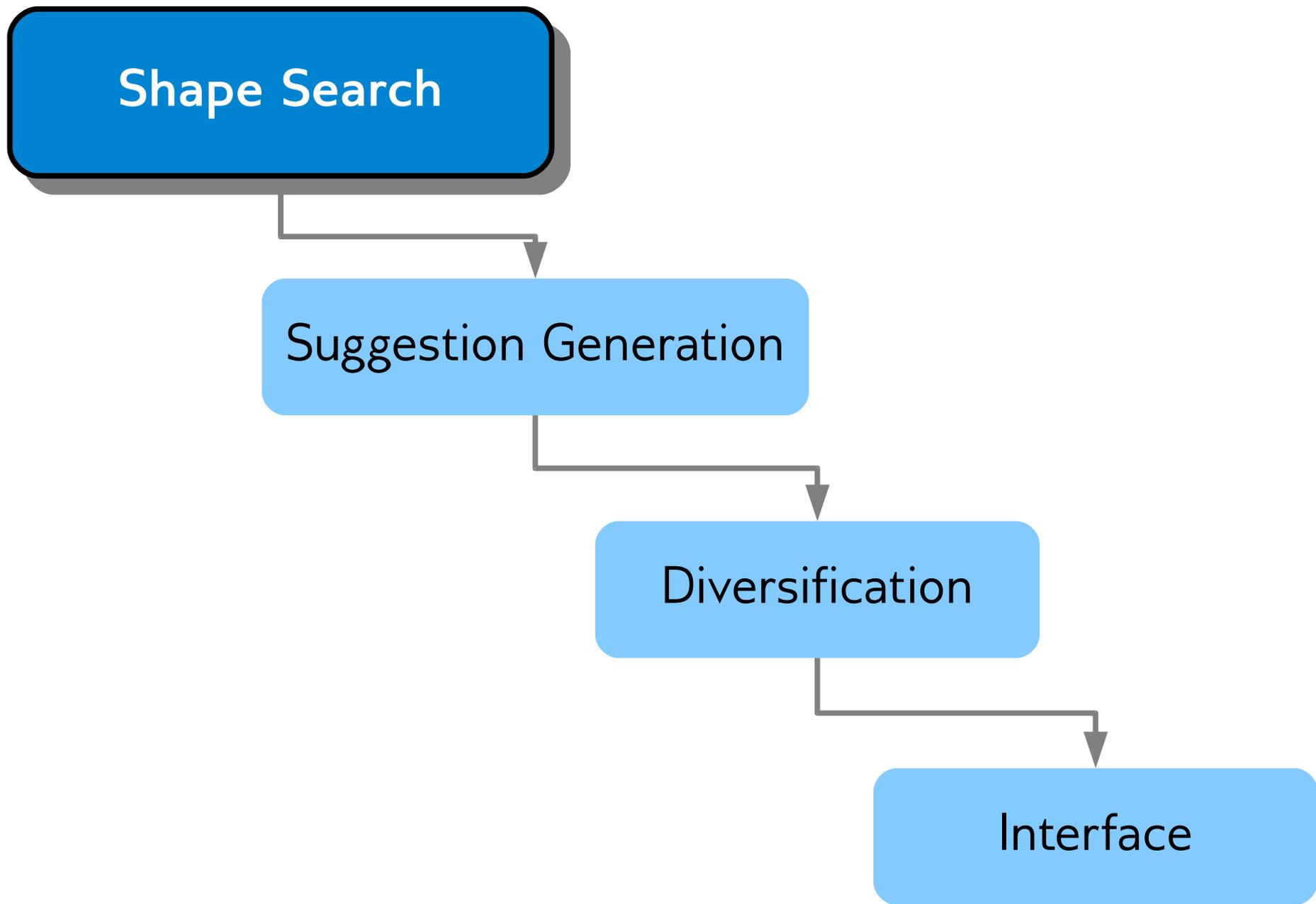
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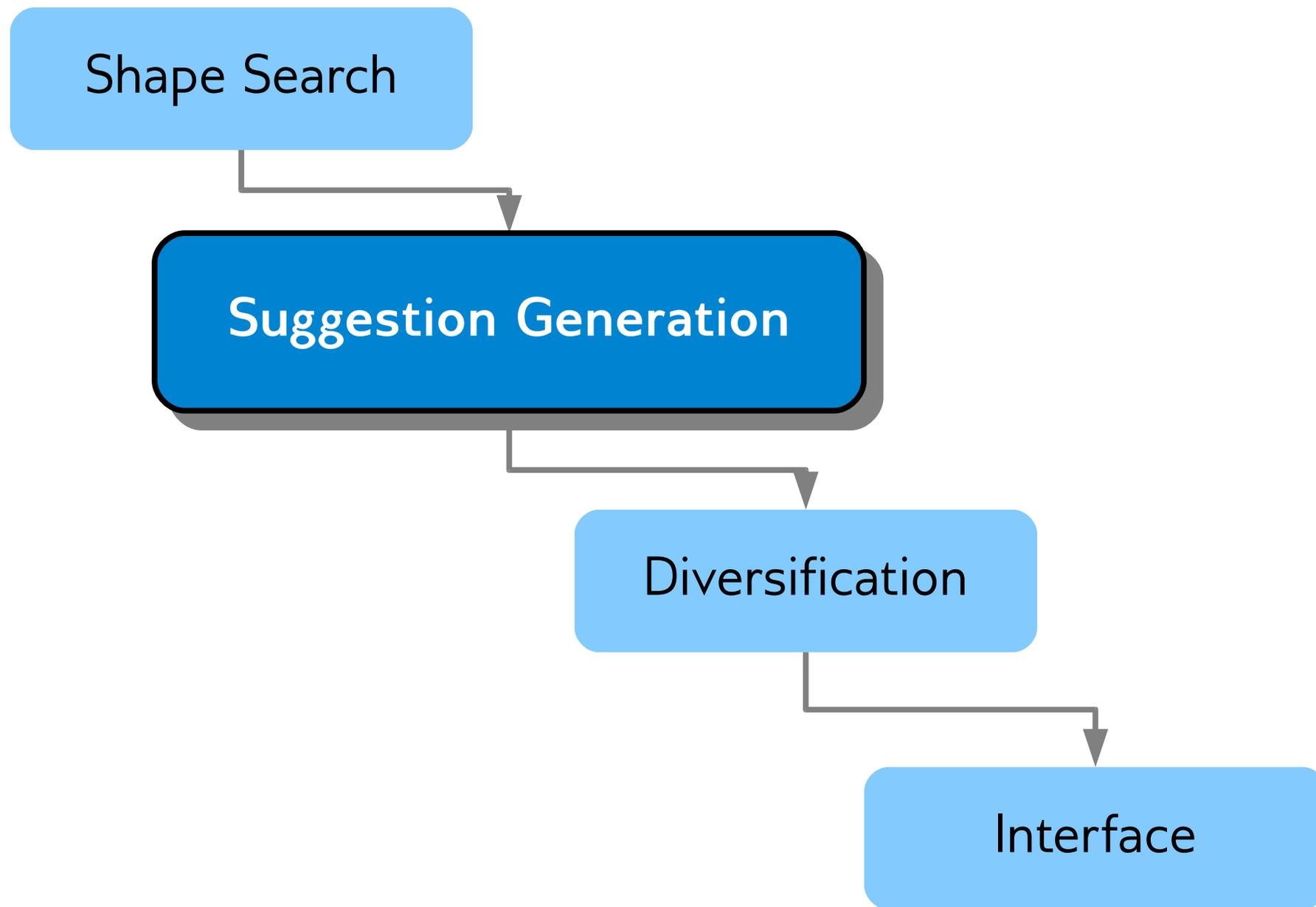


