HYBRID DRAWING SOLUTIONS IN AR: BITMAP-TO-VECTOR TECHNIQUES ON 3D SURFACES

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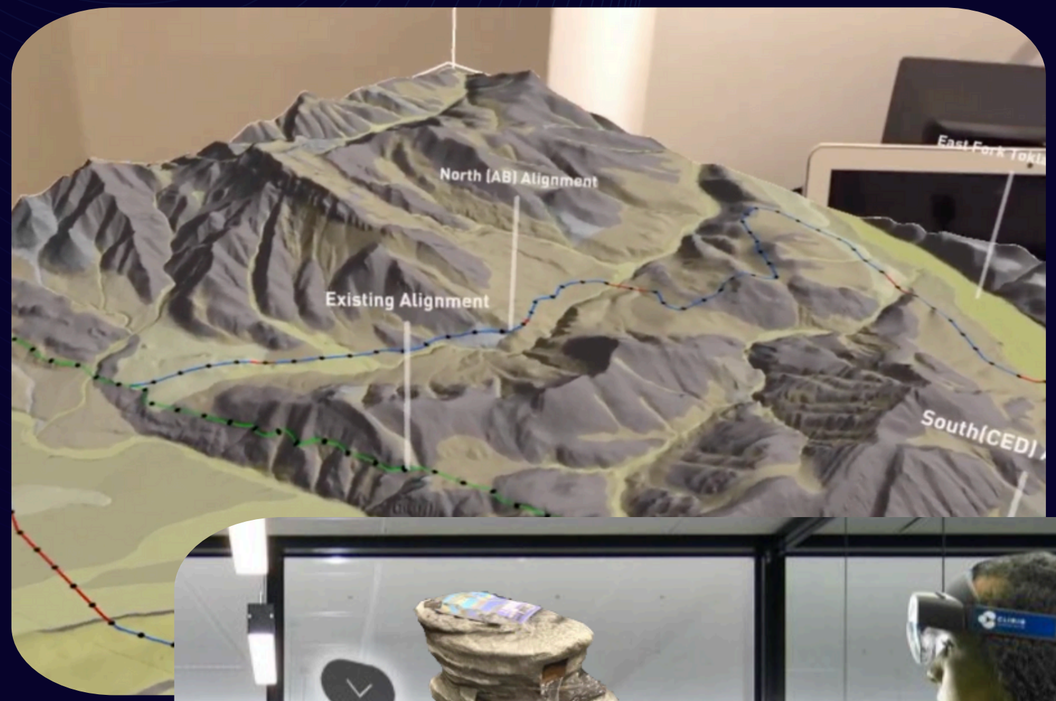
CONTENT

- Introduction & Motivation
- Research Problem & Questions
- Lit.Review & Research Gap
- Research Objective
- System Design
- User Study
- Results
- Future Work



INTRODUCTION & MOTIVATION

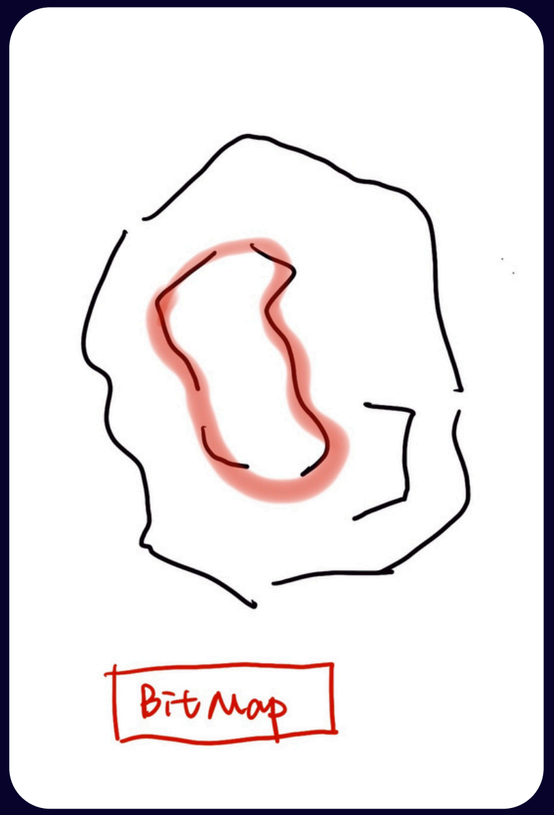
Visualizing complex 3D objects in 2D is limiting, but **AR** provides us with an **immersive environment to observe 3D objects.**

The engineering sector is increasingly shifting from **traditional 2D blueprints to work on 3D models**.

There is a growing need for intuitive **tools** for drawing on 3D models.

RESEARCH PROBLEM & QUESTIONS:

HOW TO ENABLE AR DRAWING ON 3D SURFACES THAT IS QUICK BUT ALSO SCALABLE AND EDITABLE?



WHY BITMAP?

01

Drawing onto the surface in a bitmap way.

