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True2Form:

3D Curve Networks from 2D Sketches via Selective Regularization

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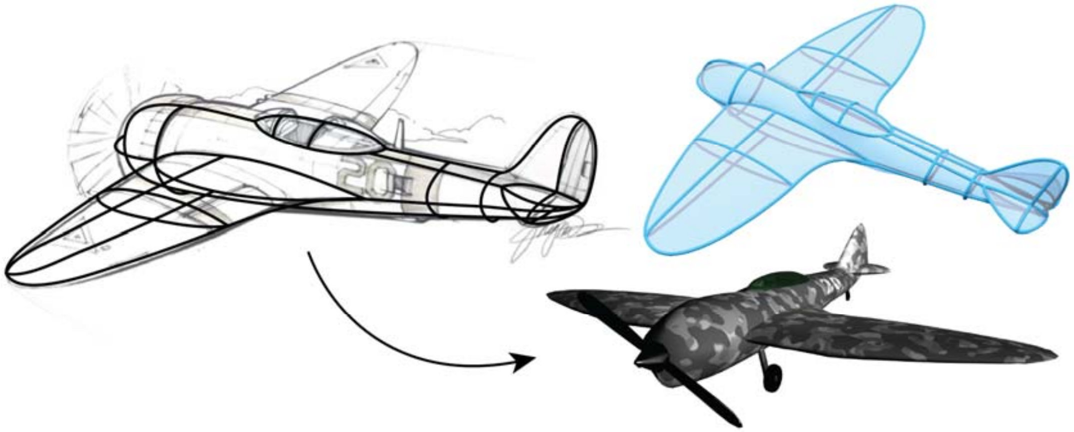