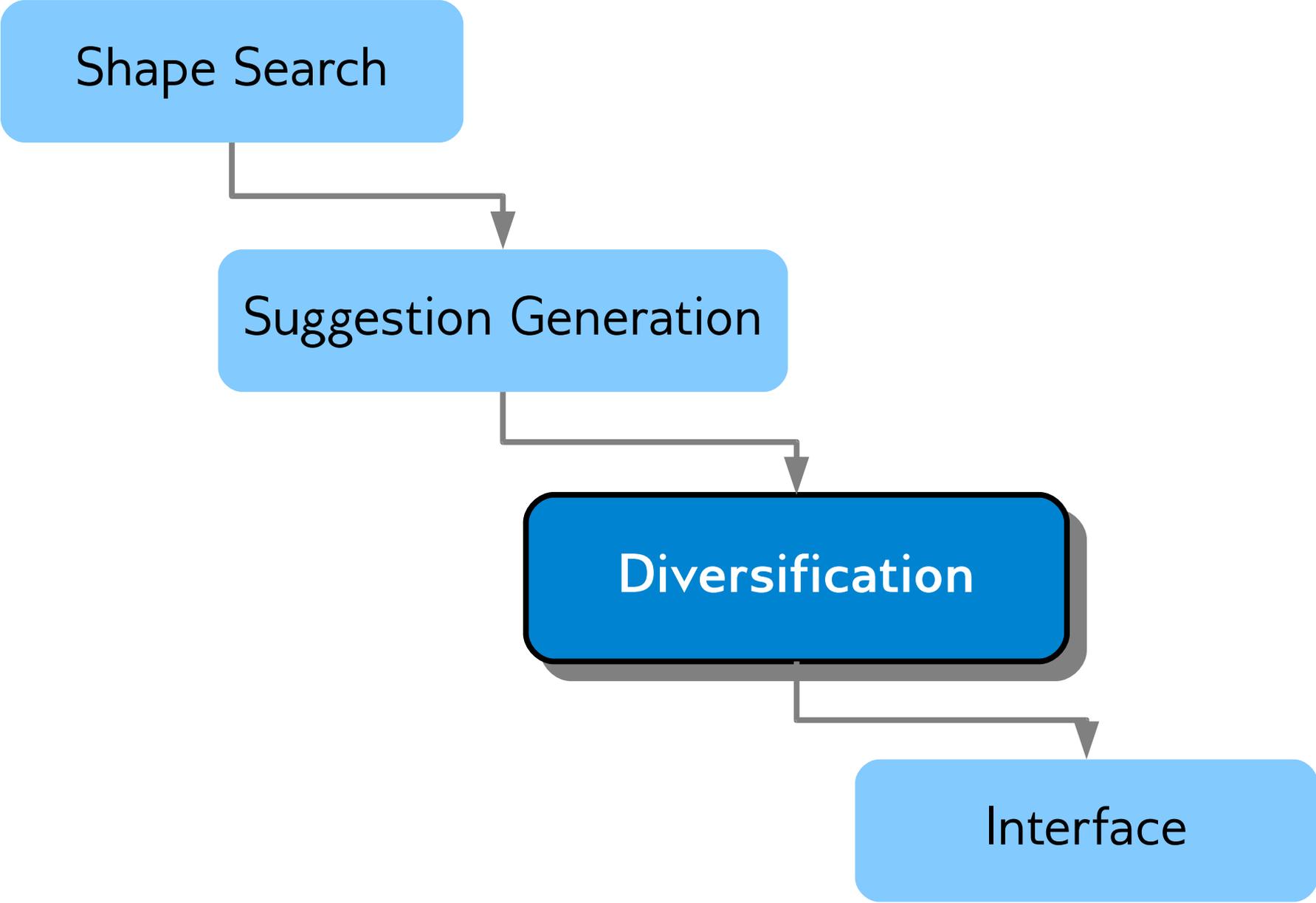
InspireMe (video)