Pros:

1. Easy to operate
2. Quick (draw a line use less time)

Cons:

1. become distorted when zoom in

Vectorize the bitmap strokes

02

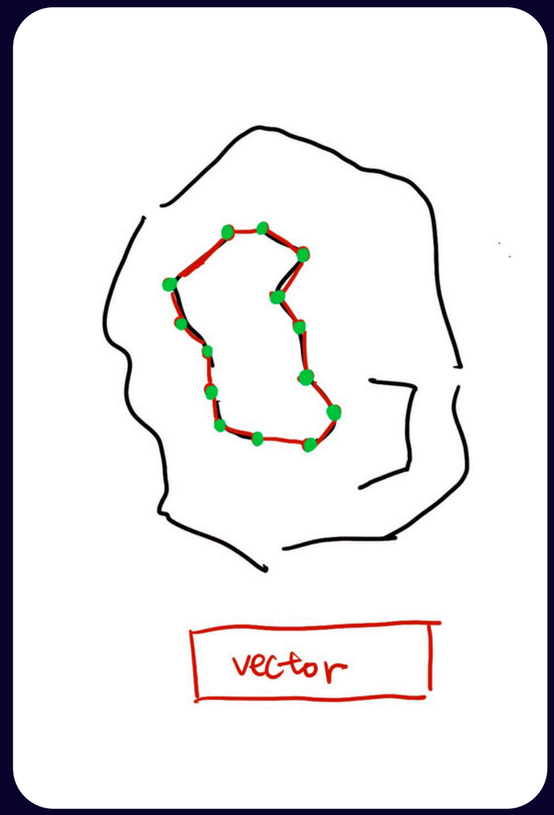
Pros:

1. Minimal data storage requirements.
2. Highly scalable.
3. Vector-based data is easy to edit and widely utilized in the engineering field

Cons:

1. Hard to implement in 3D

WHY VECTOR?



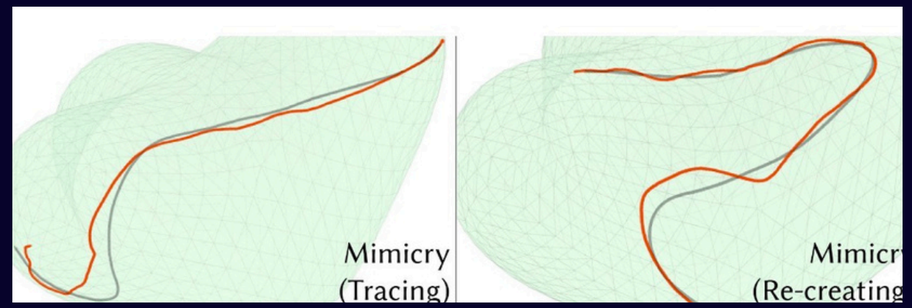
LIT.REVIEW & RESEARCH GAP

01

Mid-Air Drawing of Curves on 3D Surfaces in Virtual Reality - *Rahul Arora, Karan Singh, 2021*

Mimicry Method predicts(trace) and adjusts(re-create) the strokes in real time, make the strokes more precise(anchored raycast technique).

Limitation: relied on a **3D mesh builder** for drawing, which attaches a volumetric block to the surface



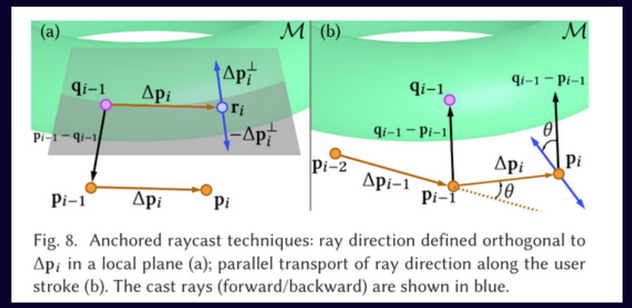
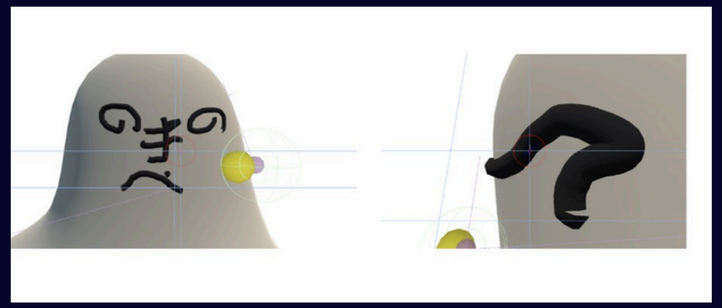


Fig. 8. Anchored raycast techniques: ray direction defined orthogonal to $\Delta\mathbf{p}_i$ in a local plane (a); parallel transport of ray direction along the user stroke (b). The cast rays (forward/backward) are shown in blue.

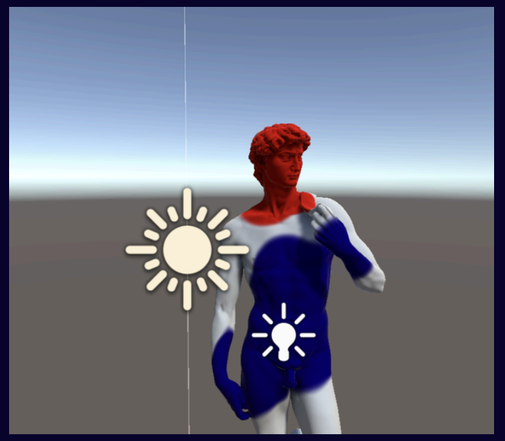


Mid-Air Drawing of Curves on 3D Surfaces in Virtual Reality

02

Mesh Texture painting in Unity Using Shaders - *Shahriar Shahrabi, 2019*

Texture Painting involves creating **separate 2D image files for each layer**, bound to the object's existing texture and material (Mtl) files.



