Fluid3DGuides: A Technique for Structured 3D Drawing in VR

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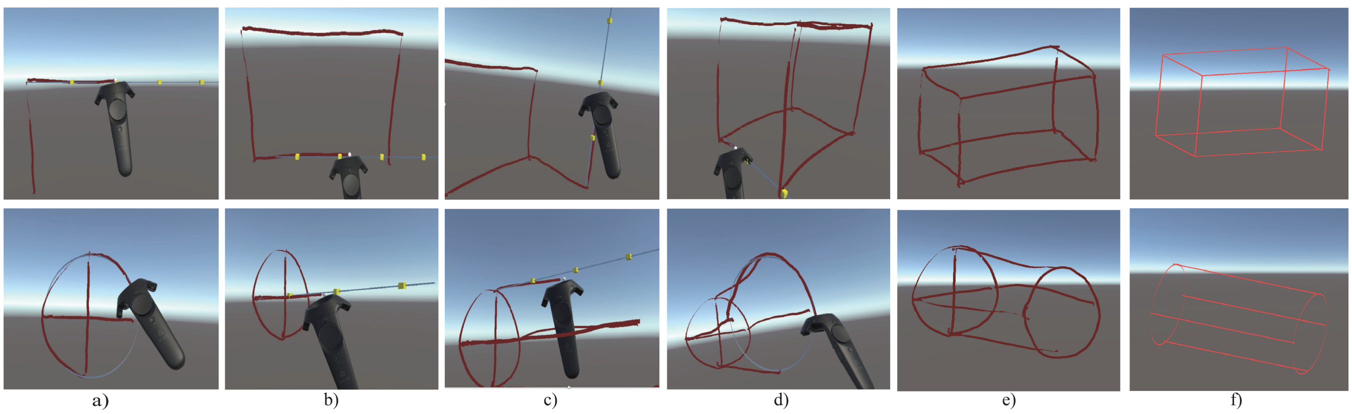

Figure 1: (a) The prototype system mainly includes a six DOF programmable robot arm, an electromagnet, and an Arduino control board. (b) Different markers are attached on a group of different physical objects and the supports for pose tracking. (c) The user can grasp a physical object and put it onto the surface of a virtual base that are rendered in an AR glass. (d) A physical support is absorbed onto the electromagnet to provide physical support for the grasped the physical object on behalf of the colocated virtual base.

ABSTRACT

We propose *Fluid3DGuides*, a drawing guide technique to help users draw structured sketches more accurately in VR. The prototype system continuously infers visual guide lines for the user based on the user's instant stroke drawing intention and its potential constraint relationship with the existing strokes. We evaluated our prototype through a pilot user study with six participants by comparing the proposed guide technique against the non-guide drawing condition. Participants gave positive comments on ease of use and drawing accuracy. They found that the technique could reduce the time and effort required to find the corrected drawing perspective and obtain more accurate 3D structured sketches.

CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**.

KEYWORDS

3D structured sketches, virtual reality, visual guidance

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1 INTRODUCTION

VR 3D sketching has the advantages of intuitiveness and naturalness. Recent studies have confirmed that it is difficult to draw accurate 3D strokes in VR due to the lack of deep perception and physical feedback[1]. Drawing structured sketches is even more challenging due to ensuring the geometric relationship between strokes and strokes. The low precision of 3D sketching makes it difficult for users to accurately express their drawing intentions, which reduces their willingness to use VR drawing tools. Studies have shown that specific visual guidance, such as grids and scaffolding curves, can help users improve depth perception and position strokes more accurately [1]. Compared with fixed visual guides that need to be placed before drawing, real-time inferred drawing guides using context information is a promising technique to reduce the number of interactions. Mayra [4][3] has proposed such drawing guides techniques but have not made full use of the existing strokes information.

We propose *Fluid3DGuides*, a drawing guide technique to improve the drawing accuracy of VR structured sketches. The prototype system continuously recognizes the user's drawing intention, infers its potential constraints based on the existing strokes, and provides a drawing guide.