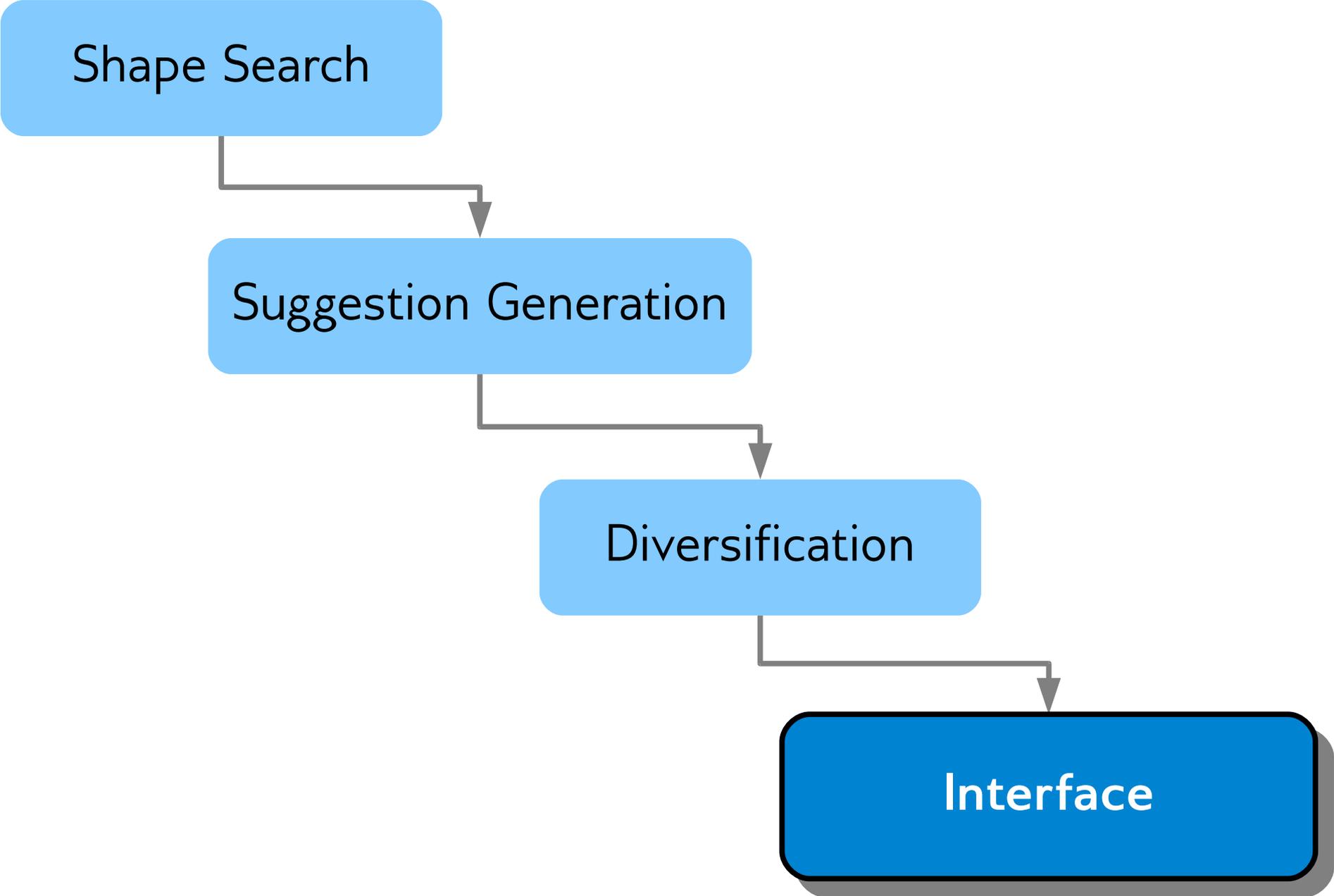


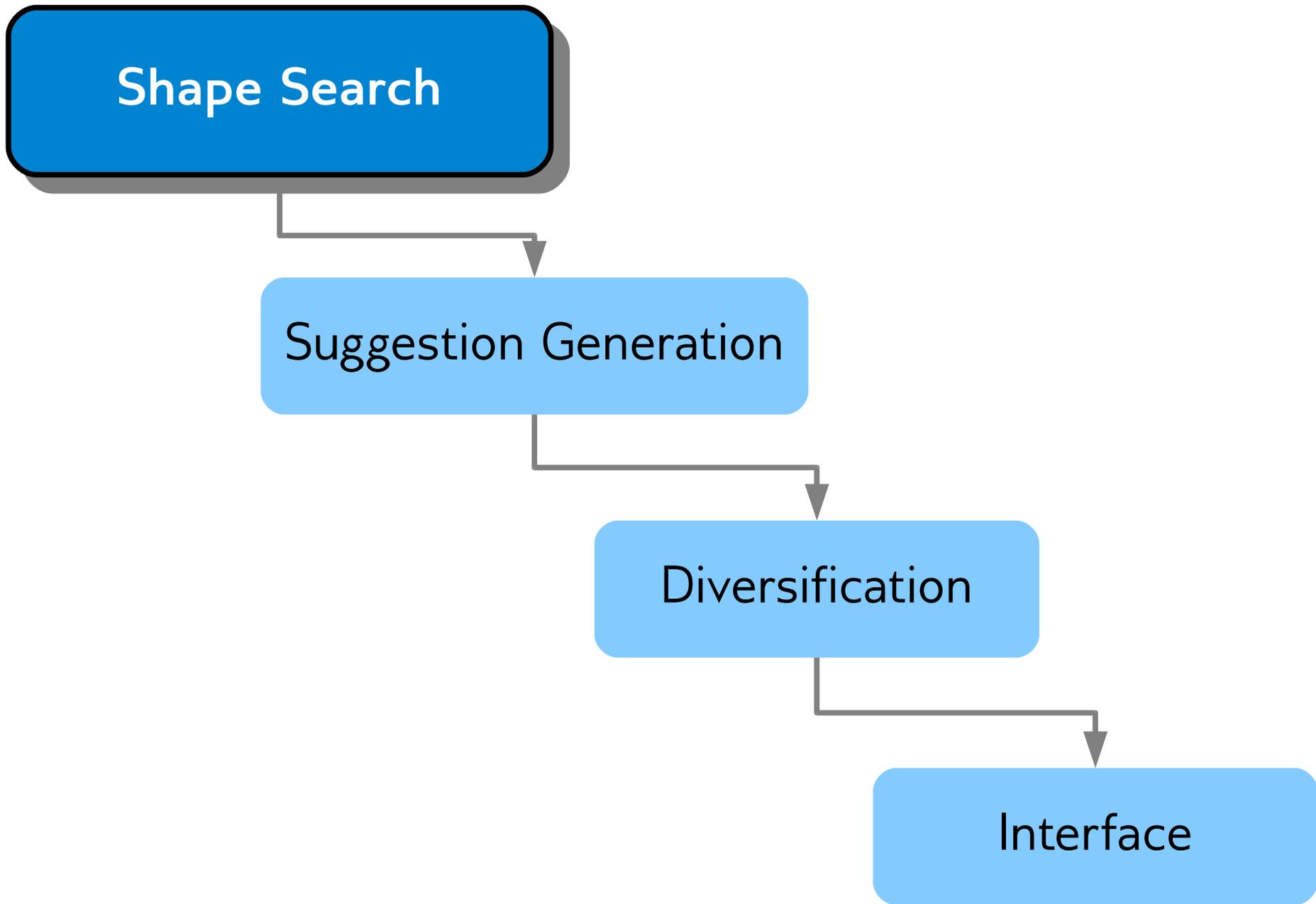












Shape Search

- **Goal:** Find database models from which suggestions can be drawn for a query shape
- Retrieved shapes should have
 - **Similar gross structure** to query
 - **Extra parts** that can be used for suggestions

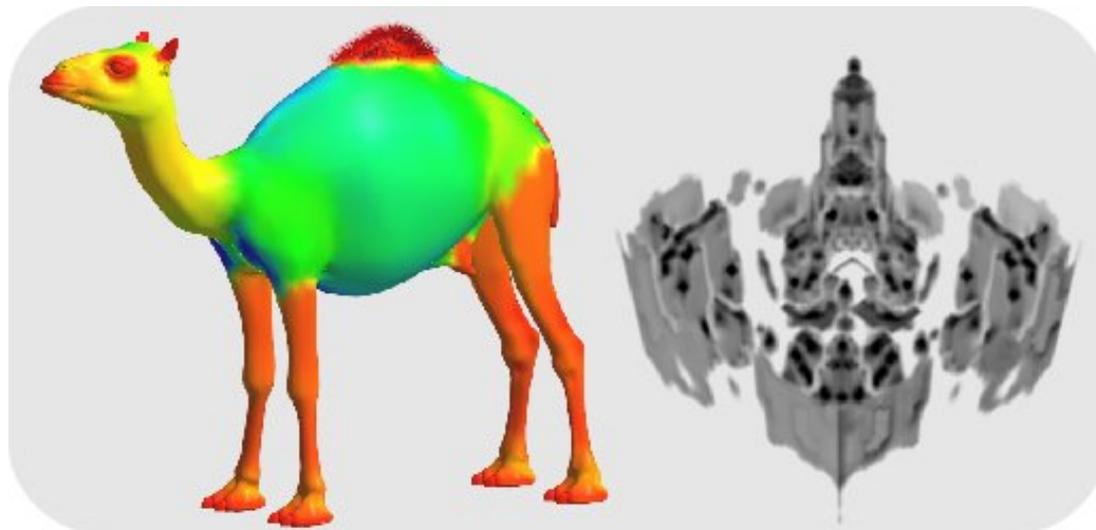
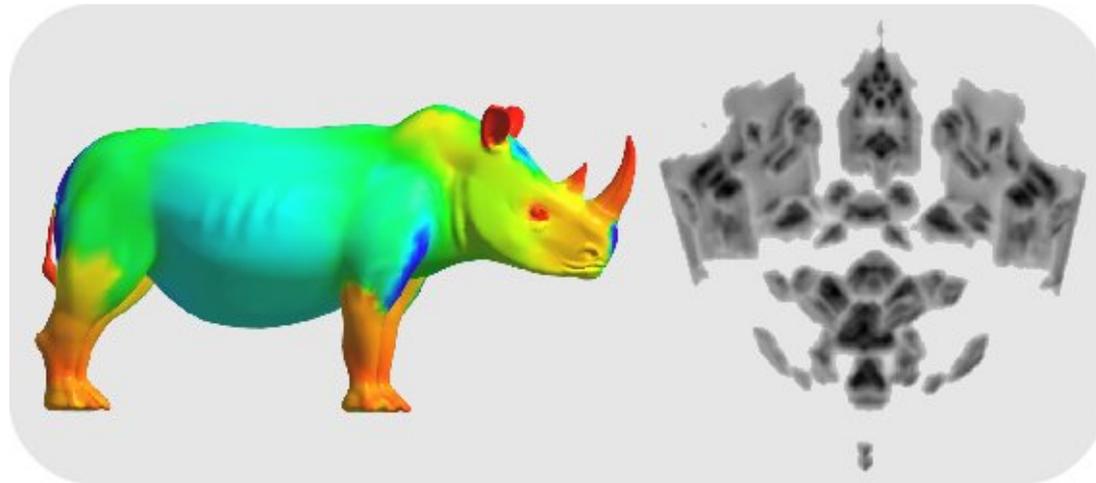
Shape Search

- Hard to compare meshes directly

Shape Search

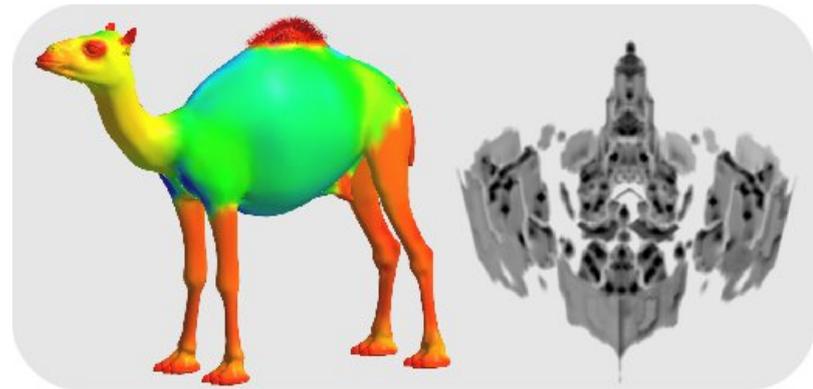
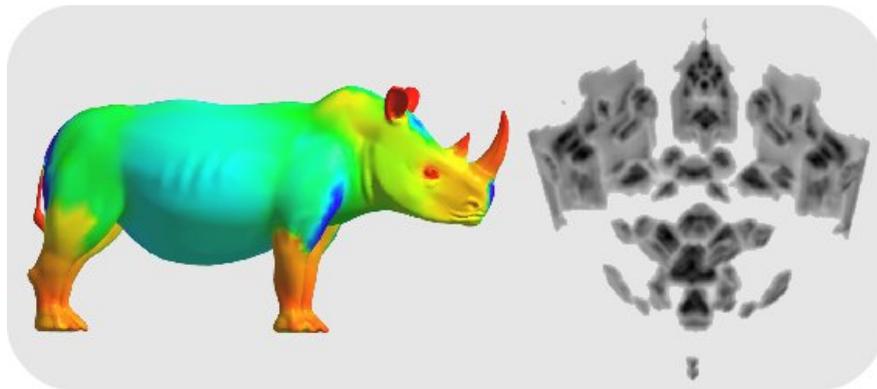
- Hard to compare meshes directly
- Represent shapes with a short **signature**
 - Signatures can be easily and efficiently compared for similarity
 - Similar signatures \Rightarrow similar shapes