Mesh Texture painting in Unity Using Shaders

LIT.REVIEW & RESEARCH GAP

01

Bare-Handed 3D Drawing in Augmented Reality - *John J. Dudley et al. 2018*

Three interaction techniques:
Freehand, Tapline and GoGo Tapline to support bare-handed drawing in AR.

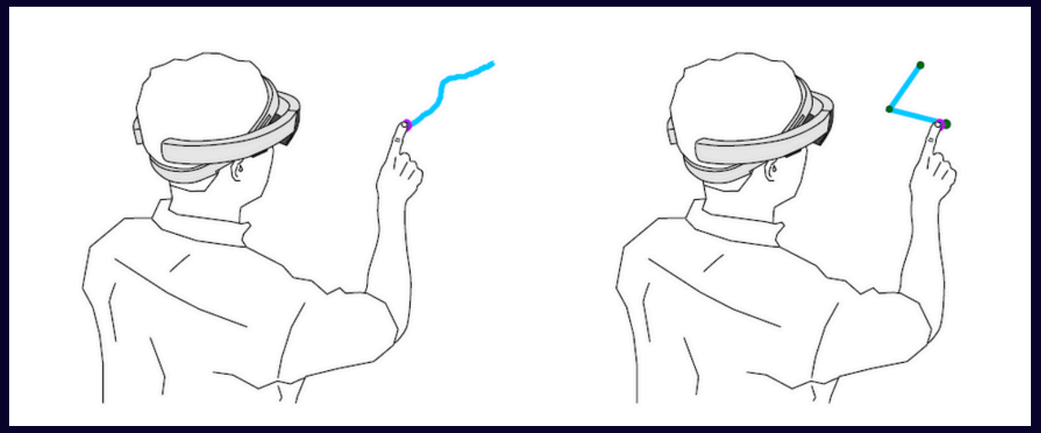
Limitation: presented as **distinct** methods without a unified approach that integrates their respective advantages.

02

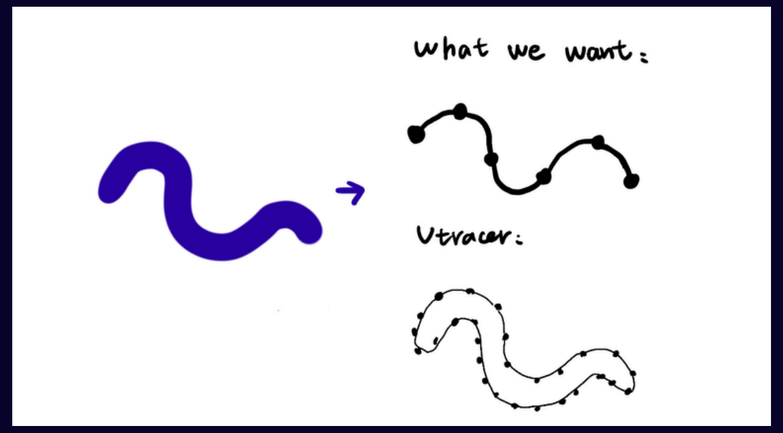
VTracer - *Sanford Pun, 2020*

Three main stages:
1 .Convert pixels into path
2. Simplify the path into polygon
3. Smoothen the polygon, approximate it with a curve-fitter

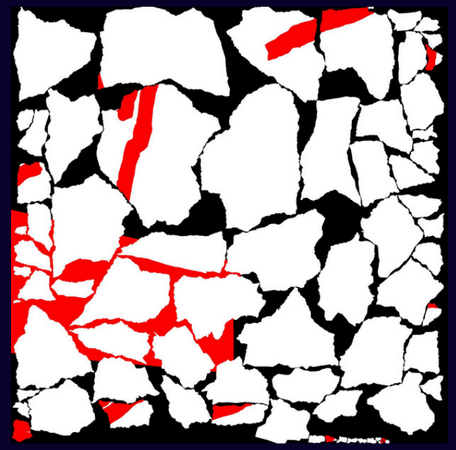
Limitation:
1. Outlines the strokes as images
2. Output 2D SVG Files less suitable for cross-platform use
3. Incompatibility with AR Editing



Bare-Handed 3D Drawing in Augmented Reality(2018)

