

Touch'n'Draw: Rapid 3D Sketching with Fluent Bimanual Coordination

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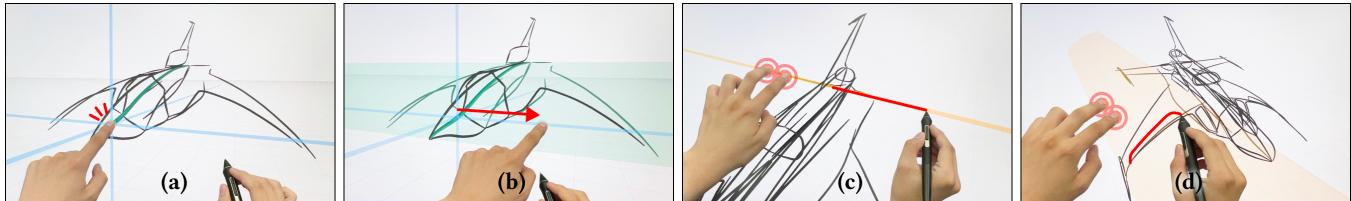


Figure 1: In our novel 3D sketching system, the user can (a) tap a curve to create auxiliary lines and (b) drag a curve along an auxiliary line to create a sketch surface. The user can either (c) hold an auxiliary line and draw a line along it or (d) hold a sketch surface and draw a curve on it.

ABSTRACT

In perspective drawing, designers express 3D shapes by drawing auxiliary lines that construct surfaces and drawing design curves on them. However, drawing auxiliary lines can be challenging, and too many of them can make the drawing difficult to understand. To address these issues, we present a novel 3D sketching system that allows the user to quickly and easily create instant auxiliary lines and instant sketch surfaces for drawing desired 3D curves with fluent bimanual touch and pen interactions. We produced a concept sketch using our system to showcase its potential usefulness.

CCS CONCEPTS

• Human-centered computing → Interaction techniques.

KEYWORDS

3D sketching, bimanual interaction

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1 INTRODUCTION

Perspective drawing enables designers to explore a broad range of 3D shape ideas by drawing auxiliary lines that construct surfaces and drawing the desired 3D curves on them [2, 9]. However, the

auxiliary lines also pose two challenges. First, it can be challenging to repeatedly and accurately draw auxiliary lines, which must pass through specific points, be straight, and converge toward vanishing points that often lie outside the paper. Second, too many auxiliary lines can make it difficult to understand the drawing; they usually become obsolete once the design curves are drawn based on them, but they continue to accumulate.

In this study, we introduce a novel 3D sketching system that allows the user to follow the principles of perspective drawing and create 3D shapes quickly and easily while overcoming the challenges associated with auxiliary lines. In our system, the user instantly creates the desired auxiliary lines from existing curves instead of drawing them manually, and instantly creates the desired surfaces from them. After the user draws the desired 3D curves, the auxiliary lines and surfaces fade and disappear. The user can perform these sequential actions fluently through bimanual touch and pen interactions in a coordinated manner.

Others have attempted to create 3D curves from 2D strokes [1, 3, 5–8, 10, 11]. Some researchers converted a completed 2D drawing into 3D automatically [3, 5, 11]. In contrast, we convert each 2D stroke instantly into a 3D curve during the natural drawing process for controllability. Some researchers inferred 3D curves from 2D strokes based on the role of auxiliary lines in perspective drawing [10]. Similarly, we utilize auxiliary lines, but also address the two challenges associated with auxiliary lines. Some researchers applied a sketch plane [6–8] or a sketch surface [1]. Similarly, we incorporate sketch planes and surfaces, but support a wider variety of sketch surfaces created through bimanual interactions.

2 TOUCH'N'DRAW

We propose a set of bimanual interactions that fluently utilize both touch and pen inputs to draw the desired 3D curves quickly and easily. We designed these interactions following the principle that the non-dominant hand sets the spatial reference of a task before the dominant hand performs it [4].

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The user can tap lines/curves to create auxiliary lines/curves (Tap4Aux) and then drag lines/curves to create sketch surfaces (Drag4Surf). Then, the user can hold the auxiliary lines/curves or sketch surfaces with the non-dominant hand and draw 3D curves with the dominant hand (Hold'n'Draw).