Shape Signature: D^3 histogram

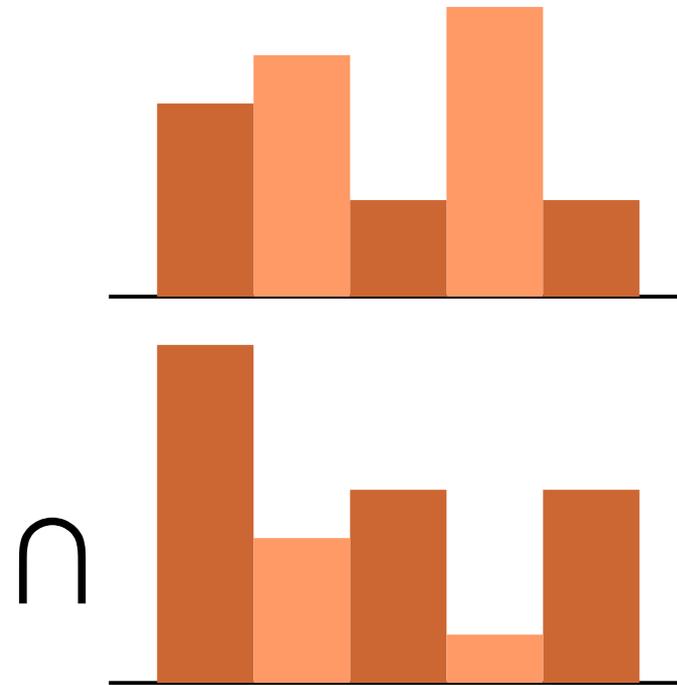


D³ histogram

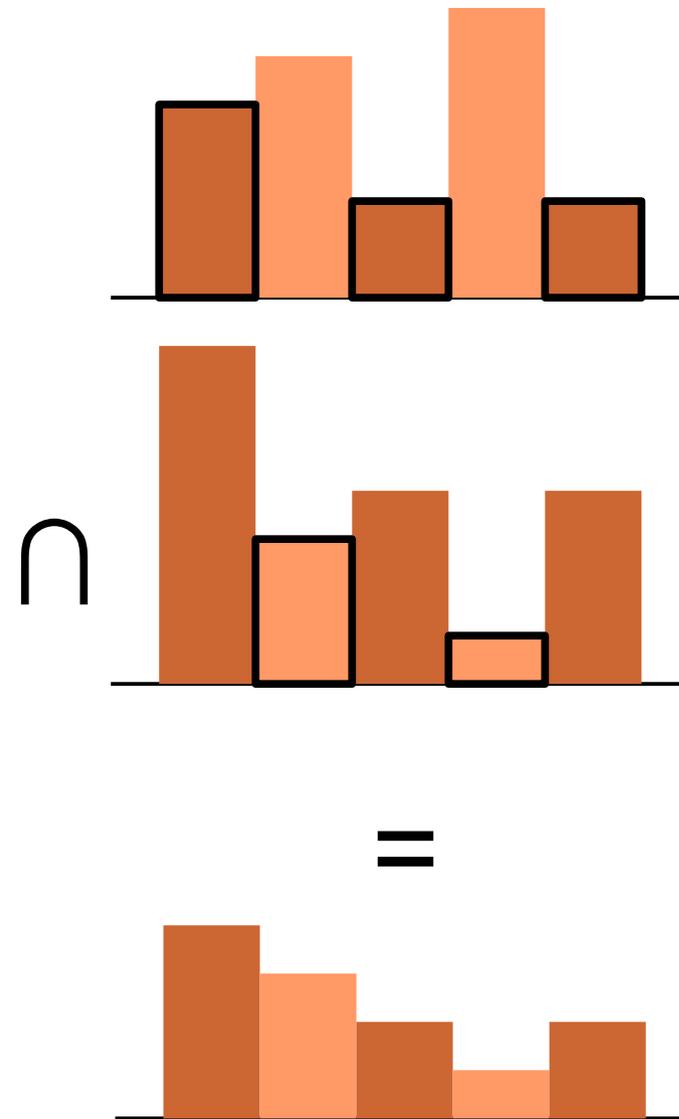
- Bin pairs of sample points on the shape
- Bins indexed by the **distance** between a pair of points, and the **shape diameter** (local thickness) of each point
- Comparison by **histogram intersection** and **pyramid matching**, for partial and approximate matches