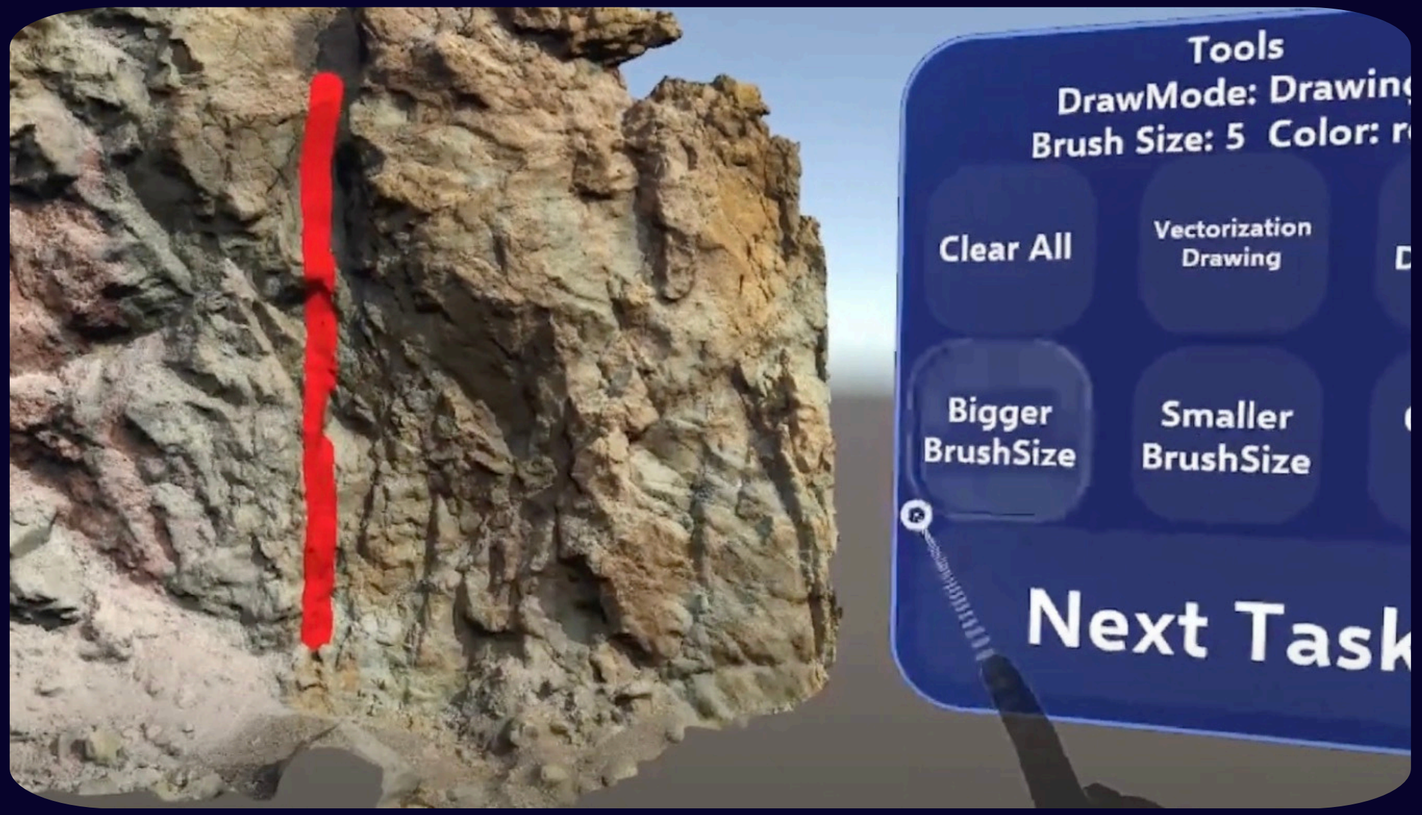


Outlines the strokes as images



Output SVG File

RESEARCH OBJECTIVE:

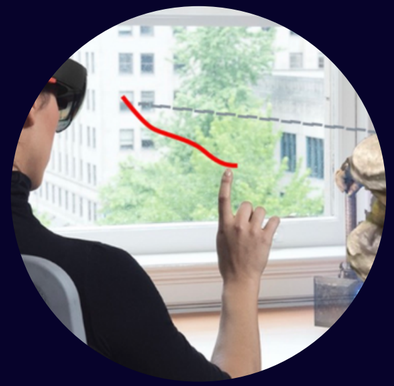


To develop a tool that merges the benefits of bitmap and vector drawing methods. This tool will enable users to draw directly on 3D model surfaces and convert these drawings into vector format.

SYSTEM DESIGN:

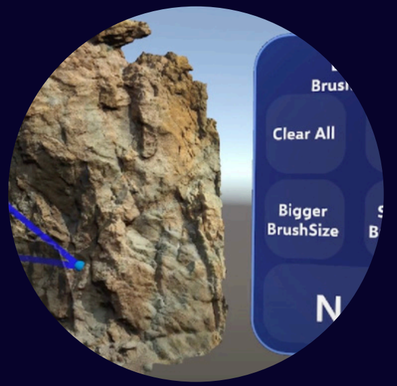
Our Workflow:

Initialization and Setup

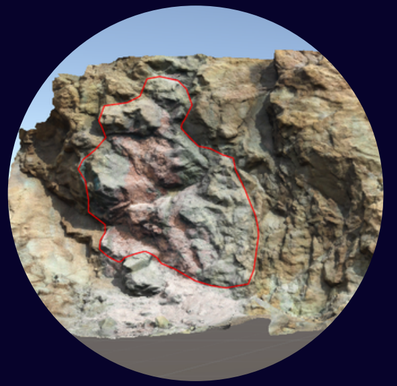


Freehand Drawing

Vectorization



Editing
and Tapline Drawing



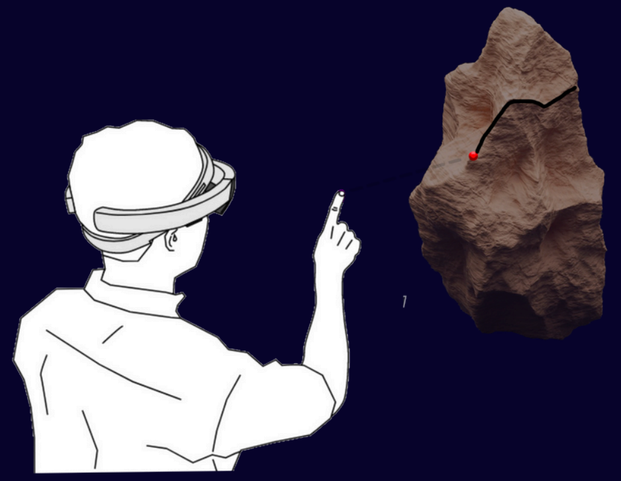
Export

Draw2Vector Workflow

SYSTEM DESIGN:

Freehand drawing(Bitmap)

1. Mimicry: uses a virtual tool that copies the user's hand movements in the air but **adjusts the curve's path** to fit the 3D object's geometry, but it **relies on a 3D mesh builder and will attache a volumetric block to the surface**.
2. Texture Painting: involves **creating separate 2D runtime render targets for each layer,** which are then bound to the object's existing materials.