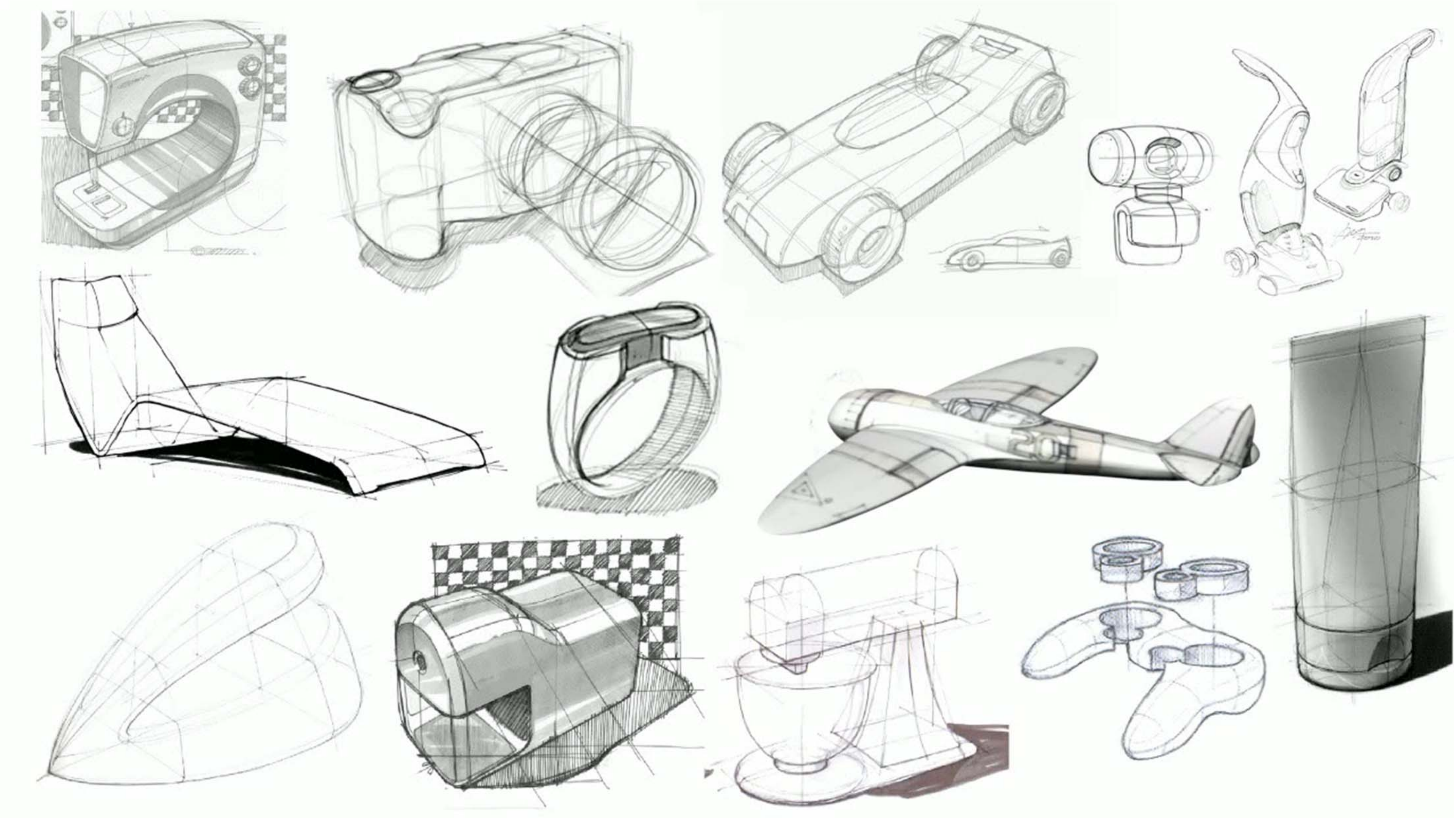
Input sketch

Output 3D model

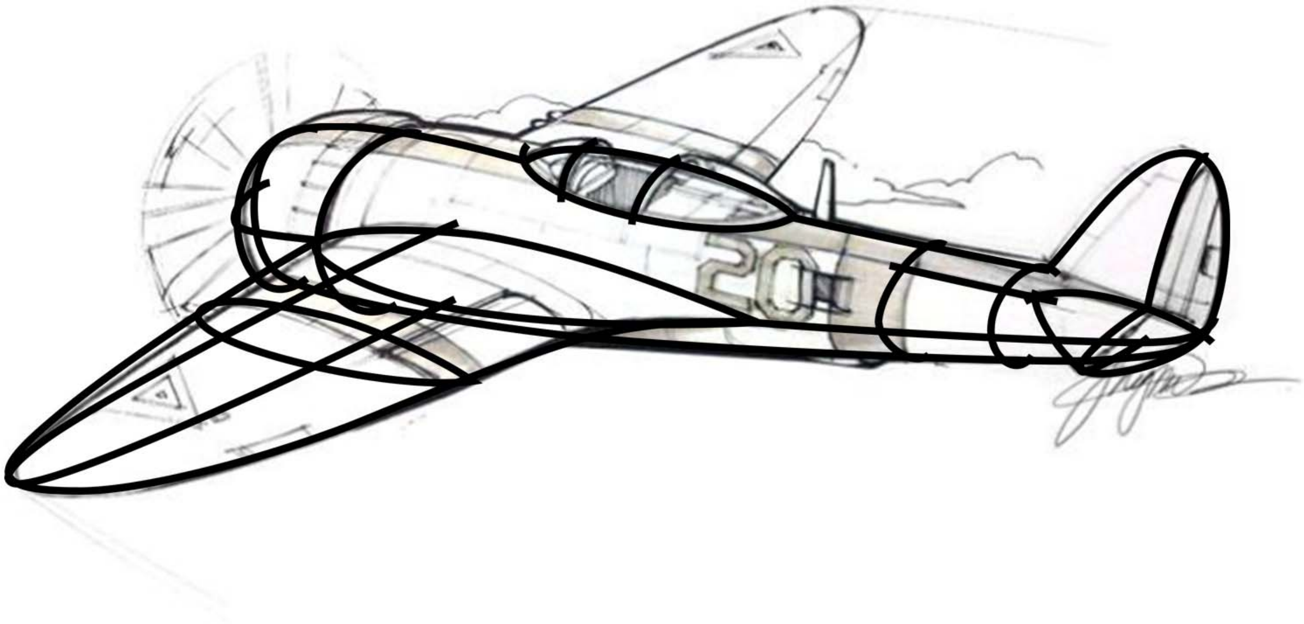
UBC

inria informatiques mathématiques

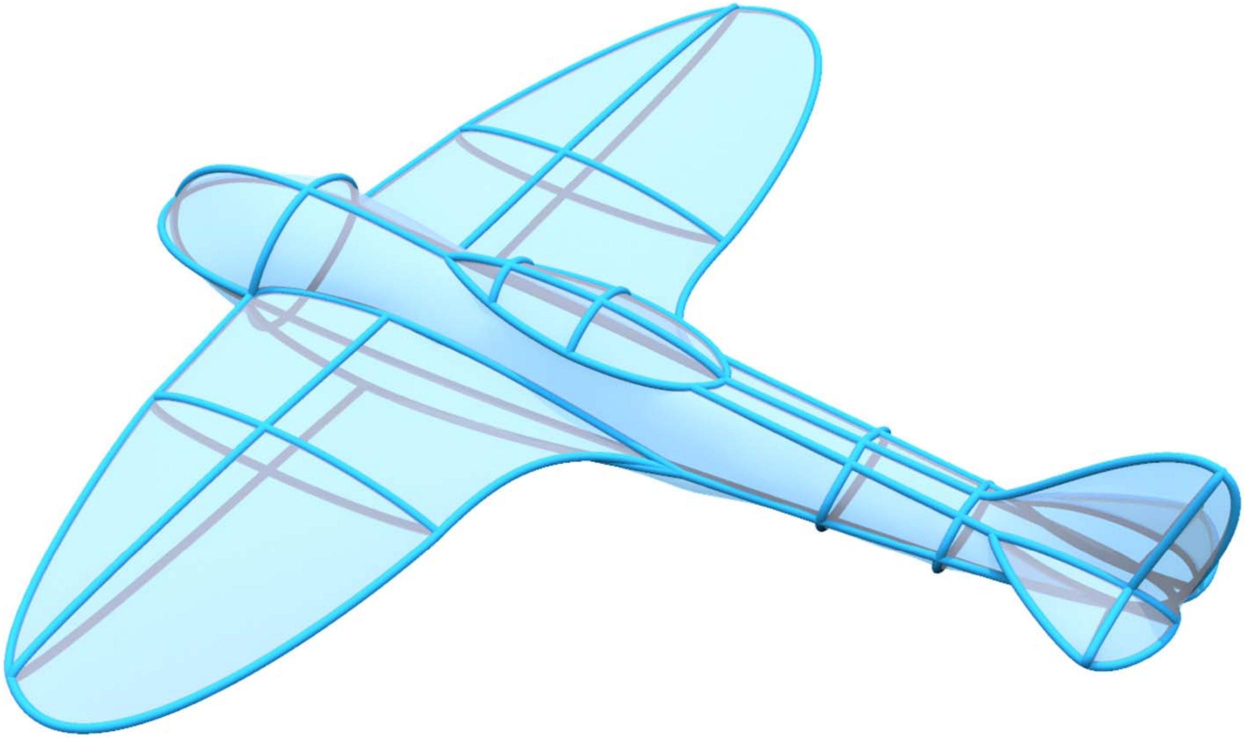
UNIVERSITY OF TORONTO



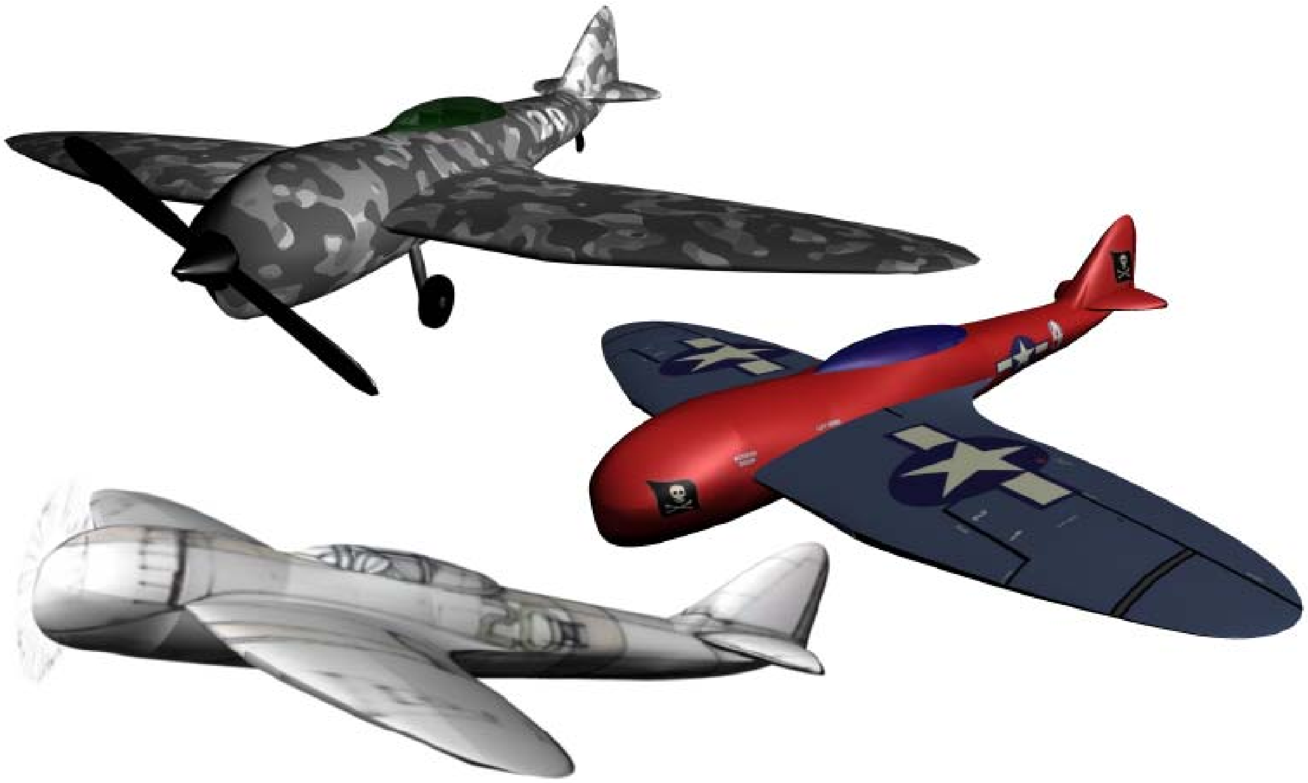
Start from a single descriptive sketch…



.. generate a 3D curve network

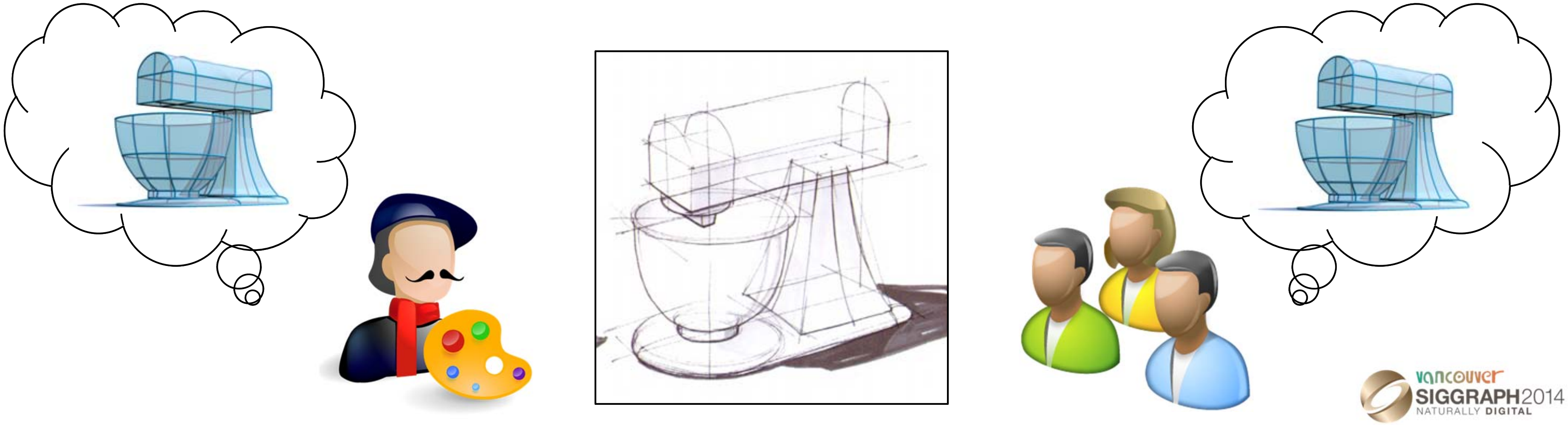


Follow by surfacing and texturing