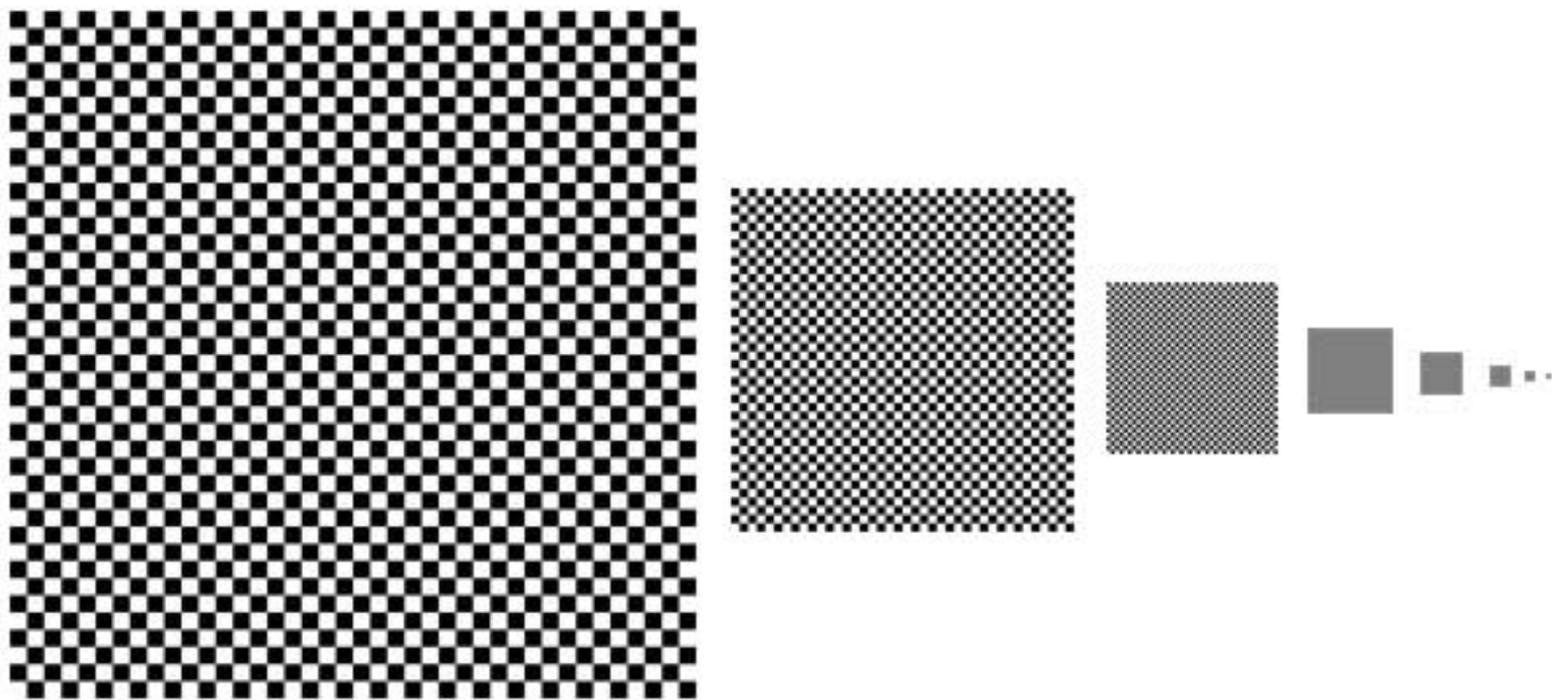
Histogram Intersection



Histogram Intersection



Pyramid Matching

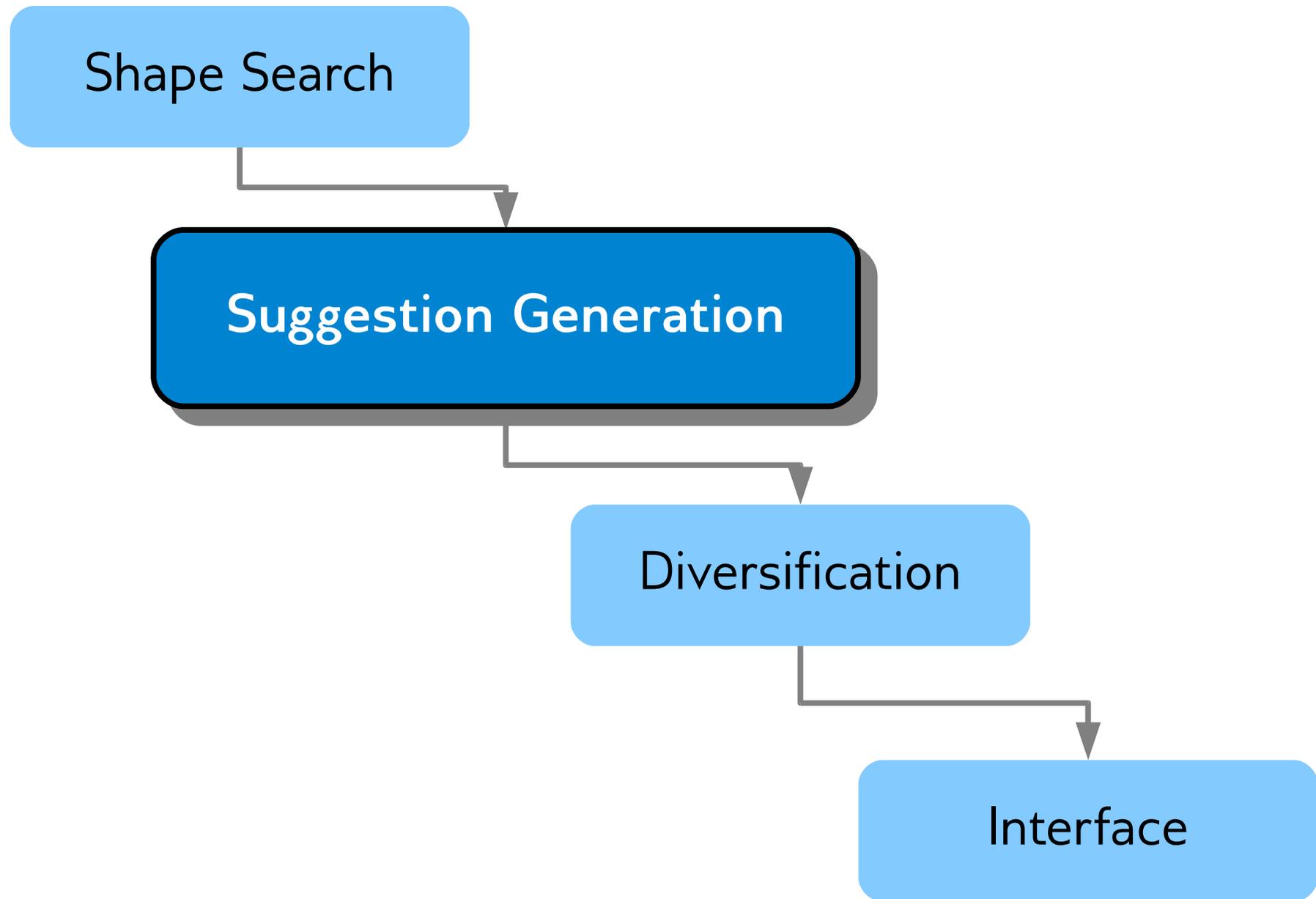


Advantage

- Robust to part addition/removal
 - Small change in model \Rightarrow Small change in similarity
 - Retrieves models that overlap the query as well as contain additional parts to be used for suggestions

$$\text{sim}\left(\text{[rectangular block]}, \text{[rotated rectangular block]}\right) = 1$$

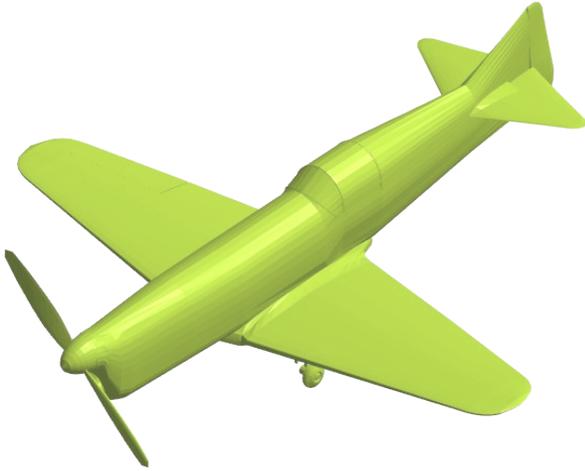
$$\text{sim}\left(\text{[rectangular block]}, \text{[L-shaped block]}\right) \approx 1$$



Suggestion Generation

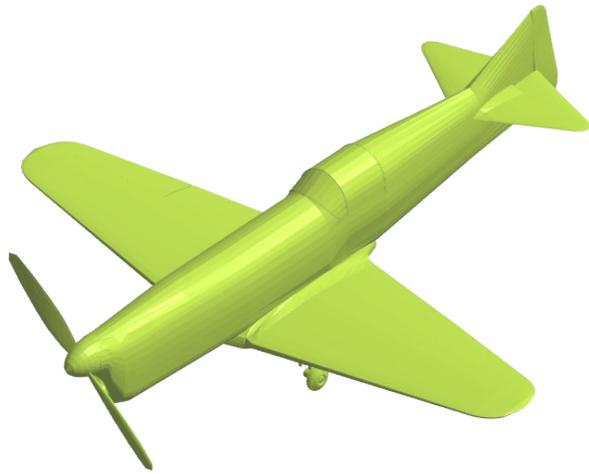
- **Goal:** Given a database model, find the parts that can augment the query shape

Suggestion Generation

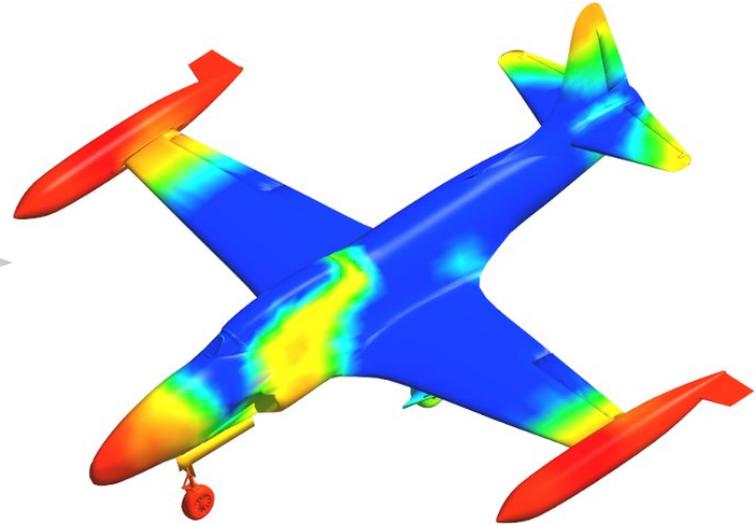
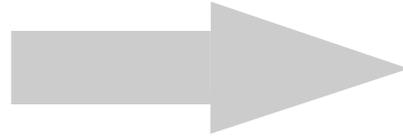


Query

Suggestion Generation



Query

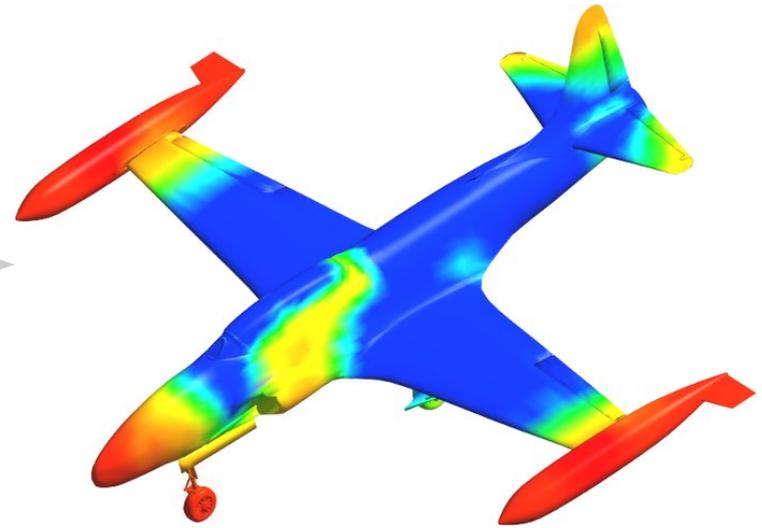
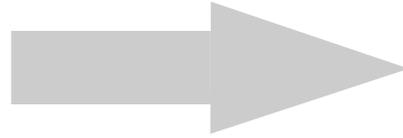


