Recognition and Generation of Leg Primitive Motions for Dance Imitation by a Humanoid Robot

Shinichiro Nakaoka[1], **Atsushi Nakazawa**[2], **Kazuhito Yokoi**[3] **and Katsushi Ikeuchi**[1]

[1]The University of Tokyo, Tokyo, Japan, nakaoka@cvl.iis.u-tokyo.ac.jp

[2]Japan Science and Technology Corporation

[3]National Institute of Advanced Industrial Science and Technology

1. Overview

The goal of this study is to realize a dancing humanoid robot which can imitate human dance performances. Pollard et al. [2] imported human dance motion acquired by a motion capturing system into a robot. However, their method is restricted to the motion of the upper body. In this paper, we attempts to realize whole body performances including leg actions. In leg motion, to use motion data directly converted from captured motion is not easy, because leg movement of a robot is too restricted to apply such data. Leg structure of present robots easily causes self collision or overrun of movable ranges. In addition, leg motion must consider balance keeping.

This study proposes a framework based on primitives of leg actions to solve the above problem. A sequence of primitives is recognized from the captured motion. Leg motion of a robot is generated from the primitive sequence. This method is more reasonable than adapting the raw motion data to the constraints. This framework also brings high flexibility to performances. For example, performances can be adapted to various stage condition or recomposed choreography sequences.

2. Primitives of Leg Actions

In our target Japanese folk dances, three basic actions are observed as primitive motions: standing (STAND), stepping (STEP), and squatting (SQUAT). Each primitive have parameters which are required to recreate leg motion for a robot. For example, STEP has position and orientation of a swing leg from a support leg, at medium state where the swing leg takes the highest position and final state. Parameters are simple enough to express characteristic of actions. Primitives are extracted by examining some captured body positions.

3. Generation of Robot Motion

Leg motion for a robot is generated from the extracted primitive sequence. First, initial feet trajectories are generated by interpolating states of each primitive within the robot constraints. Then, desired ZMP trajectory is generated by analyzing contact state of feet. Based on this trajectory, waist trajectory is modified to satisfy dynamic balance by the method proposed by Nishiwaki et al [1]. Figure 1 shows a captured dance motion and a generated robot motion in Japanese folk dance, *Jongara-Bushi*.

This motion was tested in OpenHRP dynamics simulator and a virtual robot can successfully perform the dance.

References

[1] Koichi NISHIWAKI, Satoshi KAGAMI, Yasuo Kuniyoshi, Masayuki INABA, and Hirochika INOUE. Online generation of humanoid walking motion based on a fast generation method of motion pattern that follows desired zmp. *Proceedings of International Conference on Intelligent Robots and Systems*, 2002.

[2] Nancy S. Pollard, Jessica K.Hodgins, Marcia J. Riley, and Christopher G. Atkeson. Adapting human motion for the control of a humanoid robot. *Proceedings of International Conference on Robotics and Automation*, 2002.

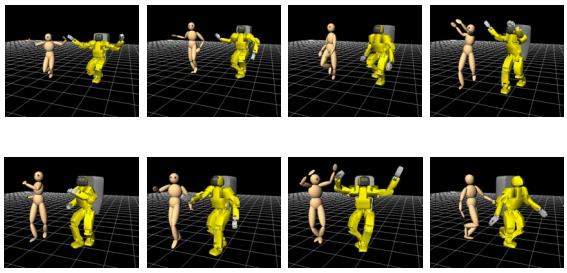

Figure 1: Original motion and generated robot motion