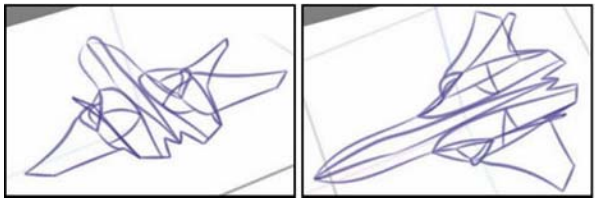
True2Form Goal

- Uncover geometric cues guiding creation and perception of concept sketches
- Use cues to compute plausible 3D reconstructions

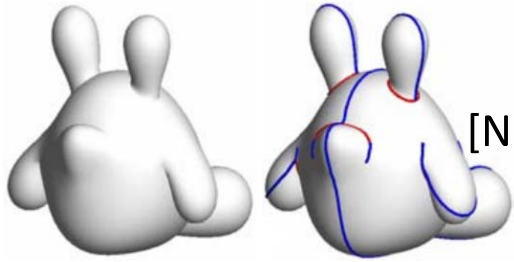


Related work: Sketch-based modeling

- Dominated by multi-view frameworks
  - Incremental rotate &draw paradigm



[Bae’08]

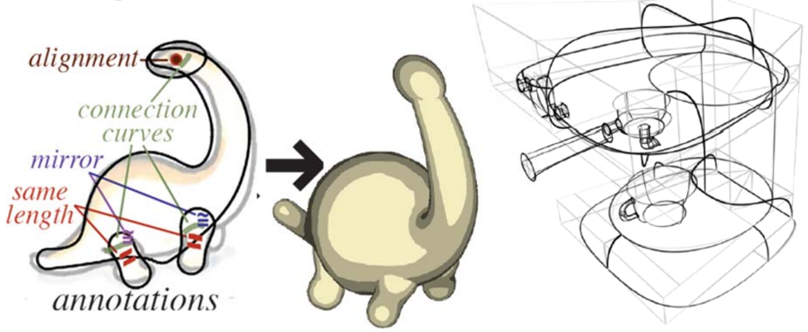


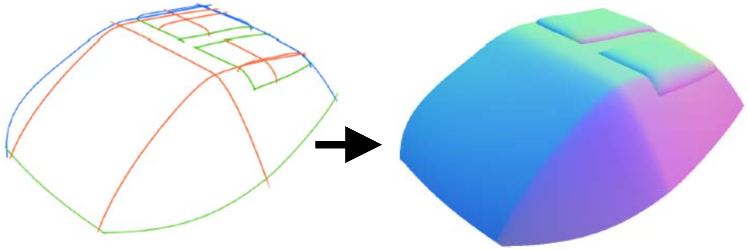
[Nealen’07]