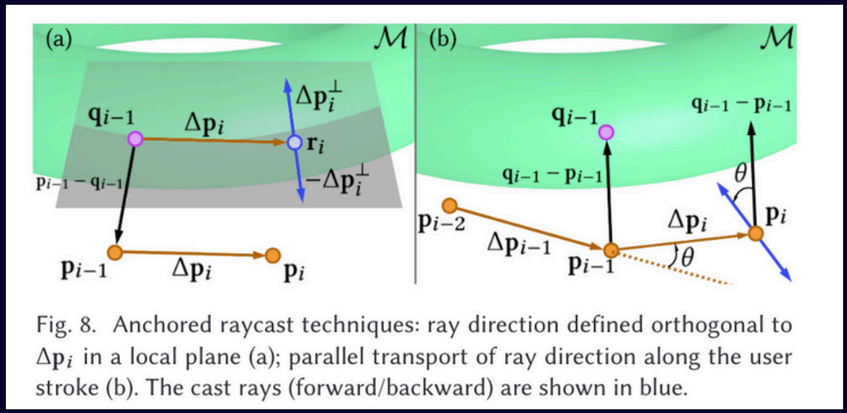
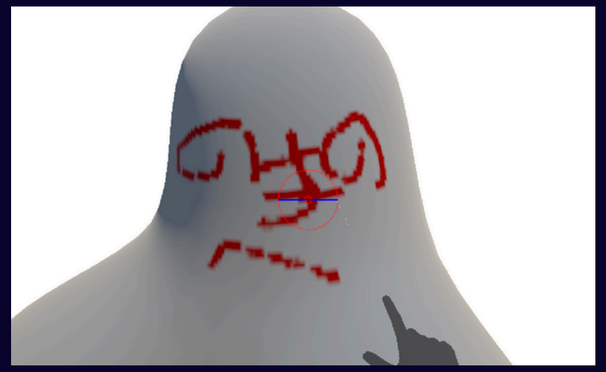
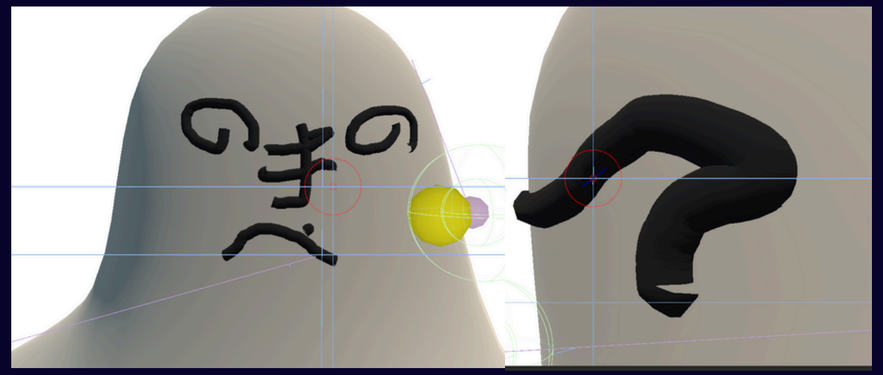


Fig. 8. Anchored raycast techniques: ray direction defined orthogonal to $\Delta\mathbf{p}_i$ in a local plane (a); parallel transport of ray direction along the user stroke (b). The cast rays (forward/backward) are shown in blue.





Texture Painting VS 3D mesh builder in Mimicry

Projection of Stroke Points

Mid-Air Drawing of Curves on 3D Surfaces in Virtual Reality

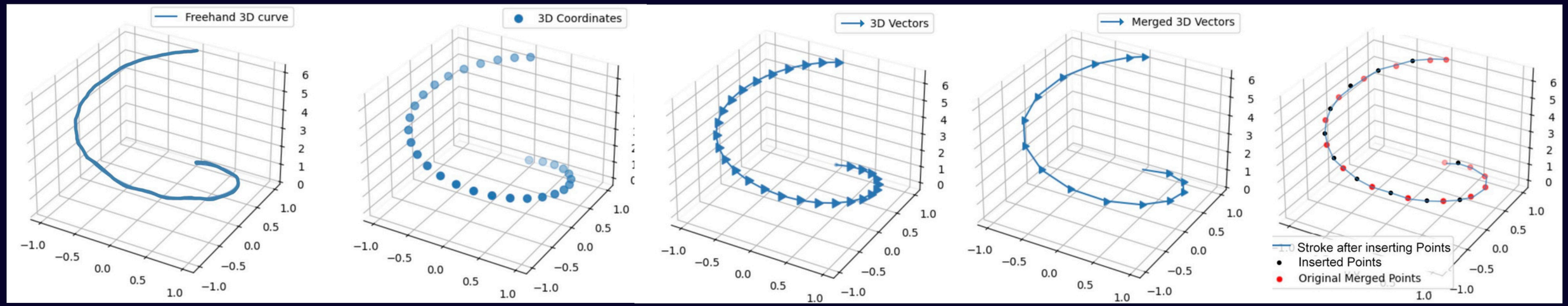
We **utilize key aspects of the mimicry technique to adjust and predict stroke points.** However, instead of a 3D mesh builder, we use **texture painting for stroke rendering,** enhancing the visual representation.

