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Motion of Humanoid Robot

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Abstract — Humanoid robots are already common in theme parks such as Disneyworld and Universal Studios where the investment for a new attraction is substantial. In this paper we represent basic introduction of humanoid robot. We mainly concentrate on actuators of robot and movements of robot. In this paper, there is an approach to teach incrementally human gestures to humanoid robot. The learning process consists of projecting the movement. As we know all robots are not the same. However, the number of degrees of freedom, range of joint motion, and achievable joint velocities of today's humanoid robots are far more limited than those of the average human subject. In this paper, we describe motion in different humanoid robots. Those robots are: Sarcos humanoid robot, Biped humanoid robot, HRP-3P, and HRP-3.

Keywords: *Humanoid robot, Biped humanoid robot, Sarcos humanoid robot, Degree of freedom, Actuators, Sensors*

I. INTRODUCTION

A humanoid robot is a robot with its body shape similar to human body. A humanoid robot is designed for functional purposes, such as interacting with human tools and environments, for experimental purposes, such as the study of bipedal locomotive, or for other purposes. In general humanoid robots have a torso, a head, two arms, and two legs. Humanoid robots are now used as a research tool in several scientific areas. Robots are having sensors and actuators. A sensor is a device that measures some attribute of the world. Sensor plays an important role in robotic paradigms. There are two types of sensors: proprioceptive sensors and exteroceptive sensors. Actuators are the motors responsible for motion in the robot. Humanoid robots are constructed in such a way that they mimic the human body, so they use actuators that perform like muscles and joints, through with a different structure.

Figure 1: Humanoid robot

II. INCREMENTAL LEARNING OF GESTURES IN HUMANOID ROBOT

Robot programming by Demonstration (RbD) also referred to as Learning by Imitation, explores methods to teach a robot new skills by user friendly means of interaction. Instead of copying a single instance of a demonstration, our approach aims at extracting what are the relevant characteristics of the gestures that needs to be reproduces. This can be achieved by observing the user performing multiple demonstrations of the same task and generalizing over the different demonstrations. Classical approaches tend to perform the skill off-line in a batch learning mode, but recent approaches proposed methods to dynamically teach new skills to a humanoid robot.

To transfer a skill between two human partners, different ways of performing demonstrations can be used, depending on the motor skill that must be transferred. For example, several methods have been investigated for skill acquisition in sport, with the aim of providing advices to sport coaches, i.e. to understand how to transfer a motor skill in the most efficient way depending on the individual capacities of the athletes.

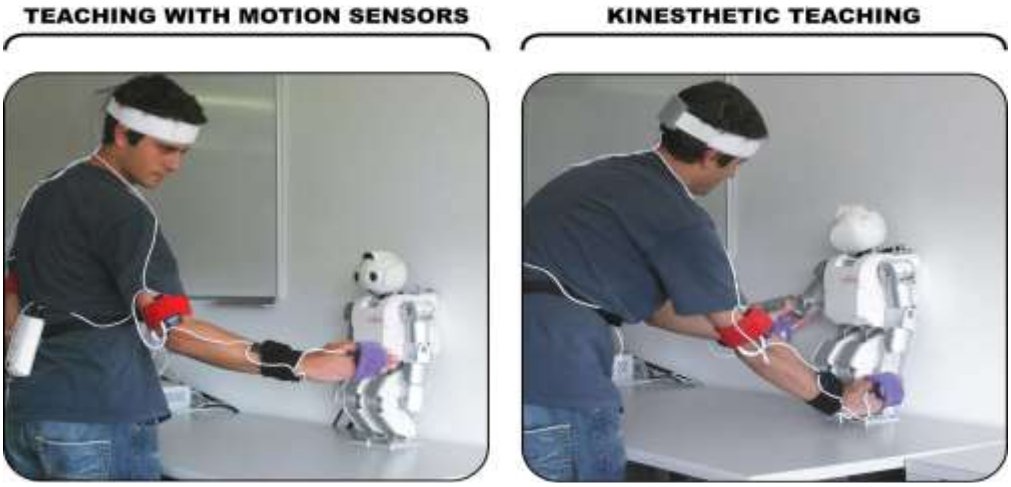

Figure 2: Illustration of the different teaching modalities used in our system.