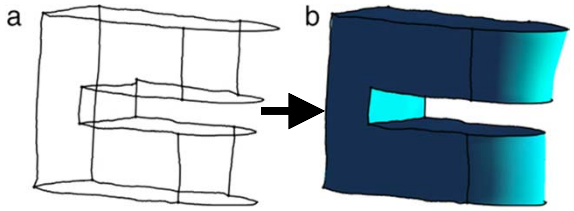
- True2Form: Single view focus
  - Mimic traditional artist workflow
  - Extends to multi-view

Related work: Single View

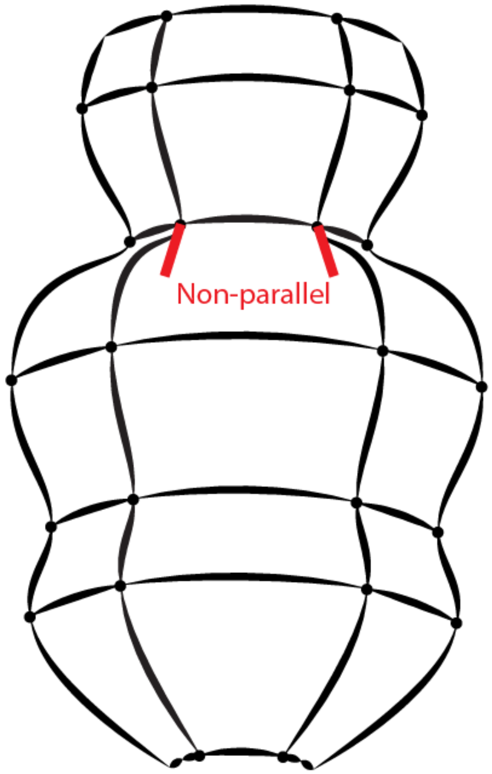
- Leverage additional user input:
  [Gingold'09, Schmidt'09, Shtof'13]
- Use annotated subset of descriptive curves (cross-sections)
  [Andre'11; Shao'12]
- CAD drawing interpretation - leverage straight & orthogonal lines [Tian'09,Wang'09]







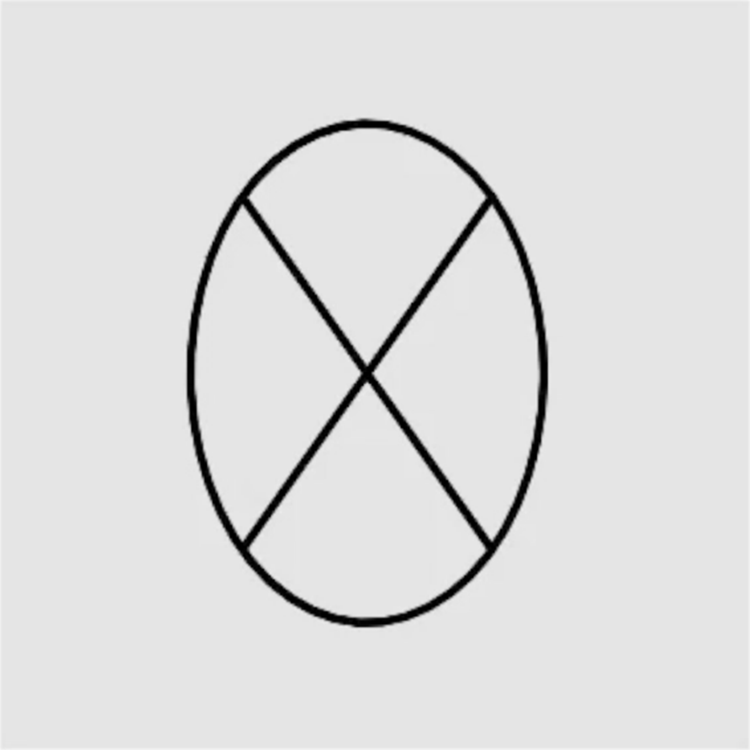
True2Form: Key Principles



- Generate 3D by using properties of *descriptive* sketch curves
- **Fidelity:** sketches reflect 3D geometry
  - Satisfied by flat interpretation
- **Regularity:** curves frequent satisfy 3D regularity constraints
  - This lifts curves to 3D
  - Regularity is **context-based**

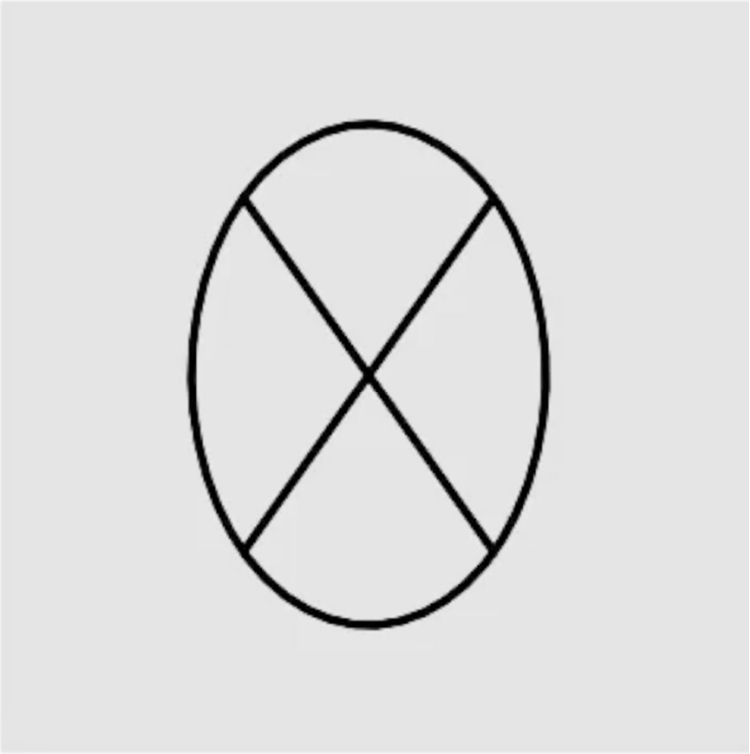
Fidelity: 2D reflects 3D

- **Projection accuracy:** 2D curves are (approximate) projection of 3D curves



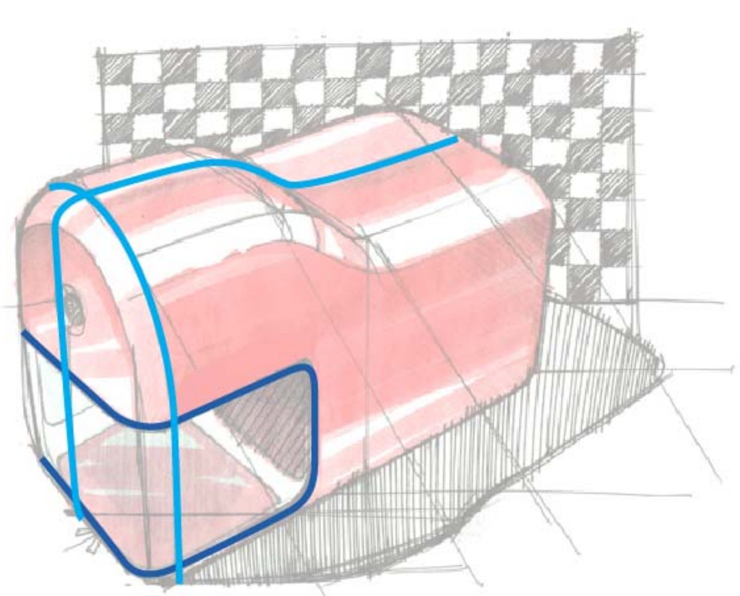
Fidelity: 2D reflects 3D

- **Projection accuracy:** 2D curves are (approximate) projection of 3D curves
- **Minimal variation:** shape of 2D curves close to their shape in 3D
  - 2D/3D curves **locally affine invariant**
  - Small foreshortening

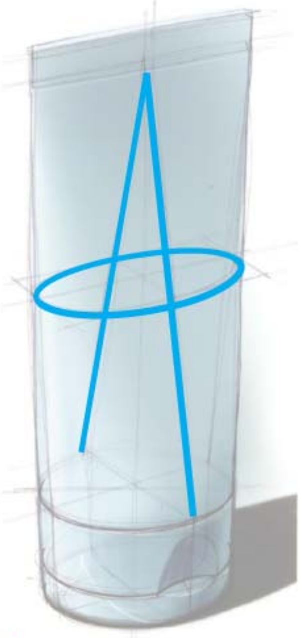


Regularity

- **Selective (context-based)** preference for regular 3D structures
  - Orthogonality
  - Parallelism
  - Symmetry
  - Curve planarity