Correspondence scores

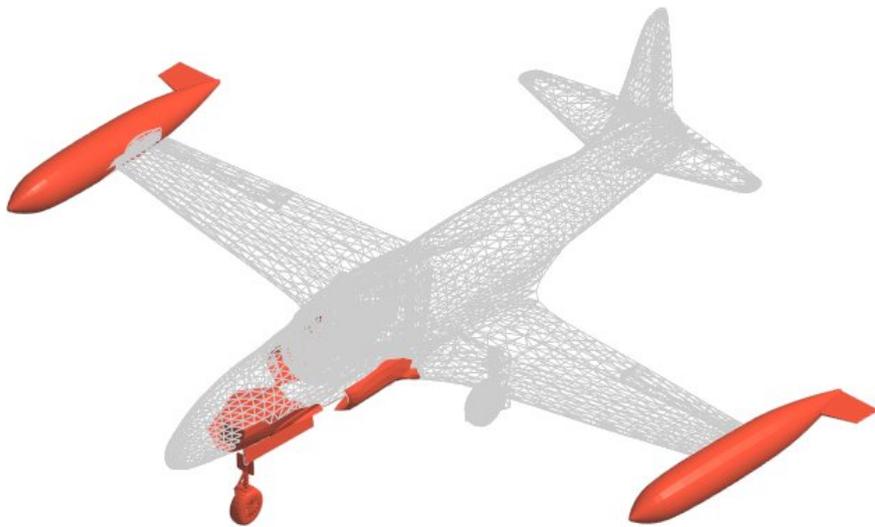
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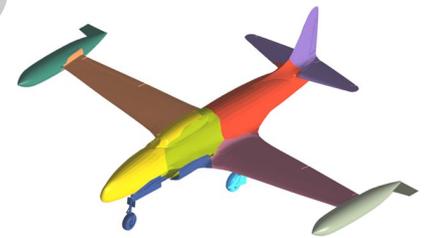
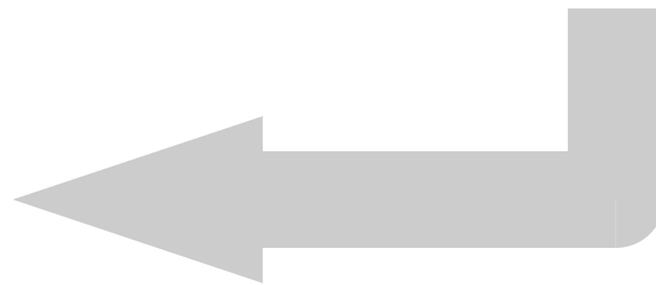
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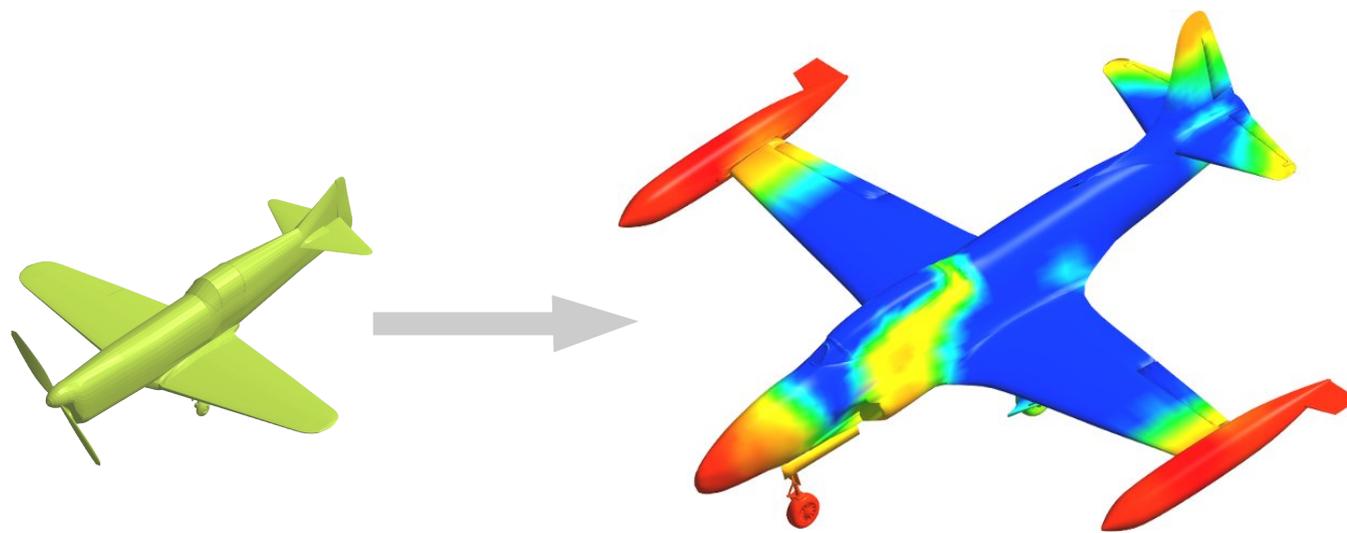


Suggestions



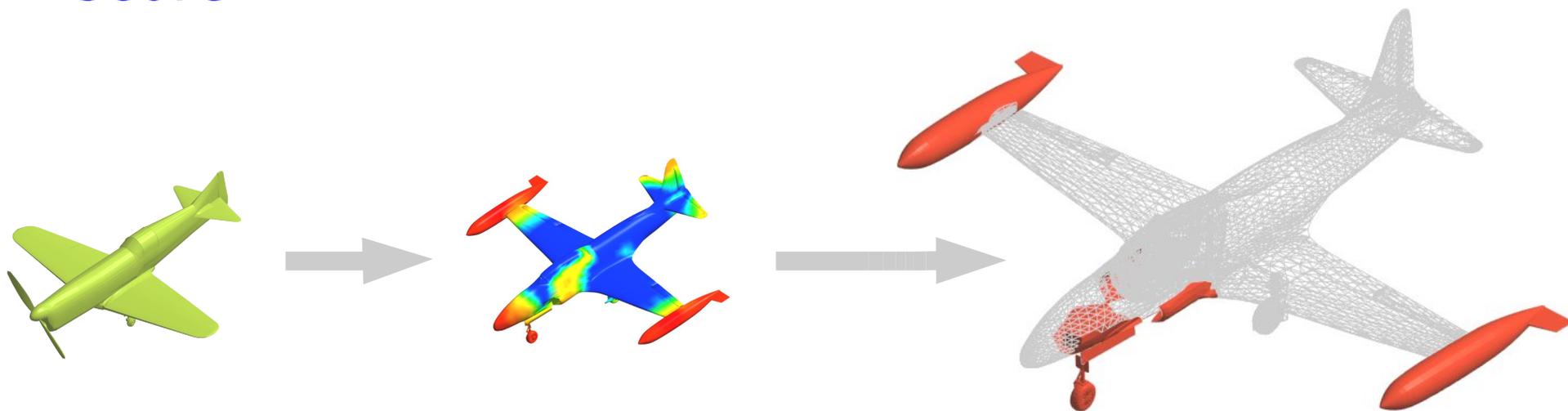
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- Compute **point-wise correspondences** between query and database models



Suggestion Generation

- **Goal:** Given a database model, find the parts than can augment the query shape
- Compute **point-wise correspondences** between query and database models
- Suggest segments with **low average matching score**



Segmentation

- Prior segmentation of database models based on shape diameter and approximate convexity
- No need for compatible segmentation of query



Computing Correspondences

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 - Spin image
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- No explicit alignment
- Descriptor at a point concatenates:
 - Spin image
 - Histogram of neighboring points binned by distance and SDF
- Descriptors compared by histogram intersection and pyramid matching, to accommodate approximate and partial matches