Left: The user performs a demonstration of a gesture while wearing motion sensors recording his upper-body movements (arms and head).

Right: The user helps the robot reproduce the gesture by kinaesthetic teaching, i.e. correcting the movement by moving physically the robot's limbs to their correct postures.

III. MOTION IN SARCOS HUMANOID ROBOT

An approach of Sarcos humanoid robot is to drive the motion of the robot with motion capture data recorded from a professional actor. Such data would contain the timing and many of the other subtle elements of the actor’s performance.

However the current mechanical limitations of humanoid robots prevent the recorded motion from being directly applied, unless the human actors use only a fraction of their natural joint range and move with slower velocities than those commonly seen in human motion.

We addressed these limitations with straightforward techniques:

The location of the markers in the motion capture data is first mapped to the degrees of freedom of the robot by inverse kinematics on individual limbs. Then joint angle and velocity limits are imposed on the motion via a local scaling technique. The robot tracks the trajectories of the transformed data using a position and velocity tracking system with one or two iterations of feed-forward trajectory learning.

This technique is tested with fourteen motion sequences from seven professional actor. Each subject performed to the same audio track of the children’s song, “I’m a little teapot.” Developers chose this selection because it was familiar enough that most actors would perform the motion in a similar but not identical way.

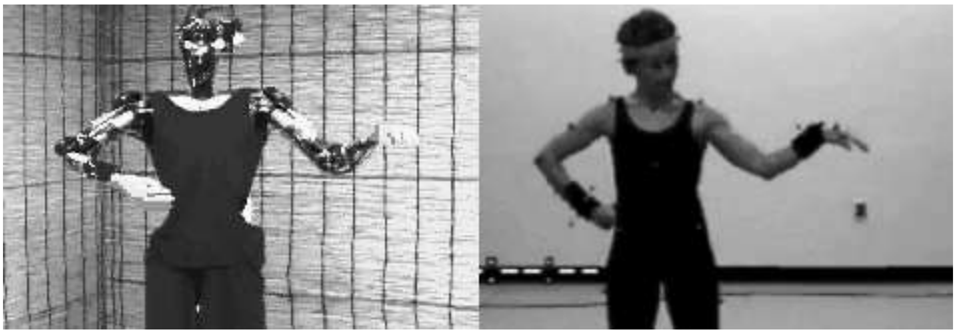

Figure 3: The Sarcos humanoid robot at ATR (DB) tracking motion

IV. MOTION IN BIPED HUMANOID ROBOT

In biped humanoid robot, motion is generated from human dance performance through a series of steps. As we see in figure-1, dance motions are acquired by an optical type motion capturing system made up of eight cameras. The robot is moved according to the joint angle trajectories. The trajectories are generated from maker positions and motion primitives. Arm joint angles are mainly calculated by inverse kinematics of makers and leg joint are mainly generated as pattern from step primitives. The generated angles are not under the constraints of the robot and they tend to have inconsistent balance for dynamic forces. Therefore the angle trajectories must be modified to solve such problems. Information of essential posture is used to express dance characteristics.