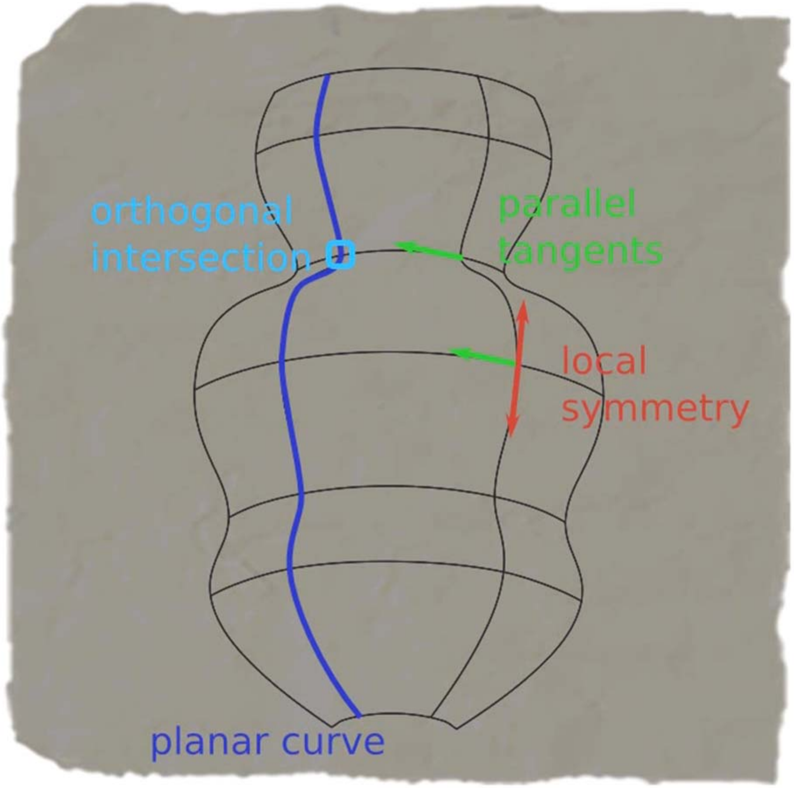
Non-planar



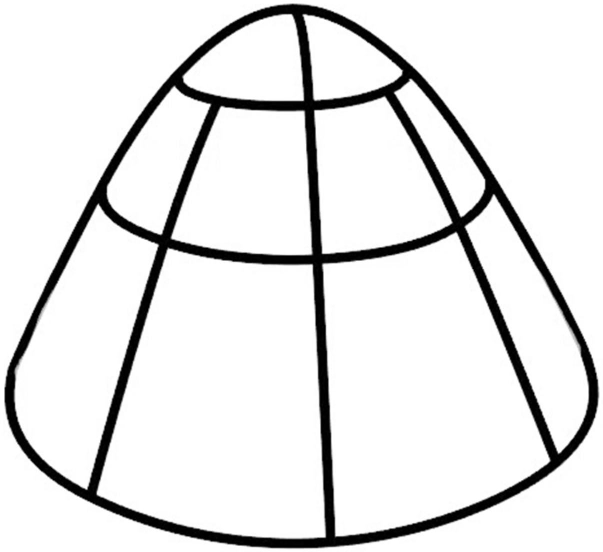
Planar

Selective Regularization

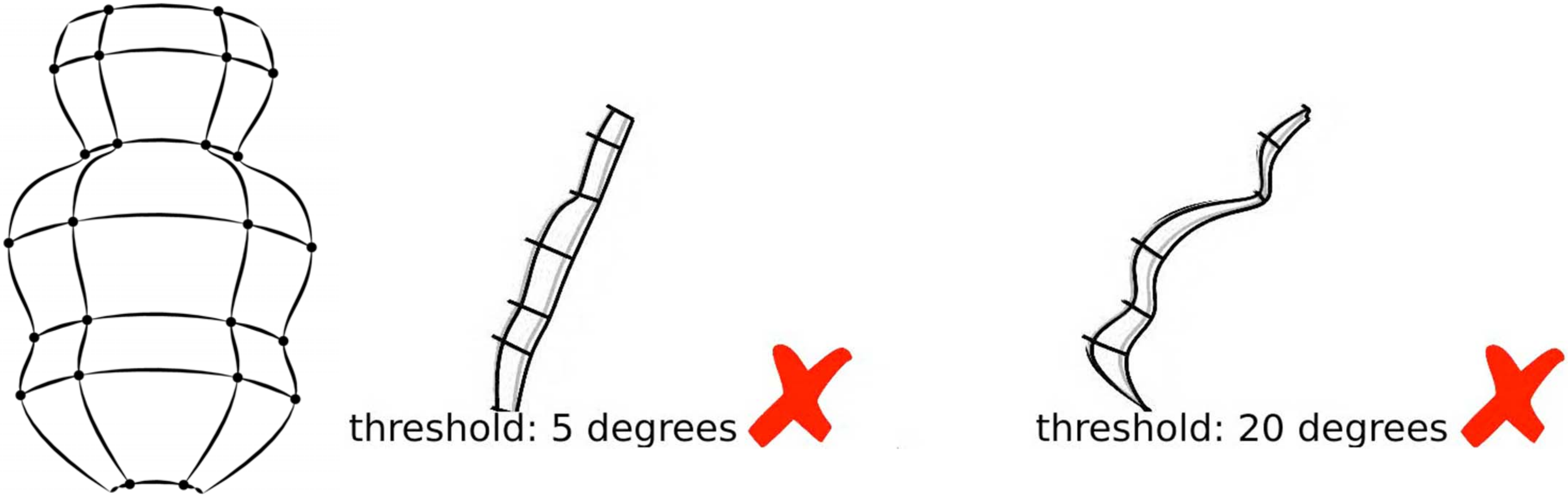
- Given known regularity set can generate 3D
  - optimize fidelity subject to regularity constraints
- **Challenge:** Applicable regularities unknown *a priori*



Naïve: Soft regularity across the board

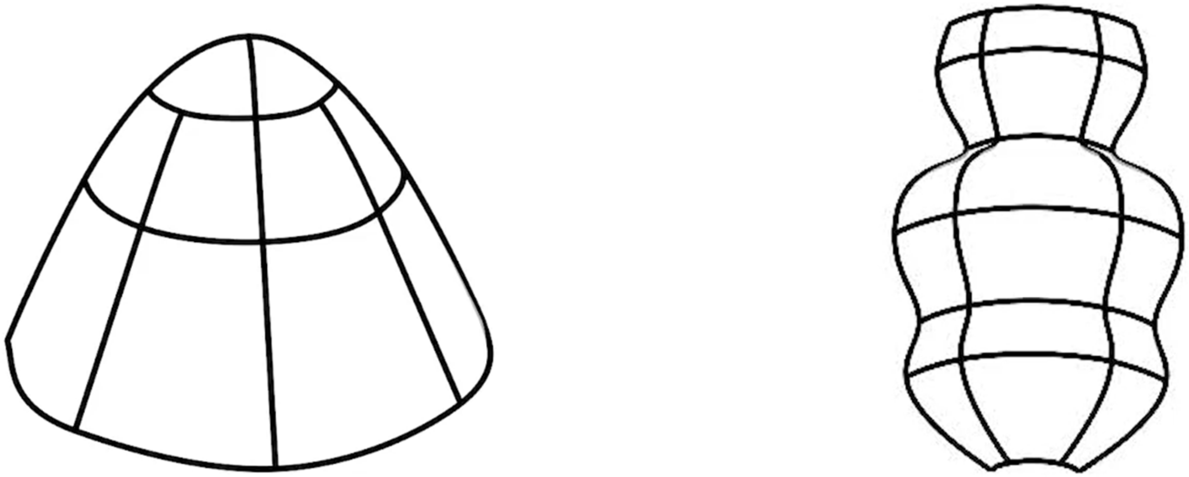


Inaccurate regularity sets result in poor reconstruction



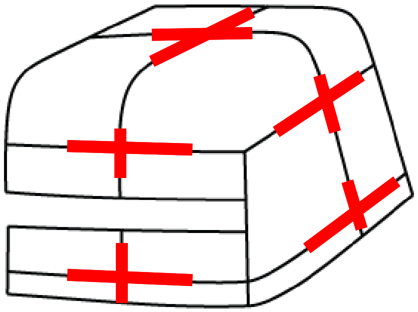
Our Solution: Progressive Regularization

- Cast regularity applicability as variable to solve for
- Determine optimal values via progressive rounding