Our auxiliary lines/curves and sketch surfaces have two key characteristics. First, they appear in different forms according to the context in which they are created. Second, they gradually fade and disappear on their own, keeping the drawing neat and clear. Reflecting on these characteristics, we named each *instant auxiliary lines/curves* and *instant sketch surfaces*.

Tap4Aux. When the user taps a point on existing lines/curves with a finger, instant auxiliary lines/curves are created (Figure 2a, 4a, 4d).

Drag4Surf. When the user taps a point on lines/curves and drags it along one of the instant auxiliary lines/curves from the point, an instant sketch surface is created (Figure 3a-b, 3d-e, 4, 5a-b).

Hold'n'Draw. Similar to pressing paper with one hand while drawing a stroke with a pen in the other hand, the user holds an instant auxiliary line/curve and draws a pen stroke along it to create a 3D line/curve snapped to it (Figure 2c, 5c). Also, the user holds an instant sketch surface and draws a pen stroke on it to create a 3D curve projected onto it (Figure 3c, 3f).

Based on these three basic rules, the user can even perform advanced skills of perspective drawing, such as a “2-curve combo” [9] that refers to drawing a 3D curve by intersecting the orthogonal extrusions of its side and top profiles (Figure 5).

3 IMPLEMENTATION

We implemented our system using the Unity 3D game engine and executed it on a Wacom Cintiq Pro 24 Touch tablet, which supports pen and multitouch inputs. We implemented all lines and curves as point curves. We also implemented the auto-mirroring feature to enable the user to draw symmetrical shapes easily.

To showcase all the features of our system, we designed a sci-fi aircraft consisting of a variety of lines and curves, such as straight lines for the tail wings, planar curves for the center profile, curves on extruded surfaces for the main wings, and curves on swept surfaces for the cockpit and fuselage (Figure 1).

4 CONCLUSION & FUTURE WORK

In this study, we introduced instant auxiliary lines/curves and instant sketch surfaces that help the user draw 3D shapes without the challenges posed by auxiliary lines in traditional perspective drawing. To provide a fluent and intuitive way to use them, we designed bimanual interactions Tap4Aux, Drag4Surf, and Hold'n'Draw that utilize touch and pen inputs in a coordinated manner. We confirmed our interactive system's potential to assist with the idea exploration in the early design stages by producing a concept sketch using the system. In future work, we will conduct a user study targeting professional designers to quantitatively and qualitatively evaluate the system's usefulness and usability.

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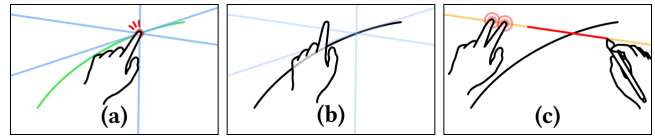


Figure 2: The basic grammar of instant auxiliary lines: (a) Tap a curve to create instant auxiliary lines in the X-Y-Z directions. (b-c) Hold one of them with two fingers before it disappears, and draw a line along it.

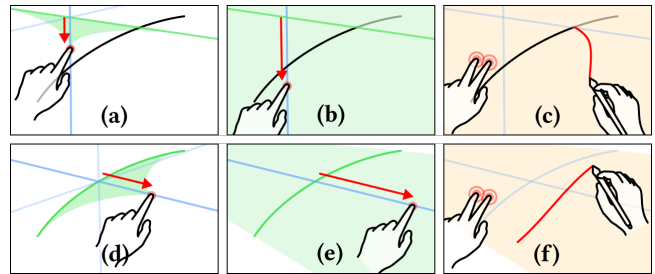


Figure 3: The basic grammar of instant sketch surfaces: (a-b) Tap an instant auxiliary line and drag it along the newly created instant auxiliary line beyond a threshold to create an instant sketch plane. (c) Hold the plane with two fingers and draw a curve on it. (d-f) Similarly, drag a curve along an instant auxiliary line to create an extruded instant sketch surface and draw a curve on it.

