A Virtual Reality Dance Training System Using Motion Capture Technology

Jacky C.P. Chan, Howard Leung, Jeff K.T. Tang, and Taku Komura

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Outline

- INTRODUCTION
- RELATED WORK
- OUR OBJECTIVE: A DANCE EDUCATION SYSTEM FOR SELF-LEARNING
- EVALUATION
- CONCLUSION AND FUTURE WORK
INTRODUCTION

• There are mainly two ways to learn dancing
  • attend a dance lesson
    • teacher demonstrates the moves, points out the mistake made by the students, and guides them to improve
  • self-learning
    • watching demonstrations in videos
    • observe the moves and practice by themselves
    • lack of feedback
INTRODUCTION

- Commercial dancing games
  (Dance Dance Revolution Hottest Party)
- played with Wiimote and a pad
INTRODUCTION

- The limitations of using recent games for training purposes
  - the captured data does not cover all the movable body parts
  - Design for entertainment, not for training
- This motivates us to develop a learning tool
  - fun and teach motions at the same time.
INTRODUCTION

- A virtual reality (VR) training application integrated with motion capture technology for dance training is proposed
  - motion capture suit
  - virtual teacher
  - feedback
- The system will evaluate the difference between learner and virtual teacher
RELATED WORK

- VR Applications
  - Practicing Tai Chi
    - Chua et al. (2003)
    - virtual master
  - martial art training system
    - Komura et al. (2006)
    - practice defense/offense with the virtual coach
RELATED WORK

• VR-Based Dance Learning
  • dance learning system
    • Davcev et al. (2003)
    • The timing-vibro device reminds users when a move should be made
  • integrated motion capture and VR technology
    • Hachimura et al. (2004)
    • User’s avatar body overlap with the professional dancer.
RELATED WORK

- Motion Matching
  - Hachimura et al. (2005), Yoshimura et al. (2001), Qian et al. (2004), Kwon et al. (2005)
  - particular joint angles are considered in the analysis of specific motion.

- Animation with Motion and Music
  - Alankus et al. (2005)
  - A virtual character can be driven according to the beat of the music
OUR OBJECTIVE: A DANCE EDUCATION SYSTEM FOR SELF-LEARNING

- System Architecture
  - 3D graphics
  - Motion matching
  - Motion database
  - Motion capture system.
OUR OBJECTIVE: A DANCE EDUCATION SYSTEM FOR SELF-LEARNING

- Presentation of Movement
  - 3D animation
  - Change demonstration speed and the viewpoint

(a)  (b)
OUR OBJECTIVE: A DANCE EDUCATION SYSTEM FOR SELF-LEARNING

- Tracking of Movement
  - optical motion capture system
OUR OBJECTIVE: A DANCE EDUCATION SYSTEM FOR SELF-LEARNING

- Feedback
  - immediate feedback
  - color shows the correctness
OUR OBJECTIVE: A DANCE EDUCATION SYSTEM FOR SELF-LEARNING

• Feedback
  • score report

Analysis of your performance

<table>
<thead>
<tr>
<th>Body Part</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>59</td>
</tr>
<tr>
<td>Lhip</td>
<td>56</td>
</tr>
<tr>
<td>Rwrist</td>
<td>45</td>
</tr>
<tr>
<td>Neck</td>
<td>67</td>
</tr>
<tr>
<td>Lknee</td>
<td>77</td>
</tr>
<tr>
<td>Rhand</td>
<td>41</td>
</tr>
<tr>
<td>LowTorso</td>
<td>78</td>
</tr>
<tr>
<td>Lankle</td>
<td>87</td>
</tr>
<tr>
<td>Rhip</td>
<td>71</td>
</tr>
<tr>
<td>Lshoulder</td>
<td>50</td>
</tr>
<tr>
<td>Ltoe</td>
<td>88</td>
</tr>
<tr>
<td>Rknee</td>
<td>64</td>
</tr>
<tr>
<td>Lelbow</td>
<td>16</td>
</tr>
<tr>
<td>Rshoulder</td>
<td>57</td>
</tr>
<tr>
<td>Rankle</td>
<td>87</td>
</tr>
<tr>
<td>Lwrist</td>
<td>32</td>
</tr>
<tr>
<td>Relbow</td>
<td>49</td>
</tr>
<tr>
<td>Rtoe</td>
<td>78</td>
</tr>
<tr>
<td>Lhand</td>
<td>29</td>
</tr>
</tbody>
</table>