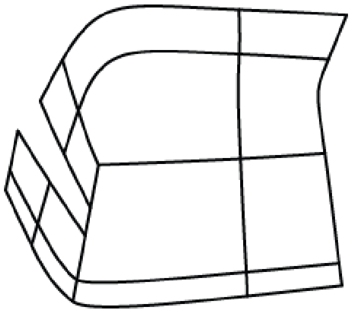


Progressive Regularization

1. Initial reconstruction
   - Fidelity + orthogonality at smooth crossings



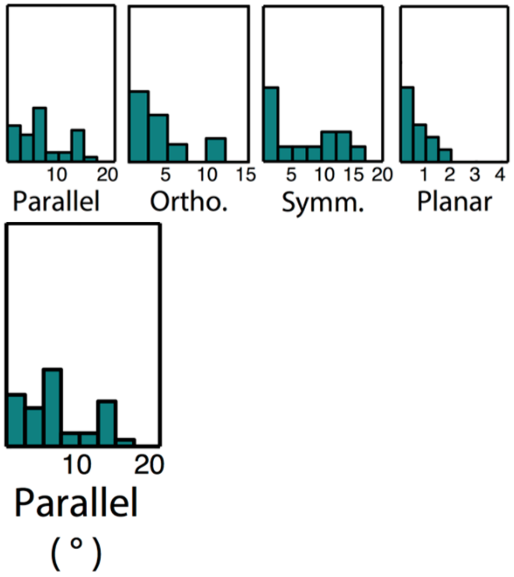
Input

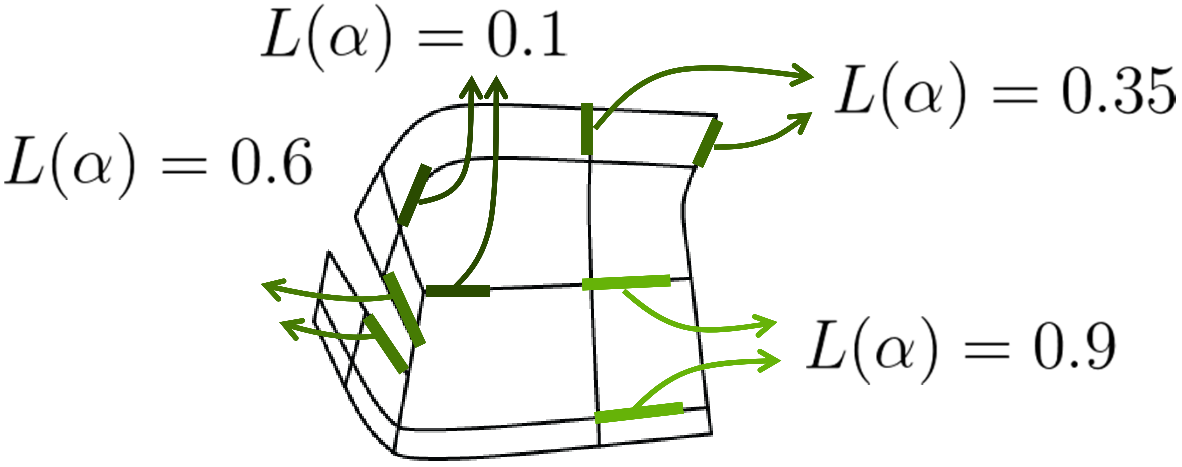


Initial reconstruction

Progressive Regularization

1. Initial reconstruction
2. Compute continuous regularity likelihoods $L(\alpha)$





$L(\alpha) = 0.1$

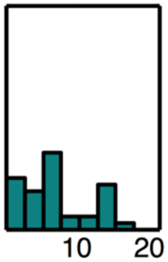
$L(\alpha) = 0.35$

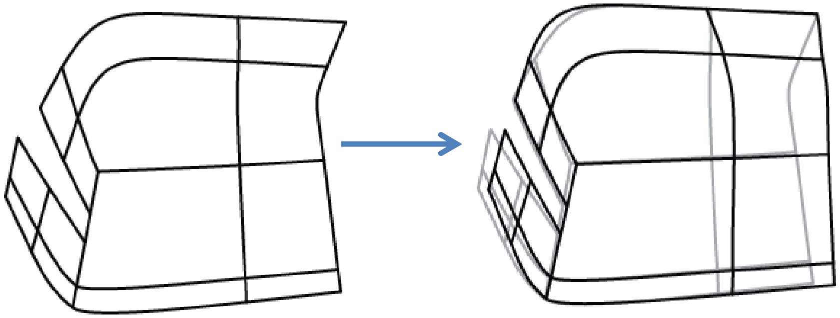
$L(\alpha) = 0.6$

$L(\alpha) = 0.9$

Progressive Regularization

1. Initial reconstruction
2. Compute continuous regularity likelihoods $L(\alpha)$
3. Solve with weighted regularity terms $\sum L(\alpha) C_{reg}^2$



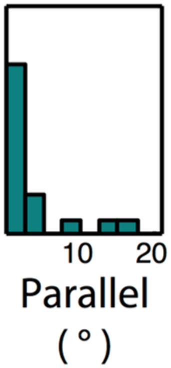


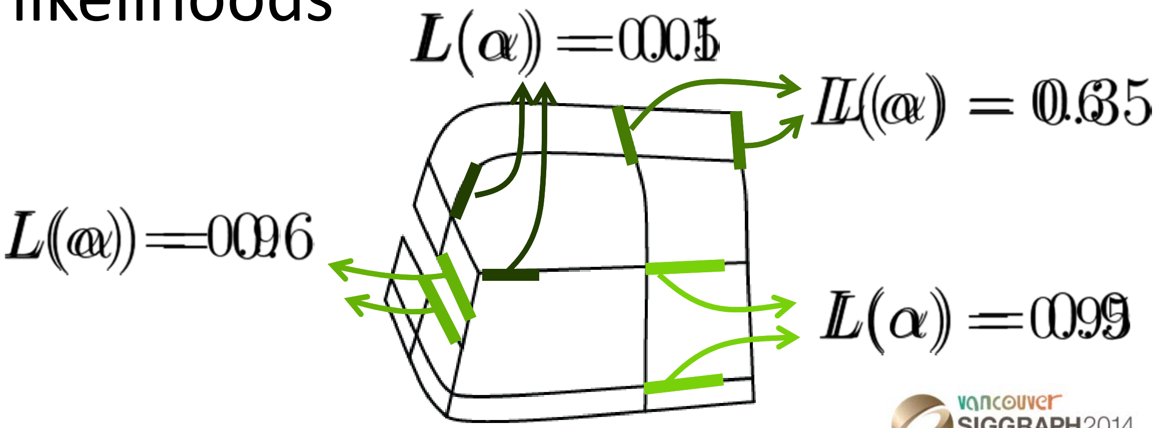
Initial

Updated

Progressive Regularization

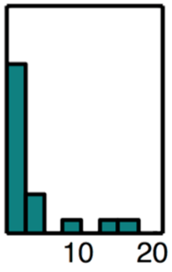
1. Initial reconstruction
2. Compute continuous regularity likelihoods $L(\alpha)$
3. Solve with weighted regularity terms $\sum L(\alpha) C_{reg}^2$
4. Update regularity likelihoods



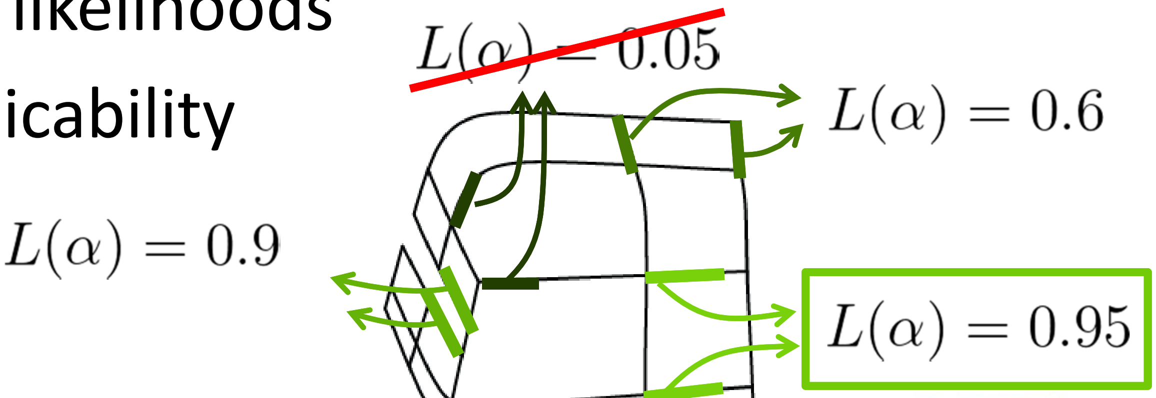


Progressive Regularization

1. Initial reconstruction
2. Compute continuous regularity likelihoods $L(\alpha)$
3. Solve with weighted regularity terms $\sum L(\alpha)C_{reg}^2$
4. Update regularity likelihoods
5. Rounding for applicability

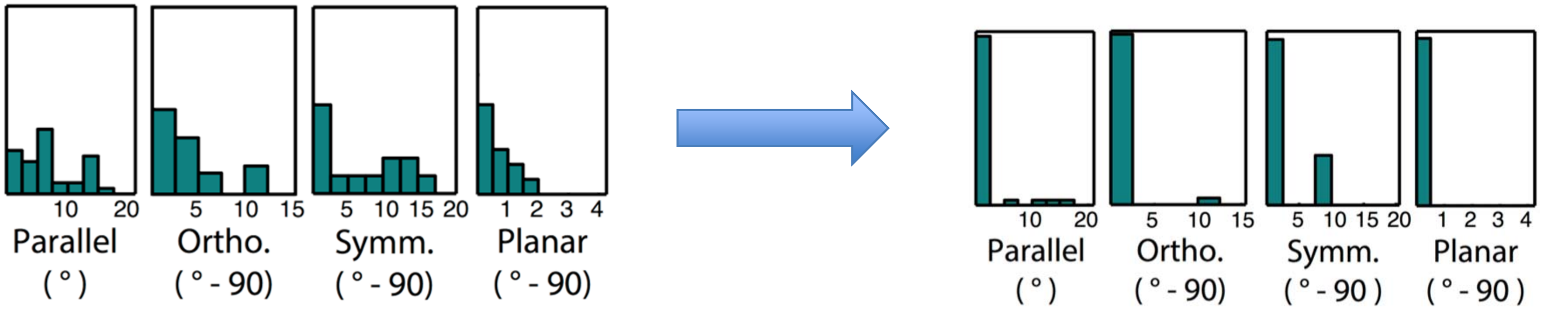


Parallel

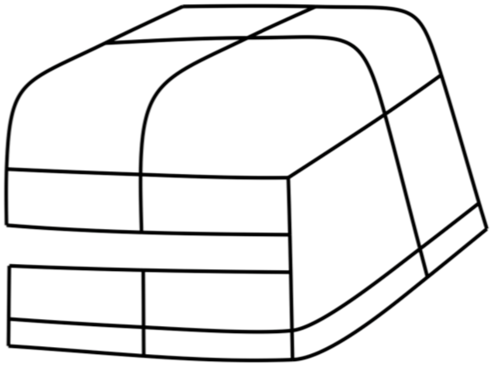


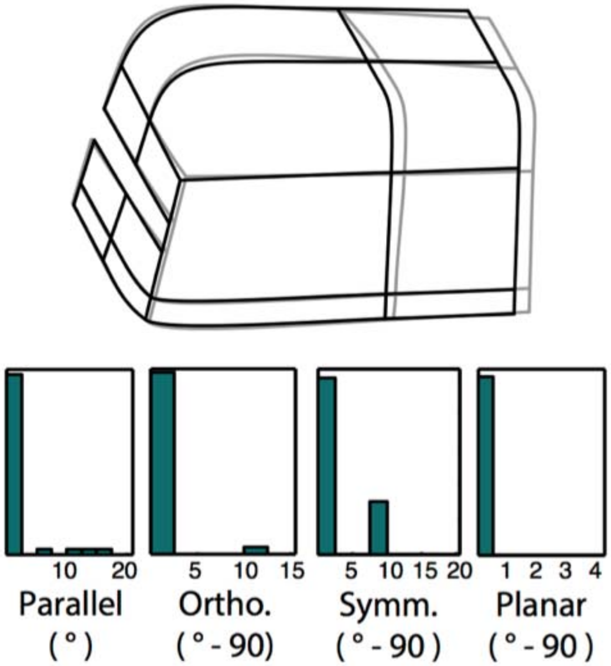
Progressive Regularization

1. Initial reconstruction
2. Compute continuous regularity likelihoods $L(\alpha)$
3. Solve with weighted regularity terms $\sum L(\alpha)C_{reg}^2$
4. Update regularity likelihoods
5. Rounding for applicability



