



3D Hermite Curve-based Path Planning on Robot Manipulator for Chinese Calligraphy

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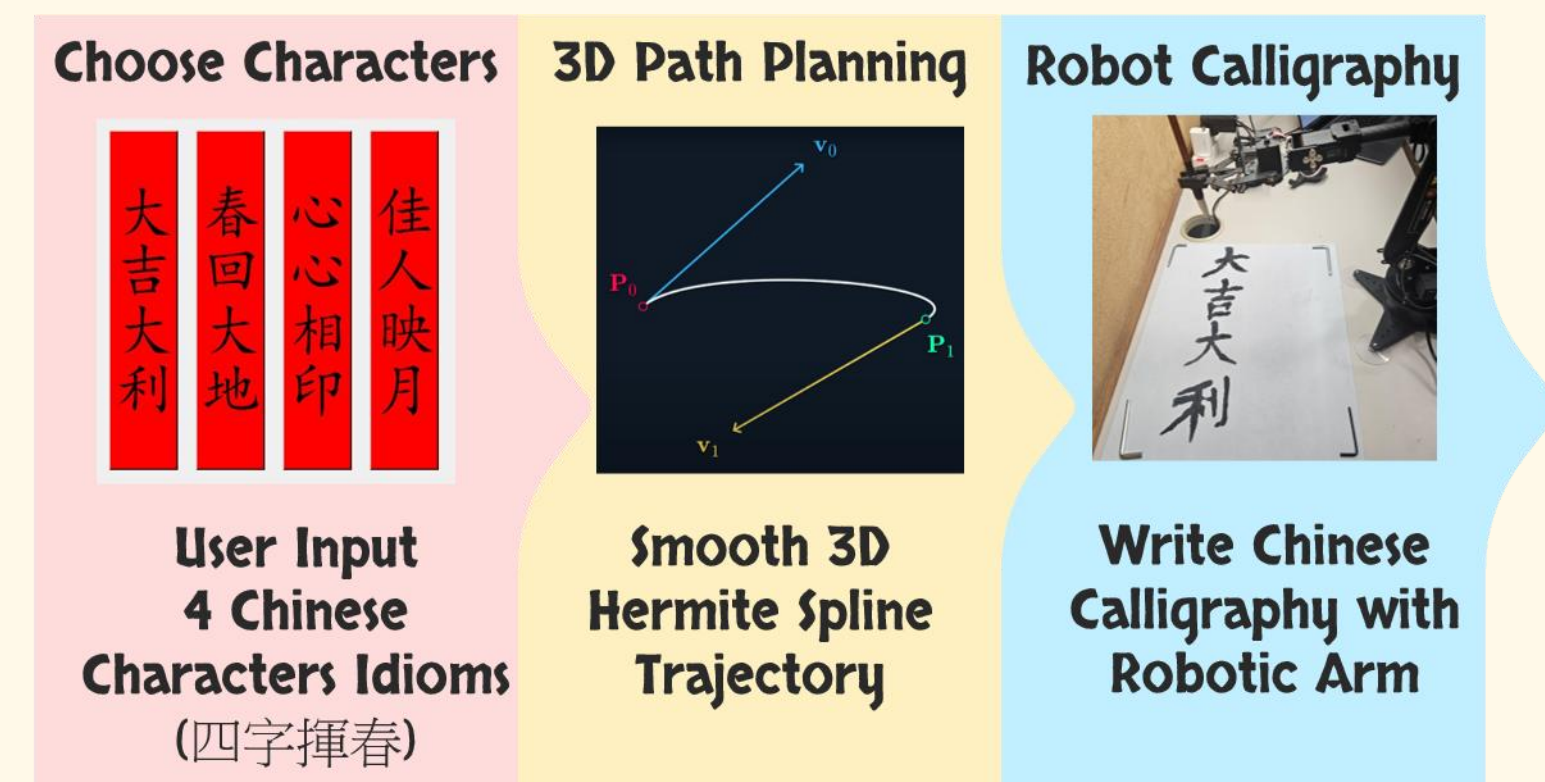
ABSTRACT

Chinese calligraphy is a sophisticated art form that requires precise control over movement and brush dynamics. Unlike typical robotic writing projects that utilize hard-tipped pens, the soft calligraphy brushes allow for writing at varying heights, resulting in strokes of different thicknesses. This characteristic presents a unique challenge for 3D trajectory planning in robotic systems. This paper presents an innovative approach that empowers robotic manipulators to generate Chinese calligraphy through 3D path planning algorithms based on Hermite Splines.

