Industrial motivations: Conceptual Automotive Styling Tools (CAST)

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Conceptual modeling

- What is conceptual modeling?

  The transformation a mental design concept into a digital object, that is easy to refine and reuse.
Conceptual modeling

• Why is it important?

Humans have an audio IN and OUT, a video IN but no explicit video OUT!
Agenda

• Desirable properties of a conceptual modeler.

• What makes automotive design unique.

• Existing modeling trends.

• A proposed workflow for conceptual automotive design.
Conceptual design desirables

• Abstraction from underlying surface math.

• Invite creative exploration.

• Allow for precision and constraints.

• Workflow mimics traditional design media.

• Leverages domain expertise.

• Intuitive and interactive.
What makes automotive design unique?

- Is free-form and exploratory.
- Smooth shapes: $C^2$ continuity.
What makes automotive design unique?

- Embodies geometric, surface and style constraints.
What makes automotive design unique?

- Character or flow lines captured intrinsically.
What makes automotive design unique?

- Flexible re-use of legacy data.
What makes automotive design unique?

- Interfaces digital and physical modeling.
What makes automotive design unique?

• Well developed design paradigms rooted in physical media.
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- Smooth shapes: $C^2$ continuity.
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- Well developed design paradigms rooted in physical media.
Object Representations: parametric patches

- **Advantages**
  - Smoothness.
  - Precision (Analytic shapes).
  - Curves (Character, flow lines).

- **Limitations**
  - Patches get in the way (Patch layout, trims).
  - Smoothness across patch boundaries.
  - Editing paradigms are restricted by topology.
Existing Paradigms: points and meshes

• Advantages
  • Smooth dense meshes are now feasible.
  • Few restrictions on topology.
  • More flexible editing paradigms possible.
  • Conversion to and from physical data is easy.

• Limitations
  • Points and Meshes are not intrinsically “smooth”.
  • Too free (no analytic shapes).
  • No concept of curves or character lines.
An automotive designers toolbox

- Ideas.
- Sketches.
- Clay/foam.
- Engineering Criteria.
- Sweeps.
- Steels.
- Paint box.

- What's missing? **A refinable digital 3D model.**
An automotive design workflow proposal

Parameterized shapes

Sketches

Small clay model (1/24-1/8)

Engineering criteria

Rough digital model from parametric shapes, digitized clay, feature lines or sketches. Character lines can be edited for stylistic change.

Refined digital model using a palette of refinement tools as shown. Iterations converge to a final design.

digital sculpting tools

analytic feature sculpting
cut and paste

NC Milling

Evaluation design fidelity checks

Refined digital model

Model presentation with photorealism using interactive large-scale display devices.

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Rough digital model Input

- Design collateral (sketches, clay, parameteric models).
- Feature lines.
- Engineering and stylistic constraints.

**CHALLENGE:** Co-locating and registering salient design content within a common 3D space.
Rough digital model
Digital model refinement tools

- Constraint preserving global deformations.
- Cut and paste.
- Feature based editing.
- Local deformations.
Modeling interfaces

- Tape Drawing.
- ShapeTape.
- Steels, Sweeps.
- Pen, puck and tablet.
- Haptic sculpting.
- 3D scanning and printing.
Modeling interfaces

- Tape Drawing.

(a) Physical tape  (b) Digital tape
Modeling interfaces

- ShapeTape.
- Steels, Sweeps.
Modeling interfaces

- Steels, Sweeps.
- Pen, puck and tablet.

Physical sweep  
Digital sweep
Modeling interfaces

- Haptic sculpting.
Modeling interfaces

- Motion Capture.
Modeling interfaces

• 3D scanning and printing.
Putting it together

Physical shape modeling

3D interaction devices (shapeTape)

Mathematical shape representations

Digital modeling (Teddy, sweepers)

Global warps (stretching)

Local space edits (sculpting)

Cut, paste/ Laplacian editing
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