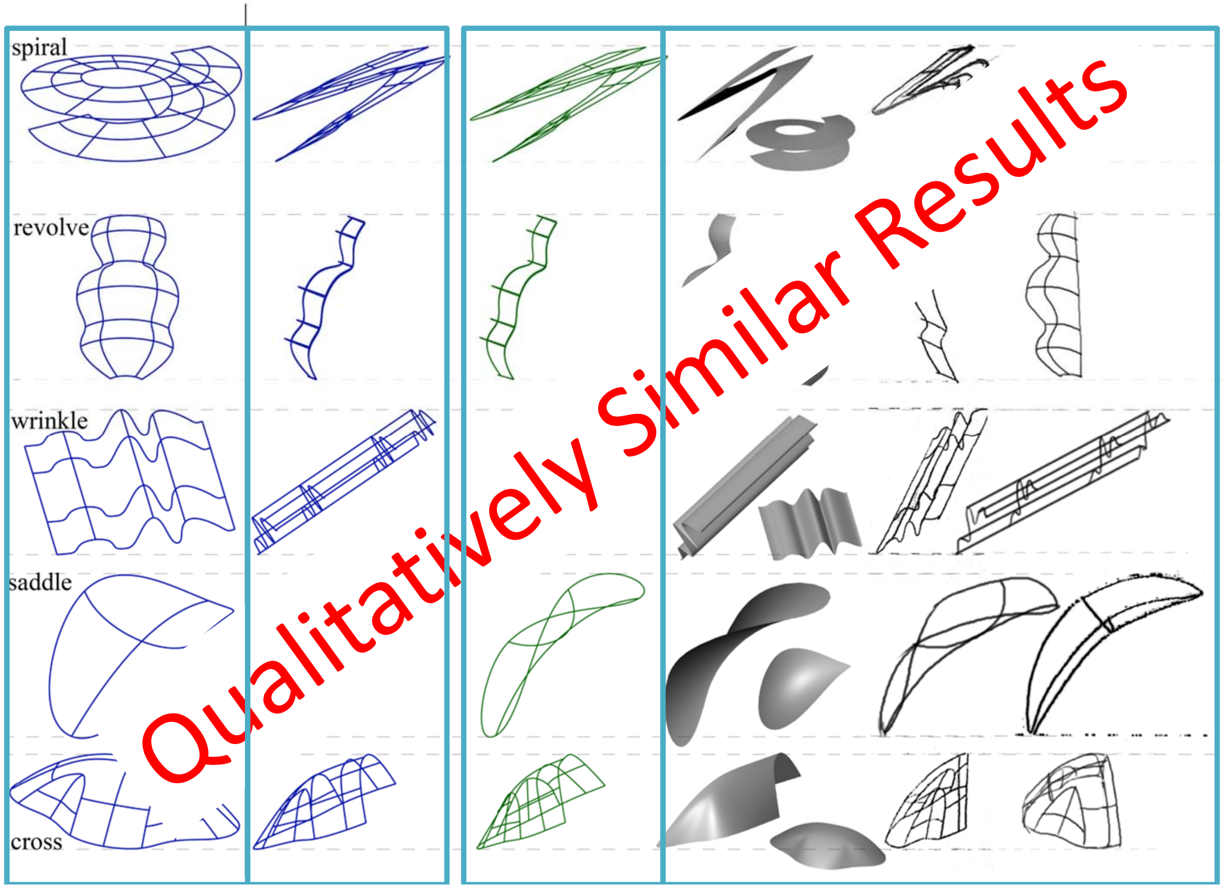
Progressive Regularization





Results & Validation

Ground Truth Validation



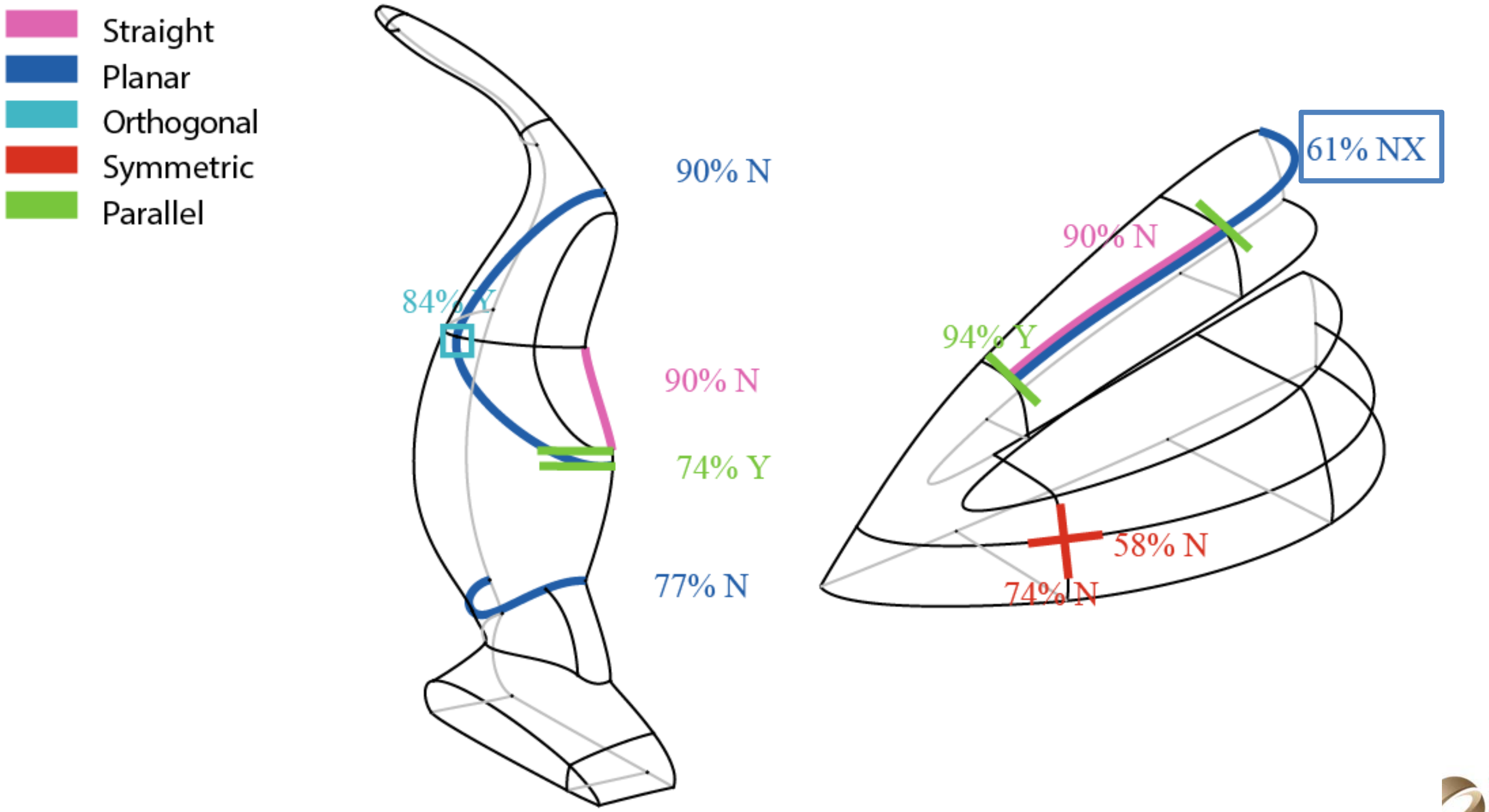
Qualitatively Similar Results

Ground truth

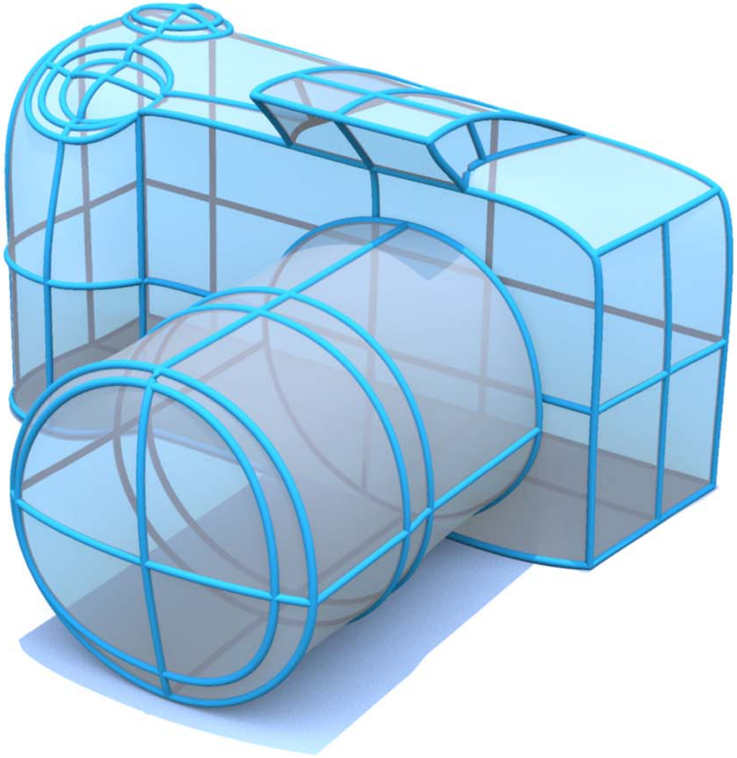
True2form output

Artist creation

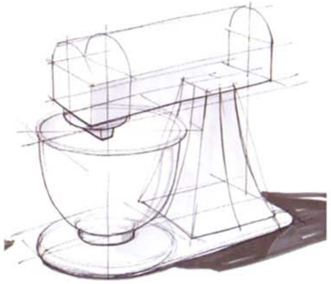
Perceptual Validation



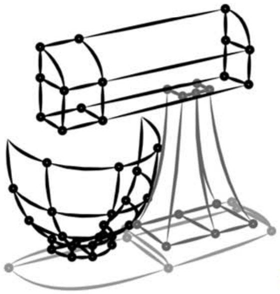
Results (over-sketching)



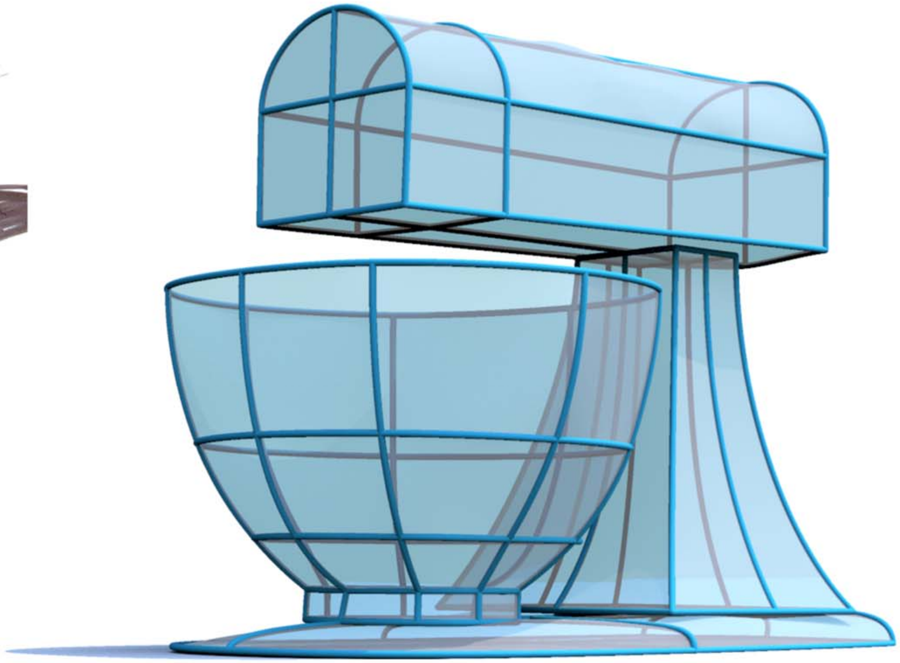
Results (over-sketching)