SYSTEM DESIGN:

3D Vectorization Process(Vector)

Using the technique in Vtracer

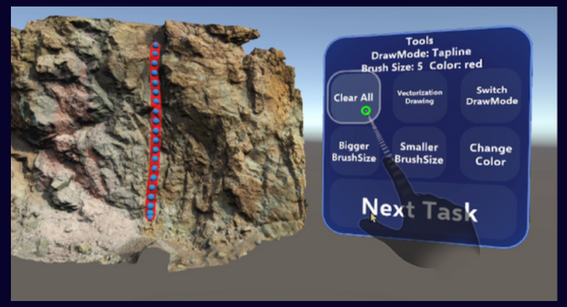
ORIGINAL STATE → TRACKING 3D COORDINATES → JOINING POINTS TO VECTORS → PATH WALKING MEGRE VECTORS → PATH SMOOTHING



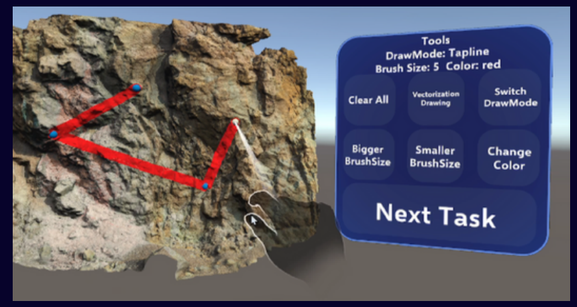
SYSTEM DESIGN:

3D Vectorization Process (Vector)

Freehand Drawing Mode



After Vetorization



Review and Edit

Exprot

What we have done: https://youtu.be/1t9GvbwA8EU

USER STUDY:

PARTICIPANTS:

10 participants (5 female, 5 male), a mean age of 38.75 (SD = 13.34).
The participants were a mix of engineers, who are the actual users of the system, and software developers, who provided valuable feedback on the system's usability and functionality.

USER STUDY:

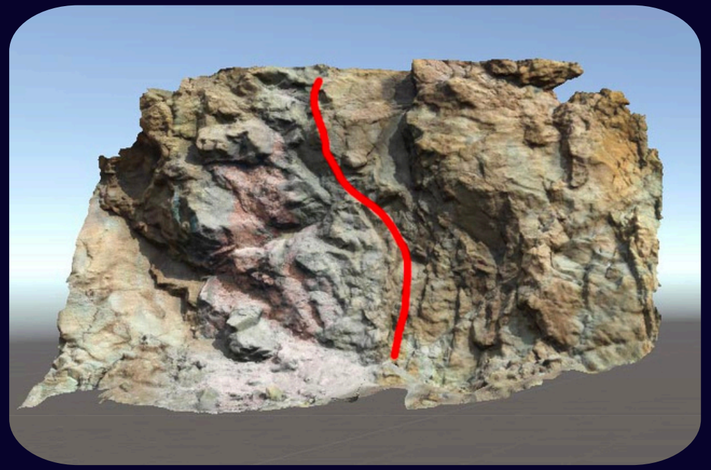
PROCEDURE:

Draw2Vector(our method):

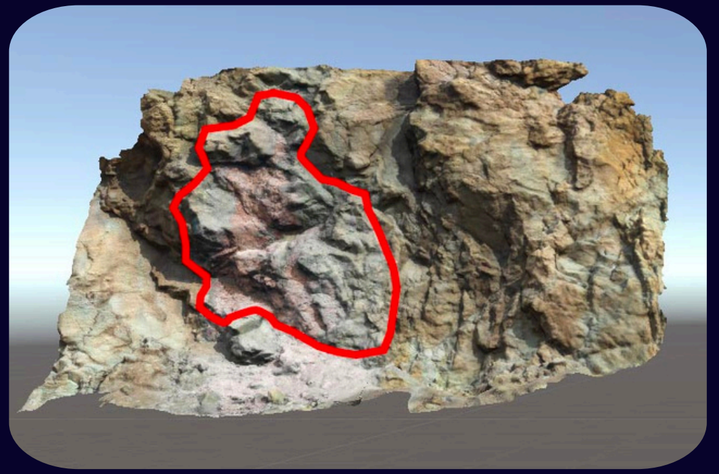
A hybrid approach to drawing that combines **speed, scalability and editability**.

Training and Familiarization Task → • **Draw a Simple Rock Fault Line** • **Outline a Specific Area of Rock** → **Semi Structure User Interview** → **Performance Metrics**