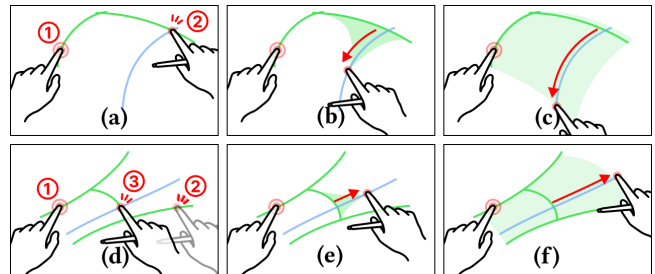


Figure 4: Creating an instant sketch surface: (a) Hold the first curve and tap the second curve to create an instant auxiliary curve with the same shape as the first curve. (b-c) Drag the second curve along the instant auxiliary curve to create a swept instant sketch surface. (d) Holding the first curve, tap the second curve, and then tap the third curve to create an instant auxiliary curve with a shape that interpolates between the first and the second curves. (e-f) Drag the third curve along the instant auxiliary curve to create a swept instant sketch surface.

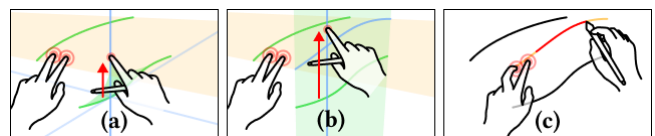


Figure 5: Drawing the intersection curve of two instant sketch surfaces: (a-b) Hold an instant sketch surface with two fingers and create another instant sketch surface to make an instant auxiliary curve corresponding to the intersection of the two surfaces. (c) Hold the instant auxiliary curve with two fingers and draw a curve along it.

REFERENCES

- [1] Seok-Hyung Bae, Ravin Balakrishnan, and Karan Singh. 2008. ILoveSketch: As-natural-as-possible sketching system for creating 3D curve models. In *Proc. UIST '08*. 151–160. <https://doi.org/10.1145/1449715.1449740>
- [2] Koos Eissen and Roselien Steur. 2011. *Sketching: The Basics*. Laurence King Publishing.
- [3] Yulia Gryaditskaya, Felix Hähnlein, Chenxi Liu, Alla Sheffer, and Adrien Bousseau. 2020. Lifting freehand concept sketches into 3D. *ACM Trans. Graph.* 39, 6, Article 167 (2020), 16 pages. <https://doi.org/10.1145/3414685.3417851>
- [4] Yves Guiard. 1987. Asymmetric division of labor in human skilled bimanual action. *J. Mot. Behav.* 19, 4 (1987), 486–517. <https://doi.org/10.1080/00222895.1987.10735426>
- [5] Felix Hähnlein, Yulia Gryaditskaya, Alla Sheffer, and Adrien Bousseau. 2022. Symmetry-driven 3D reconstruction from concept sketches. In *Proc. SIGGRAPH '22*. Article 19, 8 pages. <https://doi.org/10.1145/3528233.3530723>
- [6] Yongkwan Kim, Sang-Gyun An, Joon Hyub Lee, and Seok-Hyung Bae. 2018. Agile 3D sketching with air scaffolding. In *Proc. CHI '18*. Article 238, 12 pages. <https://doi.org/10.1145/3173574.3173812>
- [7] Yongkwan Kim and Seok-Hyung Bae. 2016. SketchingWithHands: 3D sketching handheld products with first-person hand posture. In *Proc. UIST '16*. 797–808. <https://doi.org/10.1145/2984511.2984567>
- [8] Joon Hyub Lee, Hanbit Kim, and Seok-Hyung Bae. 2022. Rapid design of articulated objects. *ACM Trans. Graph.* 41, 4, Article 89 (2022), 8 pages. <https://doi.org/10.1145/3528223.3530092>
- [9] Scott Robertson and Thomas Bertling. 2013. *How to Draw: Drawing and Sketching Objects and Environments from Your Imagination*. Design Studio Press.
- [10] Ryan Schmidt, Azam Khan, Karan Singh, and Gord Kurtenbach. 2009. Analytic drawing of 3D scaffolds. *ACM Trans. Graph.* 28, 5, Article 149 (2009), 10 pages. <https://doi.org/10.1145/1618452.1618495>
- [11] Baoxuan Xu, William Chang, Alla Sheffer, Adrien Bousseau, James McCrae, and Karan Singh. 2014. True2Form: 3D curve networks from 2D sketches via selective regularization. *ACM Trans. Graph.* 33, 4, Article 131 (2014), 13 pages. <https://doi.org/10.1145/2601097.2601128>