Perception, Drawing and Interactive Modeling

Karan Singh

Dynamic Graphics Project
University of Toronto
www.dgp.toronto.edu
Humans have an audio IN and OUT, a video IN but no explicit video OUT!

Sketchpad (Ivan Sutherland 1963)
video IN: Projection & Perception
video IN: Projection & Perception
video OUT: Sketching & Sculpting

Most children between the ages of about 9-11 have a passion for realistic drawing. 
...many adolescents say, “This is terrible! I have no talent for art. I’m not doing it anymore.”

...regardless, we all mould, gesture and doodle!
Concept Modeling

The transformation of a creative vision into a digital 3D model, that is easy to refine and reuse.
Concept Modeling comes after Ideation
History of sketching tools

Sketchpad [Sutherland 1963]

SKETCH [Zeleznik et al 1996]

Teddy [Igarashi et al 1999]

ILoveSketch [Bae et al 2008]
evolution of the espressoman...

- I❤️Sketch.
- 3D Analytic Drawing.

- 3D Curve network surfacing.

- Slices, FlatFab: planar sections.
- CrossShade.
- True2Form.

- MeshMixer.
I❤SKETCH: multi-view sketching

[Bae, Balakrishnan & Singh, ILoveSketch: As-natural-as-possible sketching system for creating 3D curve models. ACM UIST 2008]
Sketching performance & perception
Humans have an audio IN and OUT, **biased** video IN but no explicit video OUT!
Modeling Perceptual Bias

Experts and drawing systems
Analytic Drawing: single-view sketching

[Schmidt, Khan, Singh, Kurtenbach, Analytic drawing of 3D scaffolds. SIGGRAPH Asia 2009]  
www.dgp.toronto.edu/~rms/pubs/DrawingSGA09.html
Analytic Drawing: inference engine

- Scaffold constraints: position, direction, length.
- 3D curve *fitness*: snapping, geometric priors.

Redundancy resolves ambiguity.
evolution of the espressoman...

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- MeshMixer.
Curve network surfacing

Determine cycles
Patch cycles
Determine cycles: topology + geometry
[Sadri & Singh, Flow Complex based shape reconstruction from 3D curves. SIGGRAPH 2014]
Patch cycles: Coons Patch

\[ \text{interpolate}(b_0, b_2) \]

\[ \text{interpolate}(b_1, b_3) \]

bilinear interpolation
Patch cycles: design quadrangulation

[Bessmeltsev, Wang, Sheffer, Singh, Design-Driven Quadrangulation of Closed 3D Curves. SIGGRAPH Asia 2012]
Patch cycles: How do designers work?

- Cycles represent **flow-lines**
  ...smooth, low variation curves aligned with creases and curvature lines.
- Curve segment pairs like river banks define flow-lines.

- Crossing flow-line families form quads.

**Problem: segment+match**
Patch cycles: Stable matching

- matching cost = bridge curvature + segment shape.
- Interleave segmentation and matching.
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How important are non-planar curves?
Slices: problem statement

Compute a recognizable abstraction of a 3D model using a minimal set of planar sections.

Slices: Human creation => Algorithm => Human recognition

• Humans consistently selected a small set of planar sections, strongly correlated with geometric shape features.
  18 humans, 19 models, avg. 4.77 planes.

• Problem reposed as min planar section cover of shape features.

• Recognition: mesh/human/algorithm (rate >90%, response < 2s).
  PCA (rate=57%) random (rate=38%) (response > 4s).
Slices
FlatFab: interactive slices

[McCrae, Umetani, Singh, FlatFitFab: Interactive Modeling with Planar Sections. ACM UIST 2014]
http://www.flatfab.com
FlatFab: design principles

• Design collateral ...3D objects, 2D images.
• Shape Regularity.
• Near frontoparallel views.
• Single view interface.
FlatFab
CrossShade: special planar curves?
CrossShade: special planar curves?

CrossShade: design analysis

“Cross-sections on a surface explain or emphasize its curvature.”

“...bend or transform the object’s surface.”
CrossShade: perceptual study

Viewers are *persistent, consistent* and *accurate* in X-hair perception.
CrossShade: defining cross-hairs

Plane Orthogonality

Local curvature lines

Local Geodesics

Minimal Foreshortening

Orientation
CrossShade: Algorithm
CrossShade: Algorithm

- Compute X-section planes, X-hair normals: *use 5 properties.*
CrossShade: Algorithm

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- Propagate normals along X-section curves: *minimize twist.*
CrossShade: Algorithm

- Compute X-section planes, X-hair normals: \textit{use 5 properties.}
- Propagate normals along X-section curves: \textit{minimize twist.}
- Propagate normals into interior regions: \textit{Coons interpolation.}
CrossShade: Algorithm

- Compute X-section planes, X-hair normals: *use 5 properties.*
- Propagate normals along X-section curves: *minimize twist.*
- Propagate normals into interior regions: *Coons interpolation.*
- Shade!
CrossShade: Results
True2Form

[Xu, Chang, Bousseau, McCrae, Sheffer, Singh, True2Form: 3D curve networks from 2D sketches via selective regularization. SIGGRAPH 2014]
True2Form: fidelity and regularity
True2Form: Sketch Fidelity

- Projection accuracy
- Minimal variation
- Minimal foreshortening
True2Form: Shape Regularity

- Parallel
- Orthogonal
- Symmetry
- Curve Planarity
True2Form: perceptual validation

- Humans consistently perceive 3D parallelism, symmetry, orthogonality, linearity and planarity cues in 2D sketches.
- Human perception matches our algorithm, when consistent.
True2Form vs. Analytic Drawing

(a) 3D scaffolds model
(b) Traced-over curves
(b) Our reconstruction
True2Form vs. ILoveSketch

(a) ILoveSketch model  (b) Traced-over curves  (c) Our reconstruction
True2Form: results
Conceptual Design

The transformation of a creative vision into a digital 3D model, that is easy to refine and reuse.
MeshMixer

[Schmidt, Singh, MeshMixer SIGGRAPH 2010 talks]
www.meshmixer.com (acquired by Autodesk Inc.)
[Takayama, Schmidt, Singh, Igarashi, Boubekeur, Sorkine, GeoBrush: interactive mesh geometry cloning. Eurographics 2011]
Parametric boundary based deformation
Key Messages

• Centuries of visual experience captured in artistic practice.

• We have no VIDEO OUT and a biased VIDEO IN.

• Regularization: priors, procedural, constraints.

• Principled approaches to art+perception focused design:
  • Understand artistic and perceptual insights.
  • Model or statistically fit artist and viewer data.
  • Leave user ultimate creative control.
  • Validate results perceptually.

• Better tools = Better VIDEO OUT
  Better tools !≠ Better content
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