TASK1:
Draw a Simple Rock Fault Line



TASK2:
Outline a Specific Area of Rock



RESULTS : Quantitative Metrics - data from system

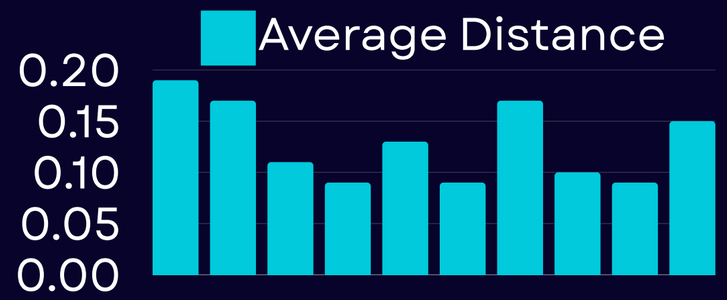
- **Data Size**

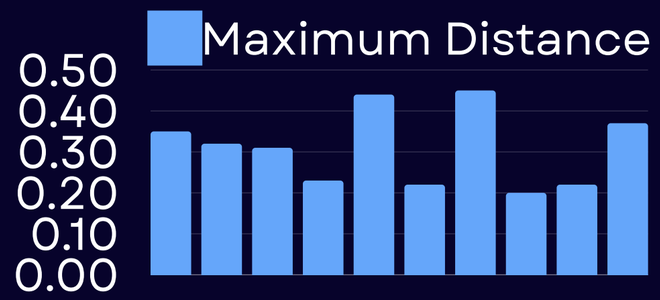
  Reduced by **86.8%** for Task 1 and **85.9%** for Task 2 after vectorization

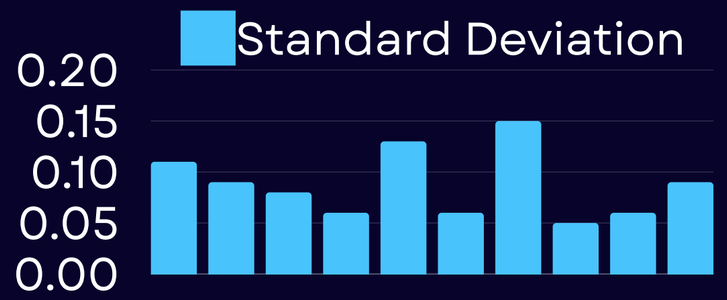
- **Curve Accuracy**

  The model's dimensions are 2m x 1.16m x 0.45m and the diagonal length is 2.36 meters. An average deviation of about 0.1 meters represents approximately **4.24%** of the diagonal length.

