ScaffoldSketch
Accurate Industrial Design Drawing in VR

Xue Yu, George Mason University
Stephen DiVerdi, Adobe Research
Akshay Sharma, Virginia Tech, Iowa State University
Yotam Gingold, George Mason University
Drawing in VR is direct yet inaccurate
Drawing in VR is direct yet inaccurate
Related Work: 3D Drawing Accuracy

[Arora, Kazi, Anderson, Grossman, Singh, and Fitzmaurice 2017]  [Machuca, Stuerzliger, and Asente 2019]
Product designers draw accurately in 2D with scaffolds
Product designers draw accurately in 2D with scaffolds
Related Work: Interpreting Scaffolds

[Schmidt, Khan, Singh, and Kurtenbach 2009]

[Kim, An, Singh, Lee, and Bae 2018]

[Gryaditskaya, Sypesteyn, Hoftijzer, Pont, Durand, and Bousseau 2019]
Drawing scaffolds in VR doesn’t solve accuracy

2x speed
Drawing scaffolds in VR doesn’t solve accuracy

2x speed
There is enough structure in scaffold and shape strokes to auto-correct

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Scaffolds are straight lines with special relationships

- Attach at endpoints
- Parallel
- Perpendicular
- Same Length
Scaffolds are straight lines with special relationships

- Attach at endpoints
- Parallel
- Perpendicular
- Same Length
Auto-Correcting Scaffolds
Auto-Correcting Scaffolds
Auto-Correcting Scaffolds

Coincident endpoints?
Auto-Correcting Scaffolds

Perpendicular?
Same length?

Coincident endpoints?
Auto-Correcting Scaffolds

Coincident endpoints?

- Perpendicular? Same length?
- Parallel? Same length?
Auto-Correcting Scaffolds

- Relationships may conflict with each other.
Auto-Correcting Scaffolds

• Relationships may conflict with each other.
• Previous attempts to resolve conflicts often use heuristics or don’t satisfy any.
Auto-Correcting Scaffolds

- Relationships may conflict with each other.
- Previous attempts to resolve conflicts often use heuristics or don’t satisfy any.
- We resolve with an iteratively re-weighted least squares scheme.
Shape strokes attach to scaffolds
Shape strokes attach to scaffolds
Same scaffold, different shape strokes

2x speed
Same scaffold, different shape strokes

2x speed
Space curves
Space curves
Tick marks

2x speed
Tick marks

2x speed
Auto-Correcting Shapes
Auto-Correcting Shapes
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Auto-Correcting Shapes
Auto-Correcting Shapes
Example

Scaffolds

User Input
Example

User Input

Auto-Corrected
Example

Scaffolds

User Input

Auto-Corrected

Shape Strokes

User Input
Example

Scaffolds

User Input  Auto-Corrected

Shape Strokes

User Input  Auto-Corrected
User Study

Without Auto-Correct

With Auto-Correct
Limitations and Future Work
Limitations and Future Work
Limitations and Future Work
Conclusion

- ScaffoldSketch…
  - … enables precise 3D curve drawing by decomposing auto-correct into scaffold and shape stages.
  - … lets people transfer industrial design drawing skills into 3D.
  - … resolves conflicting constraints with an iterative re-weighting scheme.
Thank you
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