Computing Correspondences

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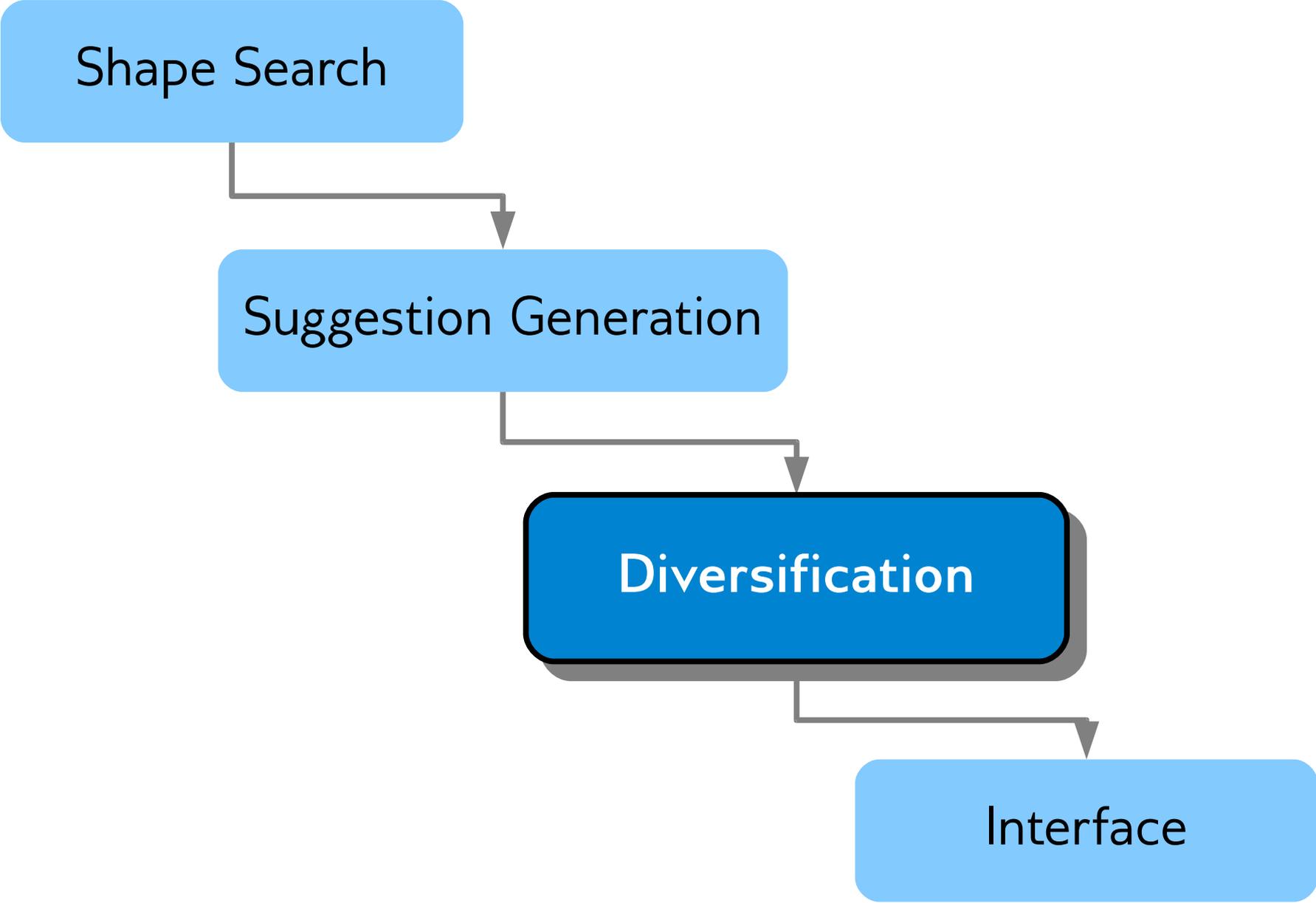
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- Effective approach: **locality sensitive hashing**
- HIK + pyramid match not an LSH-friendly metric
 - But is Mercer kernel!
 - Can use *Kernelized LSH [Kulis and Grauman '09]*
 - 6x speedup



Diversification

- **Problem:** Large databases contain many near-identical shapes
 - If one is a good match, so are its twins
 - Most of the top-ranked options look the same

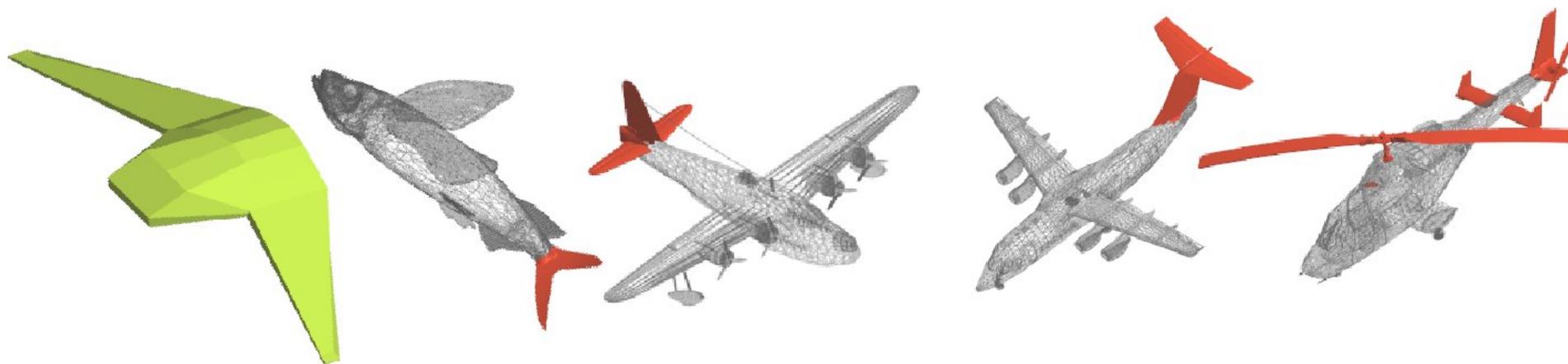
Diversification

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- Maximal Marginal Relevance (MMR) breaks up long runs of similar results in a ranked list [*Carbonell and Goldstein '98*]