Overall: 43
OUR OBJECTIVE: A DANCE EDUCATION SYSTEM FOR SELF-LEARNING

- Feedback
  - slow motion replay
OUR OBJECTIVE: A DANCE EDUCATION SYSTEM FOR SELF-LEARNING

- Feedback
  - Comparison between two motions
  - two motions are compared among their postures

- Usage for Teachers and Students
  - Students
    - Looping steps: watching the demonstration, practicing, and understanding the feedback
  - Teachers
    - help to prepare the teaching materials
EVALUATION

- Performance of Evaluation Function
  - three common features used for measuring the difference between two motions
    - joint position
    - joint velocity
    - joint angle
EVALUATION

- Performance of Evaluation Function
  - Two groups of motion pairs are manually formed
  - same movements & different movements
  - Six subjects

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Similar pairs\textsuperscript{a}</th>
<th>Dissimilar pairs\textsuperscript{a}</th>
<th>( p )-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position</td>
<td>( \mu = 16.87 ) \text{ ( \sigma = 6.77 ) }</td>
<td>( \mu = 40.37 ) \text{ ( \sigma = 6.85 ) }</td>
<td>0.0000</td>
</tr>
<tr>
<td>Velocity</td>
<td>( \mu = 1.17 ) \text{ ( \sigma = 0.60 ) }</td>
<td>( \mu = 2.05 ) \text{ ( \sigma = 0.70 ) }</td>
<td>0.0000</td>
</tr>
<tr>
<td>Angle</td>
<td>( \mu = 17.42 ) \text{ ( \sigma = 7.75 ) }</td>
<td>( \mu = 38.07 ) \text{ ( \sigma = 7.12 ) }</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

\textsuperscript{a} The values are the mean and standard deviation of the differences between motions in each group respectively.
EVALUATION

- Achievements of the Proposed System
  - evaluate the performance
  - eight subjects
  - all male
  - Age 21-30
  - experiment group were trained by the proposed system
  - control group were trained by self learning
EVALUATION

- Learning Outcome Achieved by Students
  - baseline scores
  - learned three dance moves and spent 15 minutes for each move
  - moves are about 2-seconds
  - After 15 minutes, the subjects did the post-training testing
EVALUATION

• Learning Outcome Achieved by Students
  • the scores were analyzed by paired T-test
    • The p-value is 0.000011598 (p < 0.01)
    • there is a significant difference before and after the training.
    • the mean after the training is higher than before
EVALUATION

- Arousing Interest in the Participants
  - The system is interesting and able to motivate subjects to learn.
EVALUATION

- Comparison Evaluation
  - control group were told to learn dance by self learning
  - the baseline and post-training scores were measured
EVALUATION

- Comparison Evaluation
  - The subjects in both groups have similar backgrounds and skills
    - Use a two sample T-test to compare the baseline scores of the experiment and control groups
    - The p-value is 0.2116 (p > 0.01)
    - there is no significant difference between the baseline scores between the two groups
EVALUATION

• Comparison Evaluation
  • The change between baseline and post-training scores were analyzed by the paired T-test
    • The p-value is 0.3374 (p > 0.01)
    • there is no significant difference before and after training
  • The improvement between two group
    • obtained by post-training score minus baseline score
    • The p-value is 0.0012 (p < 0.01)
    • the mean of the improvement in experiment group is higher than that of control group
EVALUATION

• Comparison Evaluation
  • Compared with experiment group
    • The system is shown capable to guide the students to improve their skill in the learning process
    • the control group faced more difficulty to learn the dance moves
    • The feedback is proven useful in guiding students into the correct direction in the learning process
CONCLUSION AND FUTURE WORK

- A dance training system using the motion capture system is proposed
- The virtual teacher can point out the mistakes made by the student
- The system can evaluate the similarity between two motions robustly
- The subjects evaluated that our system is interesting and stimulate them to learn more
CONCLUSION AND FUTURE WORK

- As future work, the generation of dance lessons from the motion templates in the database can be automated by using pattern recognition techniques.
- Student may not always face the screen
  - Equipped by movable screens or head-mounted devices
Thank You for Listening