2 PROTOTYPE

The *Fluid3DGuides* prototype system is developed based on Unity 3D and HTC Vive. Users press the trigger on the Vive controller to start and end a stroke. The pen tip of is set on the top the controller (see Figure 1). The drawing guide technique consists three core techniques: 1) Continues Stroke Recognition, 2) Guide lines Inference, 3) Fluid guide lines Generation.

Continues Stroke Recognition. The system recognizes the geometry type of the strokes currently drawn at equal time intervals (0.25s). A stroke is classified as a straight line or an arc based on the ratio of the distance between its two end points to the stroke length (see Figure 2). We fit the strokes into standard curves using least squares method.

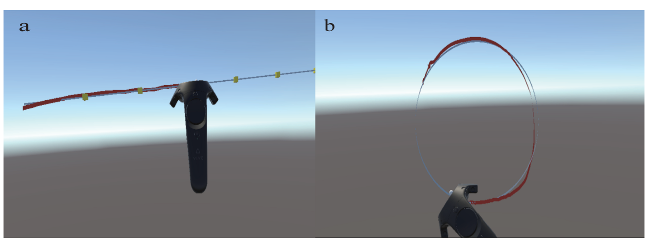

Figure 2: Stroke recognition

Guide lines Inference. Guide lines Inference infers the geometric constraint relationship between the fitted strokes and the existing strokes based on their potential spatial position relationships. In the process of geometric constraint inference, the system checks and compares the parameters of the line and the circle, and considers geometrical relations such as parallel and perpendicular. The inference process adopts the method of priority and refers to the principles of Goldmeier [2] and Gestalt[5]. In this paper, the priority determination considers the distance between strokes and the constraint itself.

Fluid guide lines Generation. The guide lines are automatically generated based on the inference results of the user's intention in the previous part and only depend on the strokes drawn by users without interactive instructions. The system automatically infers and updates the guide lines for every additional 15 user sampling points. The guide lines disappear immediately after the user stops drawing so that the guide lines will not cause visual interference to the subsequent drawing process. In addition, we add small cubes on the guide lines as scale marks to improve length accuracy.

3 EVALUATION

We evaluated our prototype with six participants (P1-P6) through a pilot user study by comparing the proposed guide technique against the baseline non-guide drawing condition. Participants gave positive comments on the role of *Fluid3DGuides*. Most of them (5/6) mentioned that the guided lines could reduce the time and effort required to find the corrected perspective to ensure the correct geometric relationship between strokes. All participants said that the scale marks on the guide lines helped increase strokes' length accuracy. Figure 1 shows two examples of a cuboid shape and a cylindrical shape drawn by P6 using the *Fluid3DGuides* system. It can be seen that the strokes have a good structural relationship. We found that the guide lines' appearance time and update frequency would affect the users' performance and experience. The setting of these parameters should be adjusted by users' habits.

4 CONCLUSION

We propose *Fluid3DGuides*, a drawing guide technique to help users draw structured sketches more accurately. The system automatically infer drawing guide lines based on the current stroke information and its positional relationship with the existing strokes. We conducted a pilot user study to evaluate the role of the proposed guide technique, and participants found the technique helped them draw 3D sketches structural accuracy more easily. In the future, we will quantitatively evaluate the impact of our technique on the accuracy of the sketch structure and the drawing time.

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REFERENCES

[1] Rahul Arora, R. Kazi, F. Anderson, Tovi Grossman, Karan Singh, and G. Fitzmaurice. 2017. Experimental Evaluation of Sketching on Surfaces in VR. *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (2017).
[2] E. Goldmeier. 1982. The Memory Trace: Its Formation and Its Fate.
[3] Mayra Donaji Barrera Machuca, Paul Asente, W. Stuerzlinger, Jingwan Lu, and Byungmoon Kim. 2018. Multiplanes: Assisted Freehand VR Sketching. *Proceedings of the Symposium on Spatial User Interaction* (2018).
[4] Mayra Donaji Barrera Machuca, W. Stuerzlinger, and Paul Asente. 2019. Smart3DGuides: Making Unconstrained Immersive 3D Drawing More Accurate. *25th ACM Symposium on Virtual Reality Software and Technology* (2019).
[5] M. Wertheimer. 1939. A source book of Gestalt psychology. *Journal of Nervous and Mental Disease* (1939).