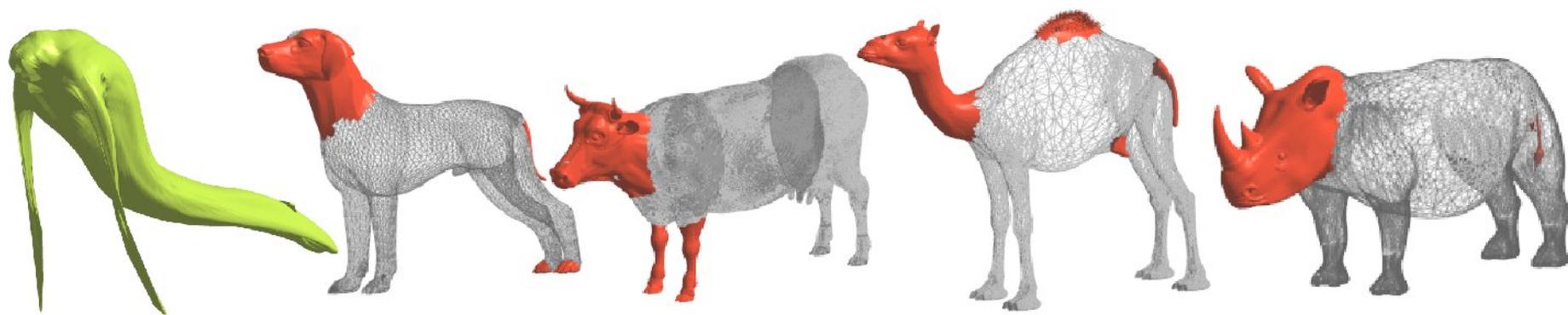
Results



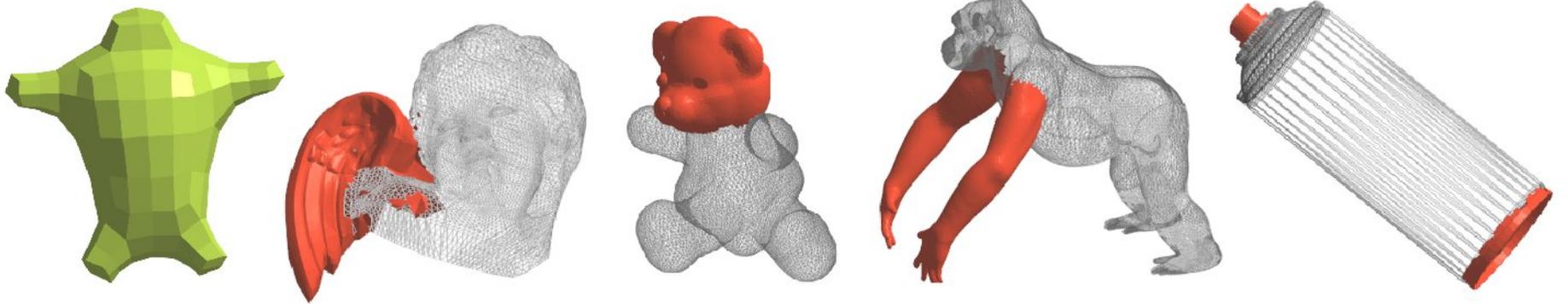
Results



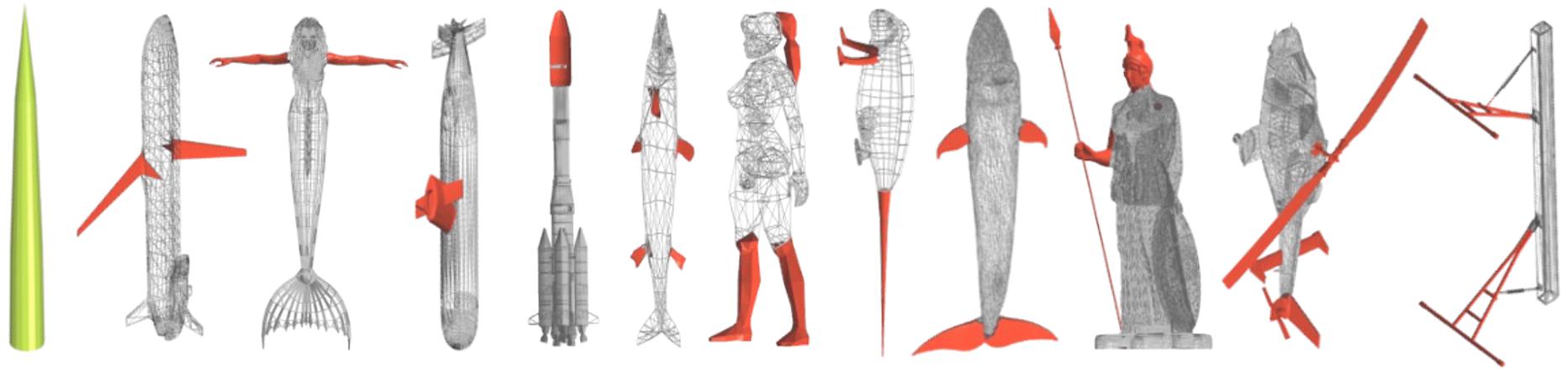
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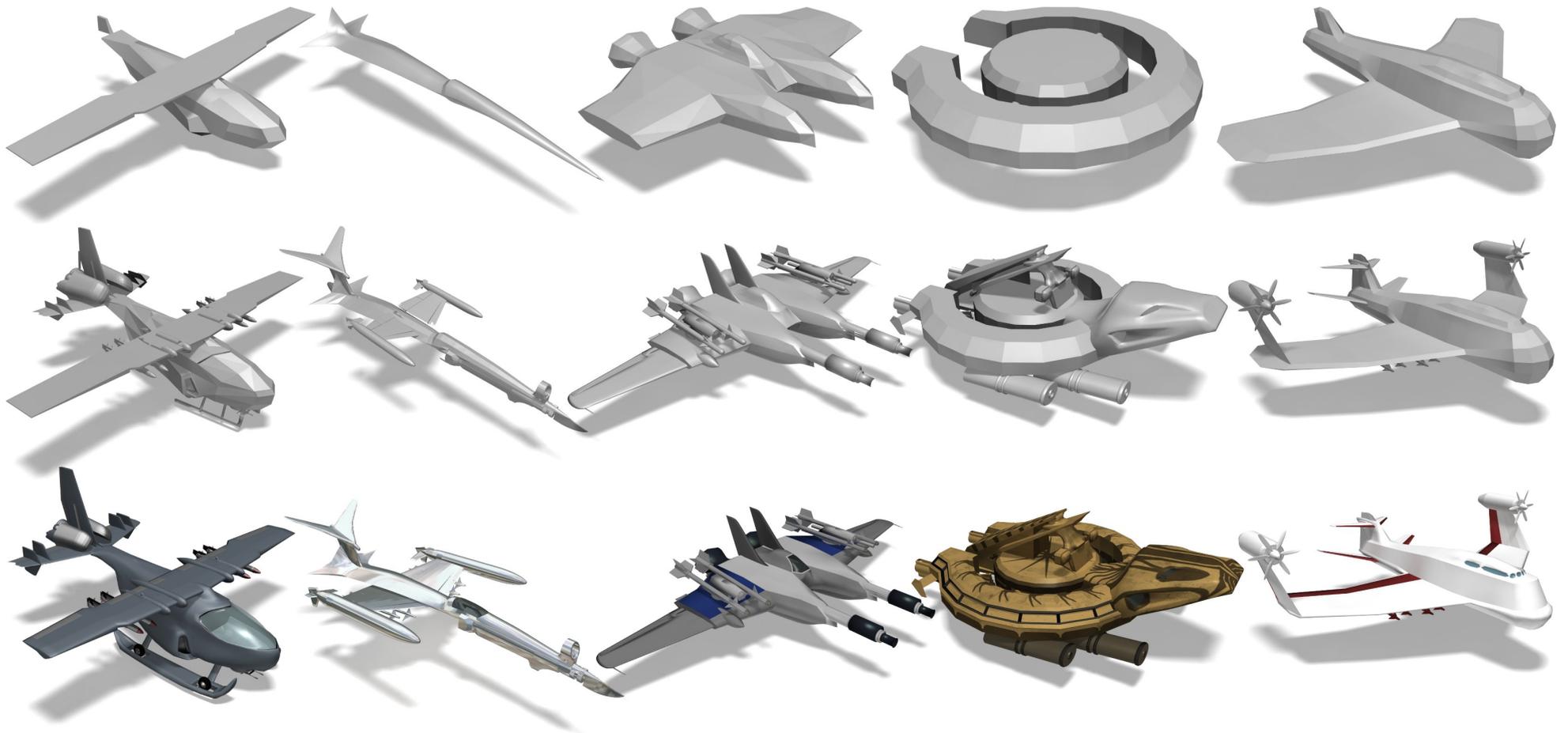
Informal Studies

- 12 artist users
 - 3 professional
 - 8 art students
 - 1 CS student + hobbyist modeler
- 2-hour sessions
- 2 prototyping tasks (~1 hour per task):
 - Creatures
 - Aircraft
- InspireMe + Maya/3ds Max (for initial query shape + adjusting placement)

Informal Studies: Creatures



Informal Studies: Aircraft



Future Work

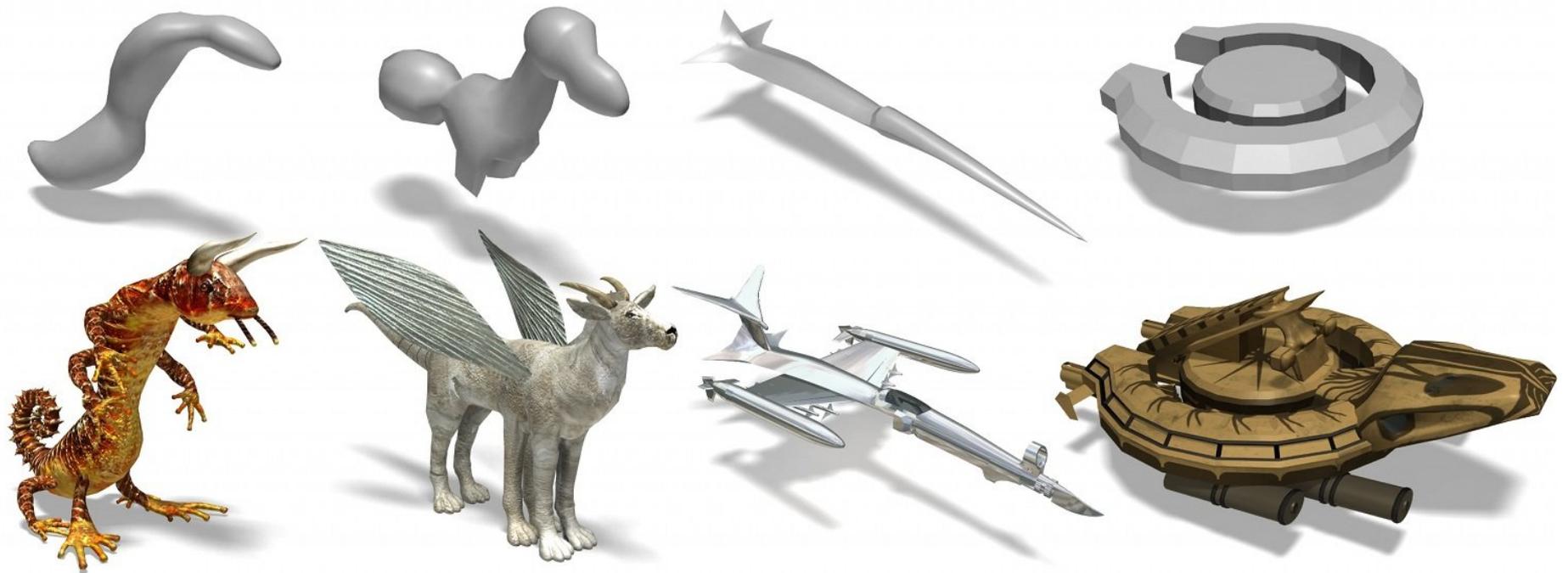
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Future Work

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- More data-driven techniques for open-ended design
- Utilize semantic information about shapes to resolve ambiguities in purely geometric methods
- Develop more large databases of 3D content, to drive data-driven content creation



Thank You