Immersive and Collaborative Taichi Motion Learning in Various VR Environments

Tianyu He, Xiaoming Chen*, Zhibo Chen*, Ye Li, Sen Liu, Junhui Hou†, Ying He††

School of Information Science and Technology, University of Science of Technology of China, China
Department of Computer Science, City University of Hong Kong, SAR China †
School of Computer Engineering, Nanyang Technological University, Singapore ††

ABSTRACT

Learning "motion" online or from video tutorials is usually inefficient since it is difficult to deliver "motion" information in traditional ways and in the ordinary PC platform. This paper presents ImmerTai, a system that can efficiently teach motion, in particular Chinese Taichi motion, in various immersive environments. ImmerTai captures the Taichi expert's motion and delivers to students the captured motion in multi-modal forms in immersive CAVE, HMD as well as ordinary PC environments. The students' motions are captured too for quality assessment and utilized to form a virtual collaborative learning atmosphere. We built up a Taichi motion dataset with 150 fundamental Taichi motions captured from 30 students, on which we evaluated the learning effectiveness and user experience of ImmerTai. The results show that ImmerTai can enhance the learning efficiency by up to 17.4% and the learning quality by up to 32.3%.

Keywords: Immersive education, motion training, VR.

Index Terms: H.5.1 [Multimedia Information Systems]: Artificial, augmented, and virtual realities.

1 INTRODUCTION

In recent years we have witnessed the increasing popularity of MOOC and such trend will never end. However, learning motion usually requires professional training and face-to-face guidance, while online learning or video tutorials in traditional PC platform are usually ineffective.

In this paper, we present our immersive and collaborative Taichi learning system, called "ImmerTai", co-designed with experienced Taichi experts. With ImmerTai, the motions of Taichi experts are captured as baseline motions, which are delivered to remote students vividly in multi-modal means, including motion-driven avatar animation and mixed natural video, in particular in our customized Cave Automatic Virtual Environment (CAVE) and in Head Mounted Displays (HMD), which allow them to immerse in the learning environments. Multiple students' motions are also captured and utilized to drive virtual avatars to form a collaborative learning atmosphere, i.e. the remote students feel that they are learning Taichi from the Taichi expert together with other surrounding companions. It is to be noticed that although there are some related work in the literature, e.g. [1] and [2], these work did not measure the Taichi learning efficiency and quality in different immersive environments.

To evaluate ImmerTai, we built up a Taichi motion dataset with 150 fundamental Taichi motions captured from 30 subjects covering 8 popular Taichi motion patterns. Learning simulation and user evaluation have been conducted based on our dataset in the CAVE, the Oculus Rift HMD, and the ordinary PC. The results show that ImmerTai would noticeably improve the learning efficiency and the quality of the learnt motion. And subjectively, 93.3% students prefer learning with ImmerTai in immersive environments instead of PC platform.

* email: chenzhibo@ustc.edu.cn
* email: xiaoming.chen@iat.ustc.edu.cn

2017 IEEE Virtual Reality (VR)
March 18-22, 2017, Los Angeles, CA, USA
978-1-5090-6647-6/17/$31.00 © 2017 IEEE

2 IMMERTAI SYSTEM DESCRIPTION

2.1 Overview

As shown in Figure 1, ImmerTai consists of 3 modules, including Motion Capture Module (MCM), Multi-modal Presentation Module (MPM), and Motion Assessment Module (MAM). MCM captures expert's and students' motions with a Kinect camera with noise removal and appropriate processing. At MPM, the captured expert's motion is delivered to the remote students in a multi-modal way with immersion and the feeling of collaborative learning (Section 2.2). At MAM, the student motion quality is automatically assessed according to baseline motion (Section 2.3).