Inspiration



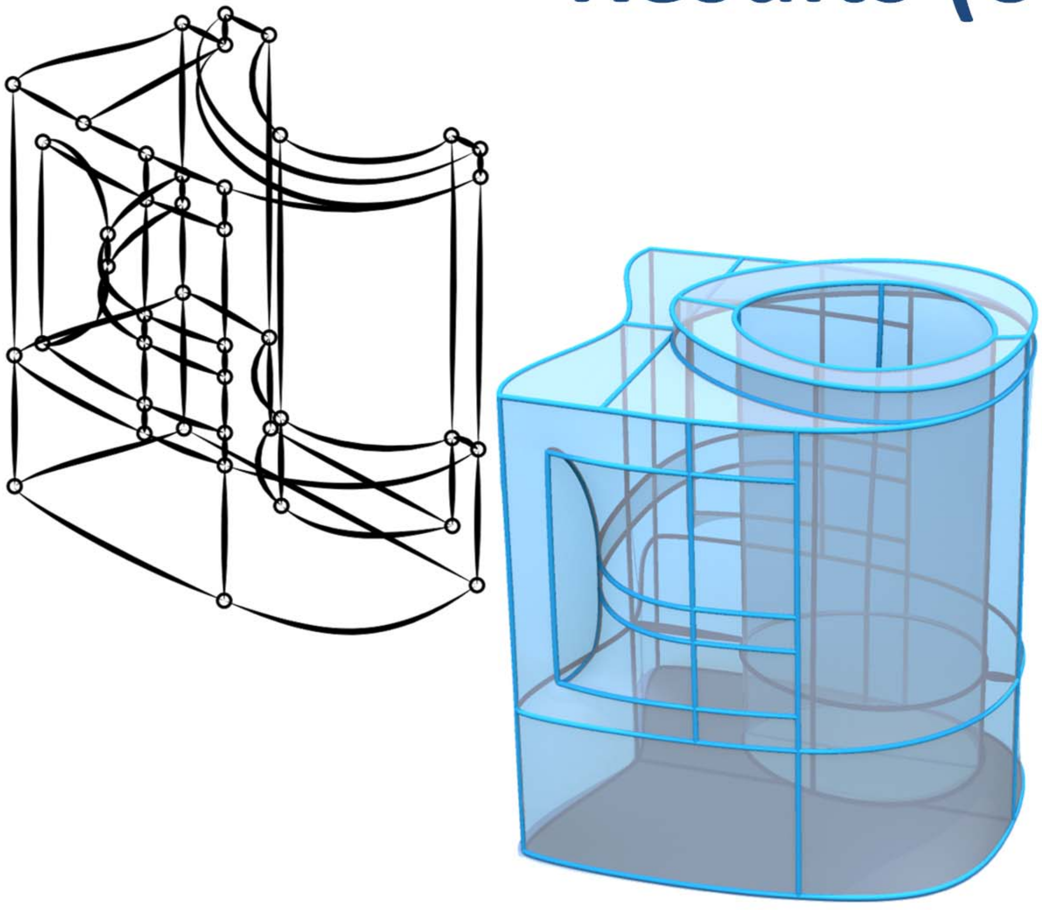
Input curves

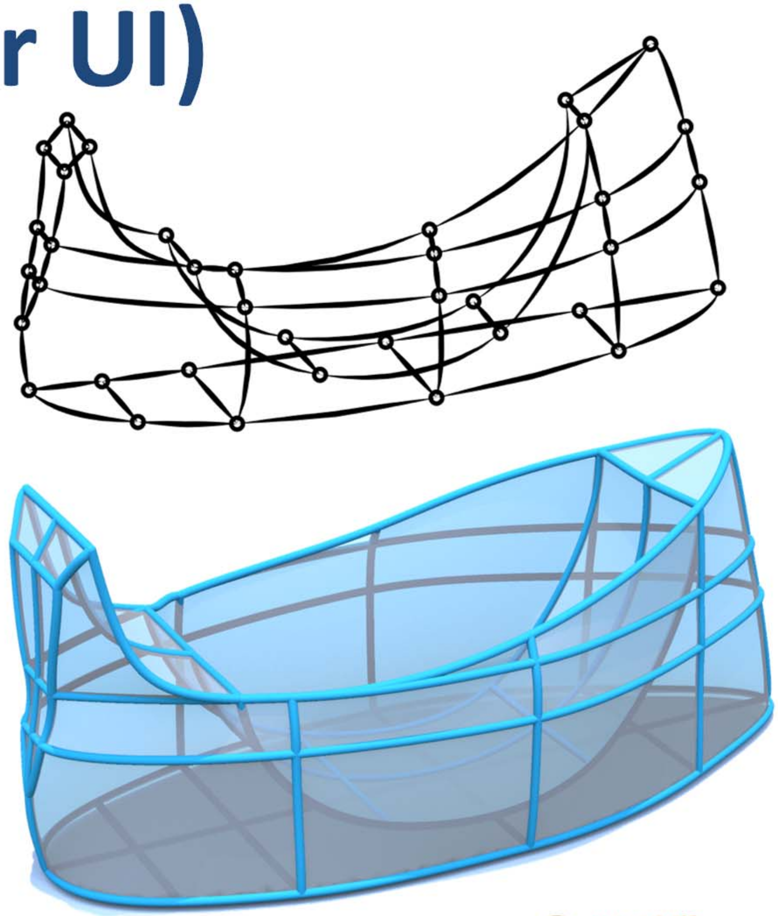


3D Reconstruction

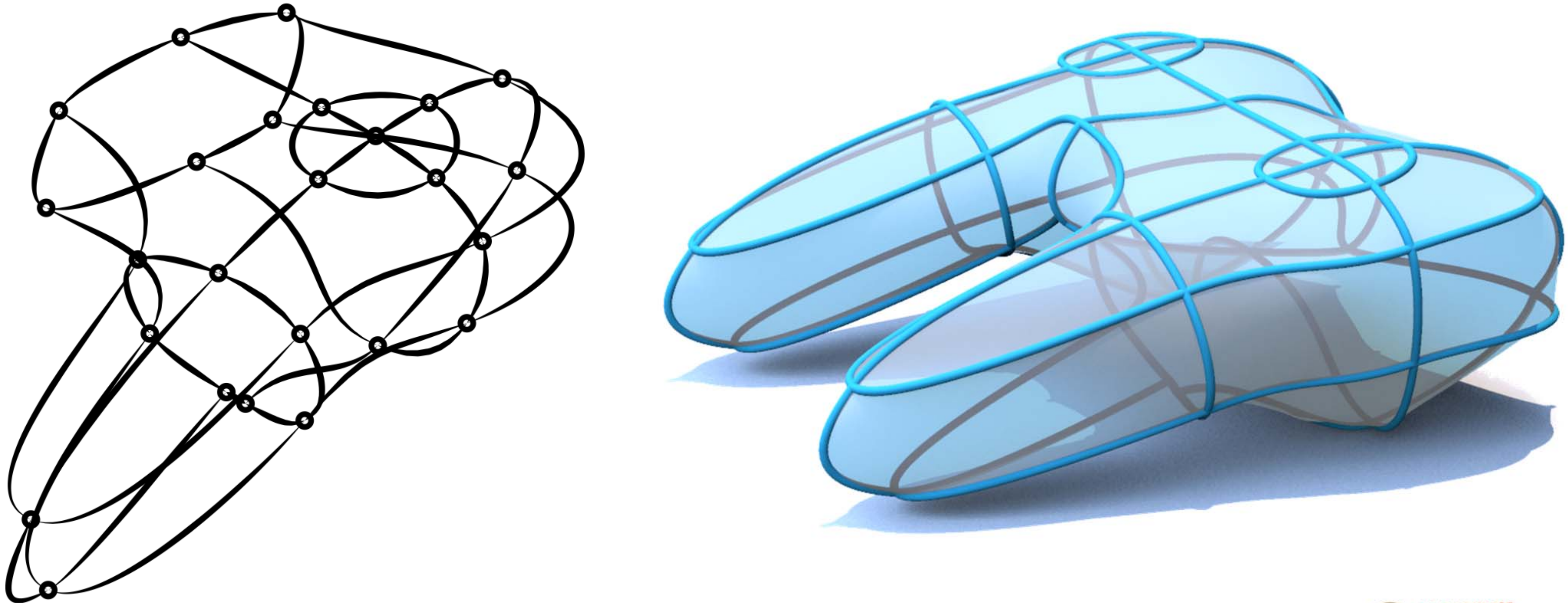
...workflow

Results (our UI)

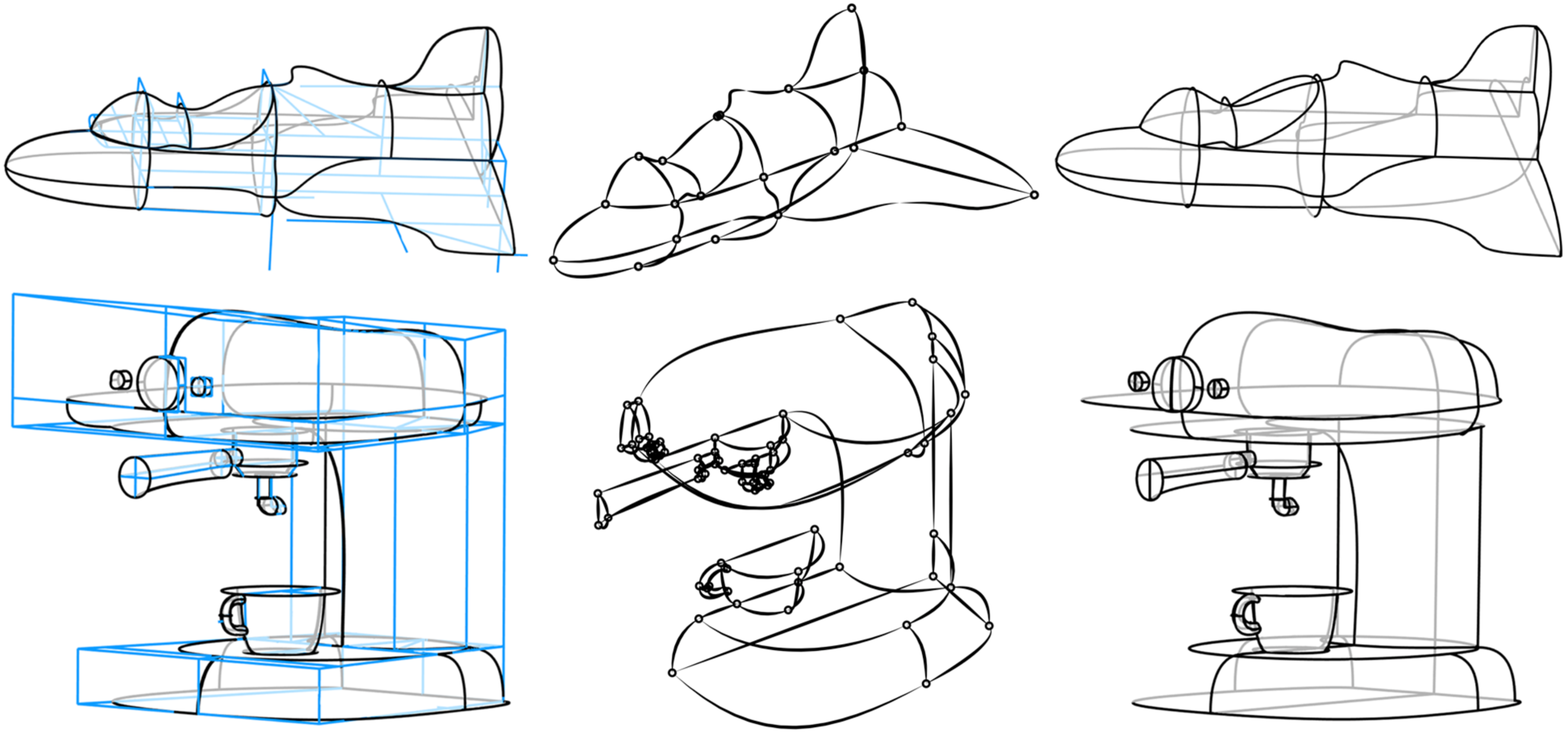




Results (drawn with out UI)



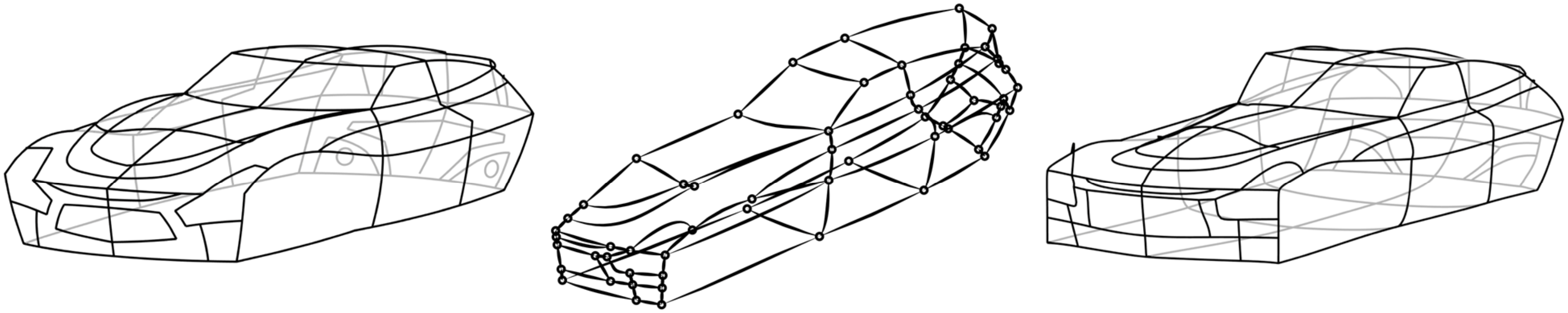
Comparison to annotation *[Schmidt'09]*



(a) 3D scaffolds model (b) Traced-over curves (b) Our reconstruction

Comparison with multi-view framework

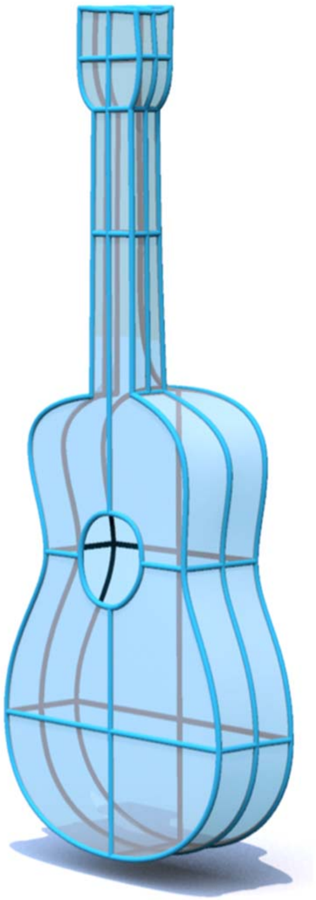
[Bae et al. 2008]



(a) ILoveSketch model (b) Traced-over curves (c) Our reconstruction

Conclusion

- Designers use descriptive curves to convey 3D information & trigger perceptual cues that aid viewers in inferring complex shapes
- True2Form mimics this 3D shape inference by:
  - formulation of fidelity principles and regularity properties
  - progressive detection of regularity cues
- Reconstructs complex 3D shapes from single sketch



Thank you!