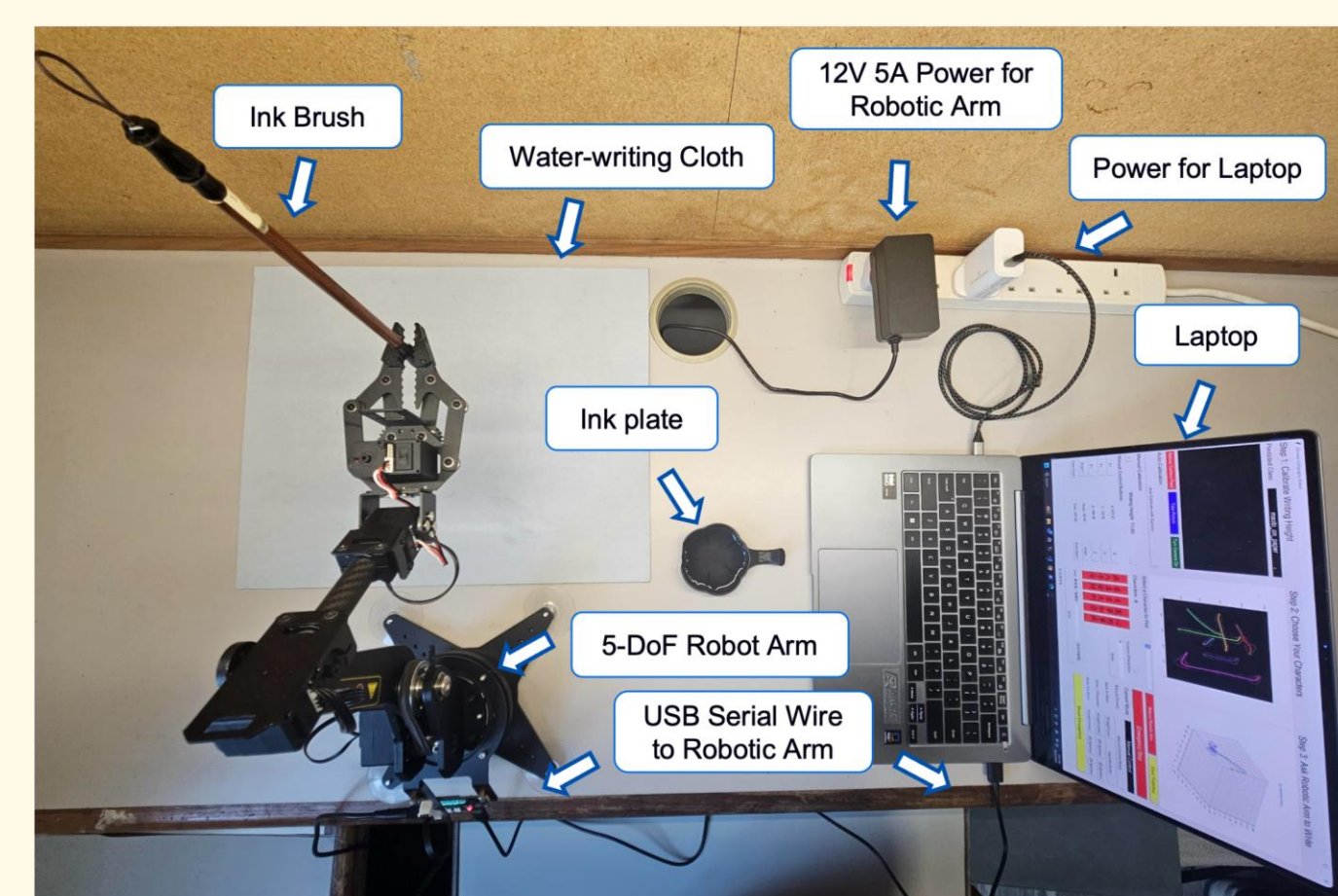
The proposed framework processes 2D stroke-ordered vector graphics sourced from an online dataset, converting them into 3D control points while taking into account the thickness and pressure of brush strokes. These 3D control points are subsequently transformed into intricate 3D Hermite spline trajectories that accurately depict the strokes of Chinese characters. To enhance realism, additional Hermite curves are introduced to replicate the lifting of the brush between strokes. The trajectories are carefully optimized to ensure that the robotic manipulator moves smoothly and precisely, effectively mimicking traditional calligraphy techniques.

Experimental results validate the effectiveness of this method, showcasing its ability to produce visually authentic Chinese calligraphy marked by high precision and artistic quality. This research highlights the promising potential of integrating large language models with advanced robotic path planning, ultimately bridging the divide between traditional artistry and modern robotic capabilities. By addressing the challenges unique to Chinese calligraphy, this work not only advances the field of robotic manipulation but also enriches our understanding of how technology can harmonize with cultural expressions.