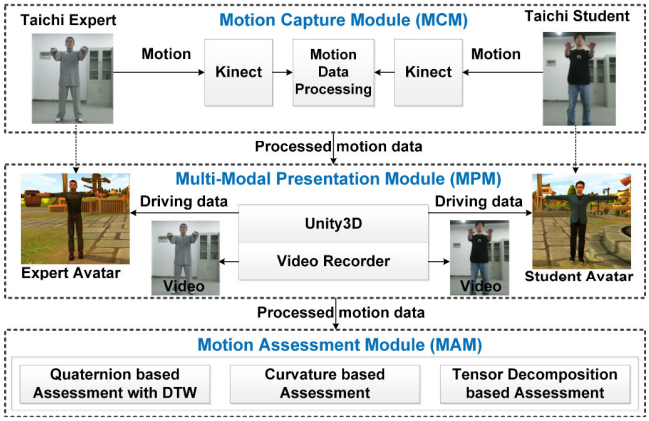


Figure 1: ImmerTai block diagram and modules.

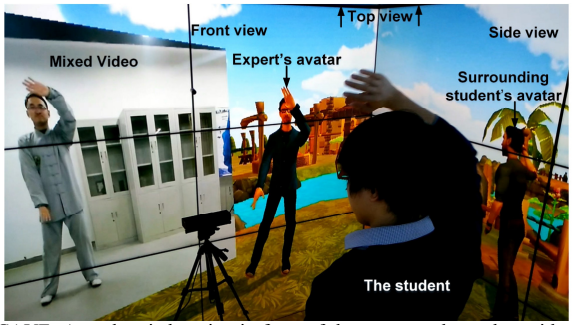
2.2 Taichi Learning in Immersive Environments

ImmerTai offers an immersive feeling to the student that he/she is practising Taichi in front of the Taichi expert and together with a group of companioning students. It works in both the ordinary PC platform and the VR environments like CAVE and HMD.

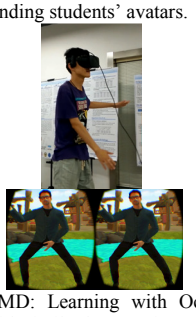
Our customized CAVE display is an immersive six-side cubic screen combination that allows students to see displayed contents in every side. As shown in Figure 2(a), in the front view, the student would see the expert's avatar (driven by the captured expert's motion). The captured video of the Taichi expert is also mixed in the front view in order to assist the learning. In the side views, the student would immerse in the surrounding learning environment and see the accompanying avatars driven by other students. Similar contents in similar layout can also be displayed to the students with Oculus Rift HMD as shown in Figure 2(b). The main difference is that the student, when lowering his/her head, would see the avatar instead of real body. At last, the contents can be displayed with normal PC platform too with the layout shown in Figure 2(c) but without immersion.

2.3 Motion Quality Assessment

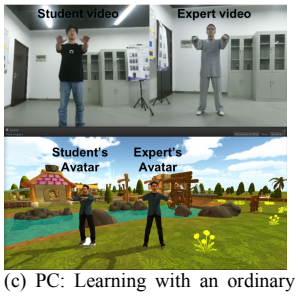
To evaluate the student motion quality in different environments, we developed 3 objective assessment algorithms, including 1) Quaternion based similarity assessment with DTW developed from [3] (Quat. for short); 2) similarity assessment using curvature property in space curve extended from [4] (Curv. for short); and 3) tensor decomposition based similarity assessment extended from [5] (Tensor for short). Based on our dataset, we invited Taichi experts to score each student motion from 1 to 5 as ground truth (for 8 Taichi motion patterns). Then we apply our algorithms to score each motion too and calculate the Pearson correlation coefficient to the ground truth (Table 1). The results show that overall Quat. demonstrates stronger correlation to the ground truth, and therefore is adopted as the assessment measure for following learning efficiency evaluation.



(a) CAVE: A student is learning in front of the expert and together with other surrounding students' avatars.



(b) HMD: Learning with Oculus Rift with similar layout of CAVE.



(c) PC: Learning with an ordinary PC without immersion.

Figure 2: Taichi training in various environments

Table 1. The Pearson correlation of the objective scores to the ground truth.

