1　Abstract

Calligraphy robot and potrait drawing robot have become an increasingly popular research area nowadays. Some papers and applications allow robot arm to perform potrait of people on paper or make quite complex and elegant calligraphy. For potrait drawing, a developed system usually contains four parts: image acuisition through a webcam, image processing to retrieve contours and features of objects, vectorization of coordinates in image plane and conversion of coordinates. For calligraphy, the process is similar but more involved in finding the connecting point between each stroke and improving the whole trajectory. Ability to write and draw could be one of the prosepective features of educational or humanoid robots, which can teach children how to write or help artists improve their work, in the future.

2　Related Work

2.1　Calligraphy robot

Ka Wai Kwok et al.[1] combined Genetic Algorithm(GA)-based brush stroke generation scheme and an experiment-based brush footprint acquisition method to replicate Chinese character. The brush footprint is captured by a video camera system below the transparent glass plate where brush moves on. Video frames are indexed with corresponding time for subsequent analysis. Chordal Axis Transform(CAT), a morphological transform, is adopted to obtain the skeleton of polygon shape(brush footprint). Constrained Delaunay Triangulation (CDT) is used as a preprocessing step of CAT. Rather than using artificial brush templates in their previous work [2], they applied GA and used the obtained experimental brush footprint to determine the (x, y) trajectory and z-depth altogether. Nico Huebel et al. [3, 4] applied a P-type iterative learning controller(ILC) to adapt the z-coordinates of the brush to form the desired trajectory(change thickness of strokes), the new trajectory is stored in database for next iteration. This method used visual feedback from installed camera and an iterative learning process to improve the quality of calligraphy by using information from previous iterations. Asymmetric point matching(APM) algorithm presented by Wei et al. had a good performance for matching limited nonlinear deform and quantity-uncertain point sets [5]. Bocheng Zhao et al [6] based their research on this and introduced a constrained global energy function (CGE) in the matching process and utilized a global spatial distribution energy function (EF) to evaluate relationship among point sets in order to solve specific problem in robot writing. Salman Yussof and his colleagues proposed a character-segmentation-based algorithm[7] which stores the character information as segments and this information is then used by robots to write. They tested this algorithm on Latin characters and the resullts turned out to be successful. Sabine Dziemian et al. implemented an eye-tracking system to continuously control a complex robot arm for writing and drawing, which could

be widely used by people with movement disorders [8]. Their results outperform other invasive or non-invasive brain-machine-interfaces in training time and calibration time.

2.2 Drawing robot

3 Hardware/Robot platform

- Sony EVI-D30/D31 Pan/Tilt/Zoom Colour Video camera with a resolution of 640*480 pixels, capture 20-30 frames/sec[1, 2]

- KUKA light weight robot, a Prosilica GC 655C camera, and a brush [3, 4]

- AxiDraw V3

- scribit, write&erase robot, https://www.scribit.design

- Mitsubishi RV-2AJ robotic arm[7]

4 Software/Github repo

- Inkscape, https://inkscape.org/en/ (for AxiDraw)

References

[1] K.W. Kwok, S.M. Wong, K.W. Lo, and Y. Yam. "Evolutionary replication of calligraphic characters by a robot drawing platform using experimentally acquired brush footprint," Proceeding of the 2006 IEEE International Conference on Automation Science and Engineering Shanghai, China, October 7-10, 2006

[2] K.W. Kwok, S.M. Wong, K.W. Lo, and Y. Yam. "GA-based Brush Stroke Generation for Replication of Chinese Calligraphic Character," Proc. of IEEE Conference on Evolutionary Computation, IEEE World Congress on Computational Intelligence, Vancouver, BC, Canada, July 16-21, 2006, pp.3802-3809.

[3] S. Mueller, N. Huebel, M. Waibel, and R. D'Andrea. "Robotic calligraphy - Learning how to write single strokes of Chinese and Japanese characters," 2013 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) November 3-7, 2013. Tokyo, Japan

[4] N. Huebel, E. Mueggler, M. Waibel, and R. D'Andrea. "Towards Robotic Calligraphy," 2012 IEEE/RSJ International Conference on Intelligent Robots and Systems October 7-12, 2012. Vilamoura, Algarve, Portugal

[5] Lian W, Zhang L, Yang M H. An efficient globally optimal algorithm for asymmetric point matching[J]. IEEE transactions on pattern analysis and machine intelligence, 2017, 39(7): 1281-1293.

[6] B. Zhao, M. Yang, H. Pan, Q. Zhu, J. Tao, "Nonrigid Point Matching of Chinese Characters for Robot Writing," 2017 IEEE International Conference on Robotics and Biomimetics (ROBIO)

[7] Salman Yussof, Adzly Anuar, Karina Fernandez, "Algorithm for Robot Writing using Character Segmentation," Information Technology and Applications, 2005. ICITA 2005. Third International Conference on

[8] Sabine Dziemian, William W. Abbott, and A. Aldo Faisal, "Gaze-based teleprosthetic enables intuitive continuous control of complex robot arm use: writing & drawing," 6th IEEE RAS/EMBS International Conference on Biomedical Robotics and Biomechatronics (BioRob) June 26-29, 2016. UTown, Singapore