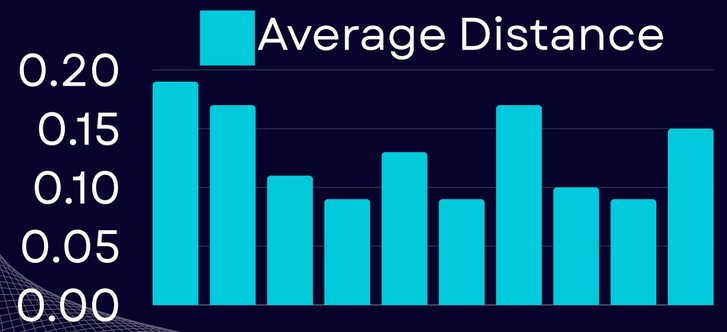
Task1

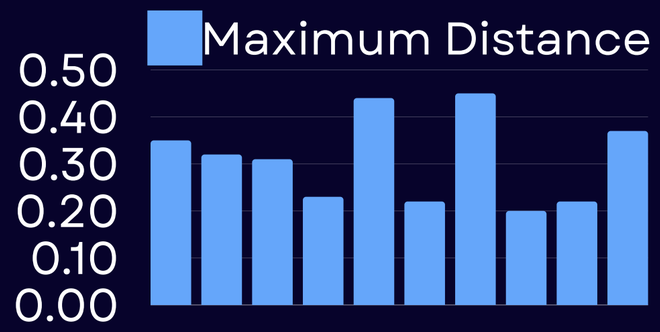


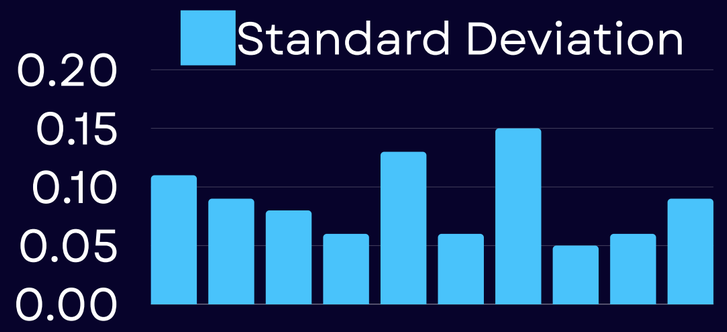




Task2





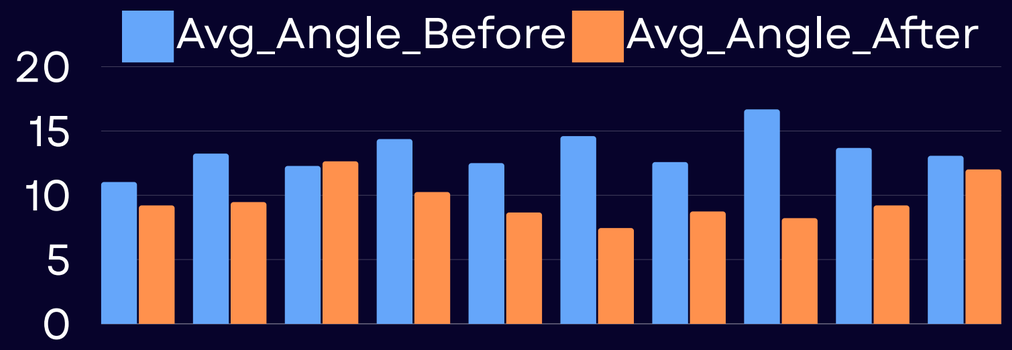


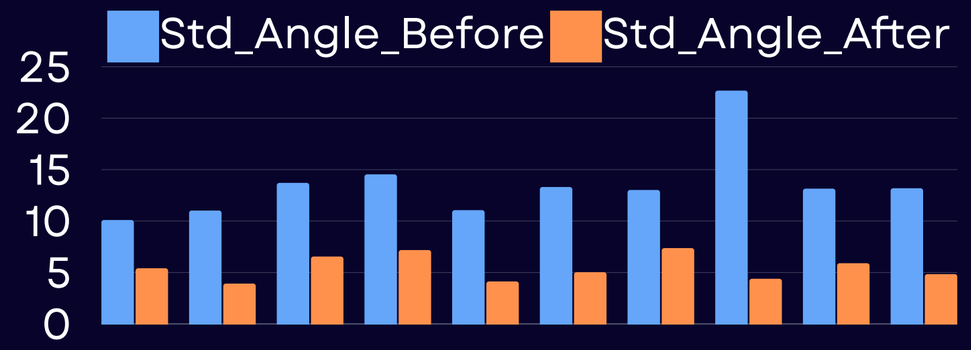
RESULTS : Quantitative Metrics - data from system

- **Curve Smoothness**

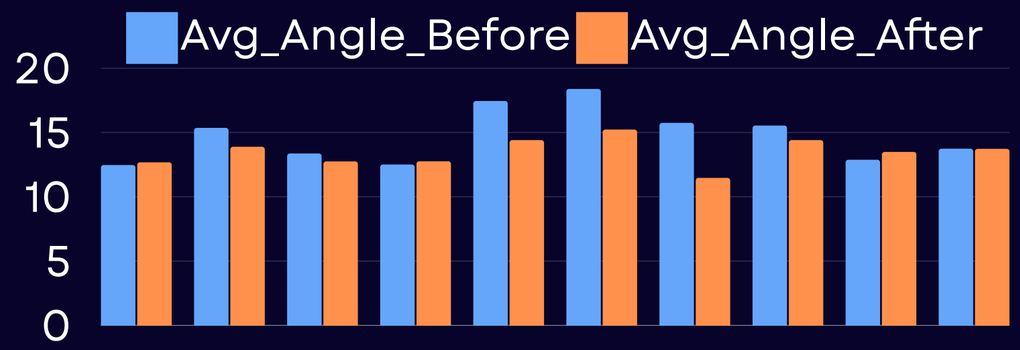
  The average angles between vectors were significantly reduced after vectorization. Task 1 demonstrates a more significant improvement due to its less complex nature compared to Task2.

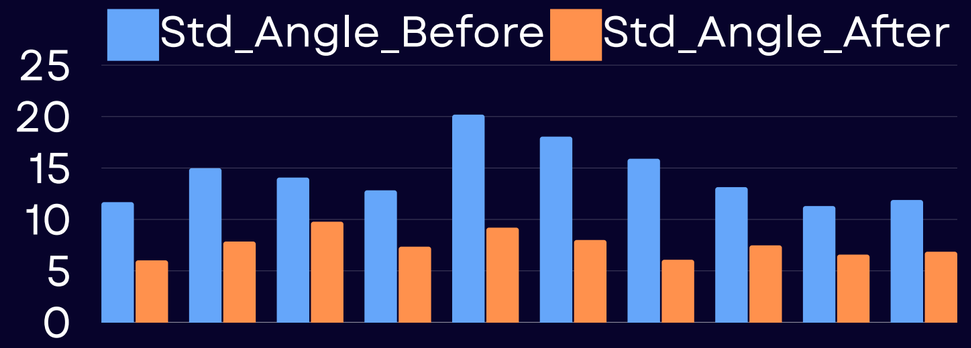
Task1





Task2





RESULTS :

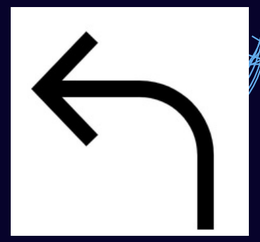
Quantitative Metrics - data from questionaires

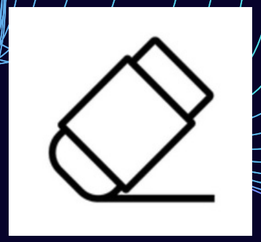
- **Responsiveness**: High scores (**mostly 4 and 5 out of 5**) indicating excellent responsiveness.
- **Editing Features:** High ratings (**ranging from 3 to 5**), suggesting functionality met or exceeded expectations, with room for minor improvements.
- **Details Preserved:** Strong positive feedback, with average scores **above 4.**

Qualitative Metrics - data from questionaires and interview

- **UI Enhancements:** need more colours, improved UI elements like buttons to be easier to understand
- **Feature Enhancements:** better feedback on touch, very likely needs a redo/undo feature, more responsive to pressure
- **Functionality:** add points of the line to reshape

FUTURE WORK:





- Implement editing tools including **"Undo" and "Eraser."**
- Include advanced drawing functionalities such as **annotation** capabilities and **color-filling** features.
- Improve **pressure sensitivity and gesture recognition.**

REFERENCES

1. https://clir.io/
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3. Mesh Texture painting in Unity Using Shaders(2019) https://shahriyarshahrabi.medium.com/mesh-texture-painting-in-unity-using-shaders-8eb7fc31221c
4. Bare-Handed 3D Drawing in Augmented Reality(2018) https://doi.org/10.1145/3196709.3196737
5. Vtracer(2021) https://www.visioncortex.org/vtracer-docs

THANK YOU!