Patterns	1	2	3	4	5	6	7	8
Quat.	0.86	0.79	0.88	0.68	0.64	0.68	0.31	0.79
Curv.	0.62	0.75	0.24	0.09	0.32	0.48	0.11	0.75
Tensor	0.40	0.83	0.26	0.59	0.53	0.61	0.41	0.83

3 Learning Efficiency Evaluation

To evaluate the learning efficiency of students in different environments, we have conducted an objective user study and subjective questionnaires. We recruited 18 students and divided them into 3 groups. Each group will start learning a motion in one of the CAVE, HMD, and PC environments and then they swap later. To avoid the side effect of learning the same motion, a student would learn 3 different motions (but with similar difficulty) in the 3 environments respectively. For a given motion in a given environment, each student has the chance to practice the motion by imitating the replay of the expert repeatedly until learnt without having to watch the replay. The number of replays is recorded. After the practice, the student will go for a motion quality test, judged by the Taichi expert subjectively and meanwhile by the motion score objectively to decide if the student already learnt. If not passed, the student will go back to do more practices with replays, and the number is accumulated. The average number of replays and the average motion quality test scores are shown in Table 2. We also conducted comprehensive questionnaires and the results are shown in Figure 3.

Table 2. Avg. number of repeats and avg. scores in different environments.

Results \ Environments	CAVE	HMD	PC
Avg. number of replay imitating (A smaller number indicates faster learning)	4.3	3.8	4.6
Avg. scores of learnt motion.	4.1	2.4	3.1

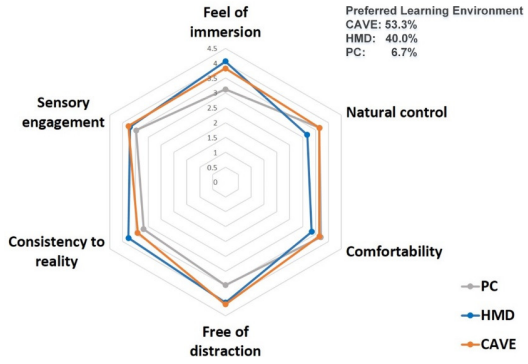


Figure 3: Results of questionnaires.

From Table 2, we observed that ImmerTai with CAVE and HMD would accelerate the learning by 6.5% and 17.4% respectively compared to PC. When it comes to the motion test scores, CAVE obtained a score gain of 32.3% over PC, but there is a score drop of 22.6% for HMD compared to PC, confirmed by our statistical tests showing significant differences. As explained in Figure 3, although CAVE is with reduced immersion compared to HMD, it offers more natural control and better comfortability. We think the low score of HMD, on the other hand, is due to that HMD is "over immersive" in the virtual environment for this application scenario, e.g. the student cannot see his/her body during the learning. Besides, some students complained about the cable of the Oculus Rift HMD for obstructing their motion. We also observed that 93.3% of students prefer learning with ImmreTai in immersive environments instead of PC.

4 Conclusion

This paper proposed ImmerTai and we evaluated it in different environments. The results show that ImmerTai in immersive environments are attractive to the students and would noticeably improve the Taichi motion learning efficiency and the learnt motion quality. Overall, ImmerTai with CAVE demonstrated good immersion, natural control, and good comfortability thus it appeared to be the best combination in this research.

Acknowledgements

This work was supported in part by the National Key Research and Development Plan under Grant No. 2016YFC0801001, NSFC under Grant 61571413, 61632001,61390514, and Intel ICRI MNC.

References

[1] P. Chua et al., "Training for physical tasks in virtual environments: Tai Chi," IEEE Virtual Reality, Los Angeles, 2003, pp. 87-94.

[2] Yu Jin, Xiaoxiang Hu and GangShan Wu, "A Tai Chi Training System Based on Fast Skeleton Matching Algorithm", European Conference on Computer Vision (ECCV) Workshop, Firenze, 2012, pp. 667-670.

[3] D. S. Alexiadis et al., "Quaternionic Signal Processing Techniques for Automatic Evaluation of Dance Performances From MoCap Data," in IEEE Trans. on Multimedia, vol. 16, no. 5, pp. 1391-1406, Aug. 2014.

[4] M. T. Pham, et al., "Three-dimensional gesture comparison using curvature analysis of position and orientation," Int. Conf. of the IEEE Eng. in Medicine and Biology, Buenos Aires, 2010, pp. 6345-6348.

[5] Sun, C.; Junejo, I. N. & Foroosh, H. (2011), "Motion Retrieval Using Low-Rank Subspace Decomposition of Motion Volume.", Comput. Graph. Forum 30 (7), 1953-1962.