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Research progress on and prospects for virtual brush modeling in digital calligraphy and painting

Key words: Painting and calligraphy; Virtual brush; Human-computer interaction; Force feedback; Spring; Texture mapping

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Motivation

- In virtual painting, virtual brush modeling plays the most important role. A powerful virtual brush model can truly reflect the characteristics of a real brush and enhance the reality of virtual painting.
- Researchers have done a great deal of work researching models for a virtual brush. They have used different modeling methods to construct models for virtual brushes that possess the characteristics of brushes. Although some achievements have been made in this respect, there are still some areas in need of development to realize the ideal goal.
- By reviewing the state of the art on virtual brush modeling, we summarize the basic principles, merits, and drawbacks of typical modeling methods, and discuss simulation results based on empirical methods and physical methods separately.
- We review the state of the art regarding the modeling methods of virtual brushes to provide guidance for further development.

Research status

- Researchers have carried out various types of research on brush modeling from different perspectives, and many important results have been obtained. According to the simulation results, virtual brush modeling can be divided into empirical brush modeling and physical simulation based brush modeling.
- The influences of brush-paper, paper-ink, and human-computer interactive devices on virtual brush modeling are analyzed briefly.
- We can find that the above systems either model a brush using a deformable model without individual bristles (Chu and Tai, 2002; Baxter and Lin, 2004), or model a bristle brush but ignore the simulation of 3D paint completely (Sun MJ, et al., 2009).

Research status

- Many brush models do not consider the mechanical properties of the variable stiffness that exists in a real brush. Some brush models do not consider the real-time force feedback.
- The existing paper model and the ink diffusion model can simulate the general effect of paper-ink interaction.
- However, there is still difficulty in the simulation of more complex painting effects, such as the superposition of strokes and the gradual change of ink color in the strokes. The fiber structure of rice paper and the transmission mechanism of ink on rice paper should be studied in depth in the future, and the paper- ink interaction can be realized by constructing a more effective rice paper model and ink diffusion model.

Research prospect

- In the future, we can construct a new color mixing model and design a new color simulation algorithm based on Kubelka-Munk theory. In addition, multi-color simulation in painting can be realized through the construction of a palette module.
- With the rapid development and wide application of MEMS technology, a MEMS force sensor and a MEMS inertial measurement unit can be integrated to construct a simulation brush based on MEMS, for real-time detection of pressure and gesture of the brush in the painting and calligraphy processes (Fig. 1).

Research prospect

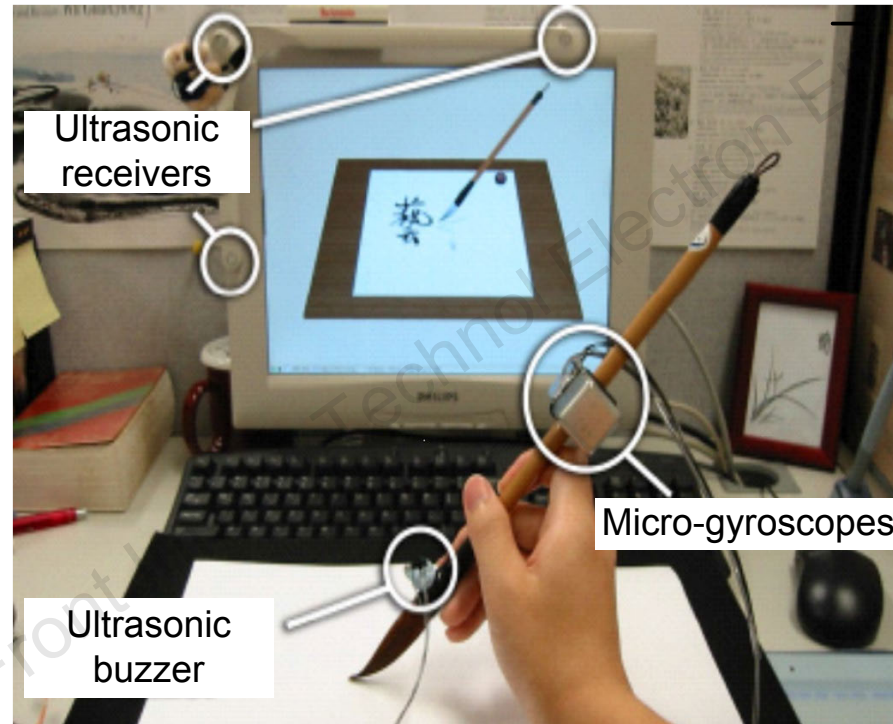


Fig. 1 Chu's input device for a virtual brush
Reprinted from Chu and Tai (2002), copyright 2002,
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Conclusions

- The computer simulation of Chinese painting and calligraphy has achieved progress. However, there are still some problems in brush modeling, construction of the ink diffusion model, and the formation mechanism of Chinese painting and calligraphy.
- In the future, interdisciplinary research in computer graphics rendering technology, artificial intelligence technology, and MEMS technology should be considered comprehensively to promote the computer simulation of Chinese calligraphy and painting.