OVERVIEW

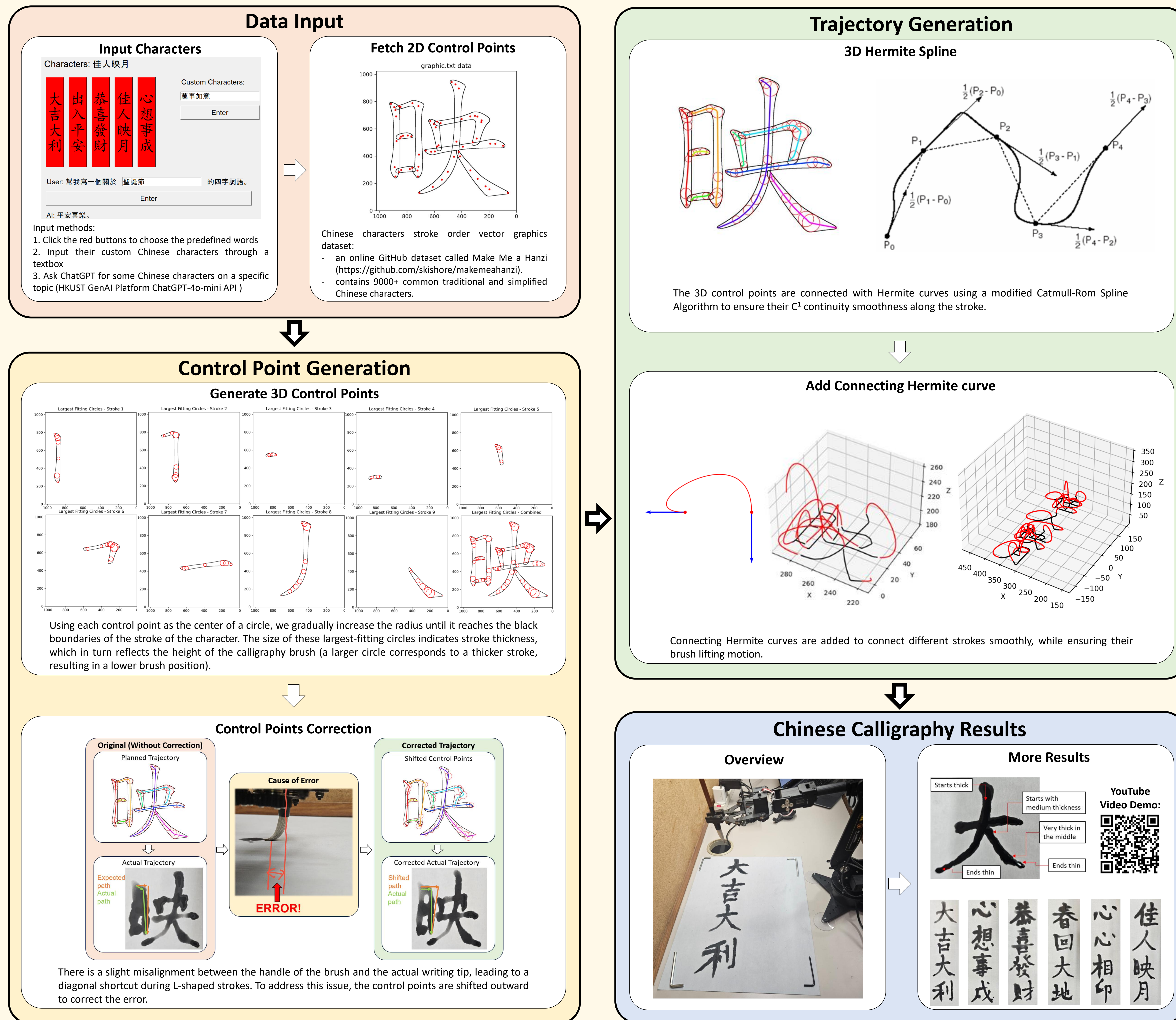


EXPERIMENT SETUP



5-DoF Robotic Arm: Waveshare RoArm-M1
Chinese Writing Brush (毛筆): 0.9cm diameter
Water-writing Cloth (水寫布): turns black when wet, white when dry

WORKFLOW



Why Use 3D Path Planning When Writing on 2D Paper?

Because Height of Brush affects the Thickness of Lines

Lift the Brush High Up → Thin Line



Press the Brush Down → Thick Line



FUTURE WORK

Here are a few different directions that we can continue to develop in the future:

1. Support Different Fonts and Calligraphy Styles	2. Support English and Other Languages Alphabets
3. Drawing Different Shapes and Images	4. Write and Draw on Curved Surfaces

CONCLUSION

This research demonstrates a significant advancement in the integration of robotics and traditional Chinese calligraphy through innovative 3D path planning techniques. By leveraging Hermite spline algorithms, we have successfully enabled robotic manipulators to produce high-quality calligraphic strokes that reflect the nuances of human artistry. The method's ability to account for brush dynamics and stroke thicknesses highlights its potential to bridge the gap between technology and cultural heritage.

Our experimental results confirm the effectiveness of this approach, showcasing not only the precision of robotic writing but also its aesthetic authenticity. As we explore further enhancements and applications, this work opens pathways for the fusion of advanced robotics with various forms of traditional art, enriching both fields and offering new avenues for artistic expression.

We invite further exploration and collaboration in utilizing these techniques to preserve and innovate within cultural practices, emphasizing the harmonious coexistence of technology and art.