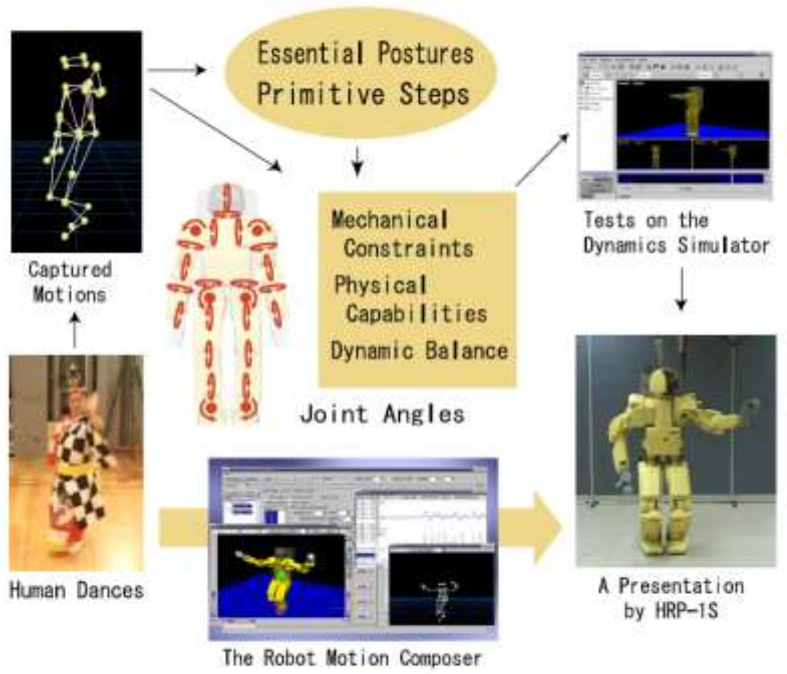

Figure 4: Overview of the system

V. MOTION OF THREE FINGERED HAND OF HRP-3P

Design concepts for designing the hand of HRP-3P are:

i. Build upon the capabilities of HRP-2.
ii. Improve object manipulation.
iii. Dust proof and splash proof design.
iv. Gripper like functionality of the HRP-2 hand.

To achieve improvement of object manipulation wrist and hand of HRP-3P is newly developed. When experiments are applied on HRP-2, manipulation of 6 D.O.F. (Degree of Freedom) arm. In which 3 D.O.F. are of shoulder, 1 D.O.F. for elbow and 2 D.O.F. for wrist. The upper-arm link frequently collided with the chest cover. To overcome this issue, HRP-3P is designed with 7 D.O.F. for each arm as shown in figure 2. HRP-3P has a 3 D.O.F shoulder, a 1 D.O.F. elbow and a 3

D.O.F. wrist. Hand of HRP-2 is mainly used as a gripper where HRP-3P can wrap around grasping objects because its thumb has 1 D.O.F. , while second finger is imitatively constructed by building up index, middle, and little finger has 2 D.O.F. Although the capability of grasping objects by HRP-3P is a little improved over HRP-2.

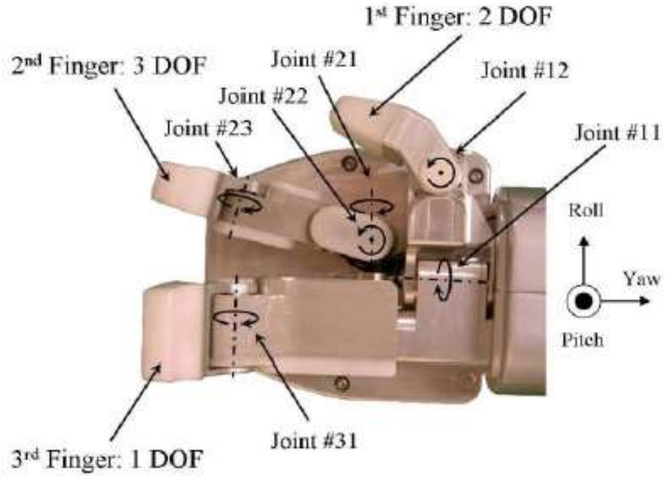

Figure 5: Pitch axis view

Figure 3 shows how three-fingered hand performs different tasks. It is remarkable that gripper like functionality can be applied by so few joints.

Figure 6: Wood panel in 3-fingered hand

Figure 7: 350ml can hold by 3-fingered hand

VI. MOTION OF MULTI-FINGERED HAND OF HRP-3

Design concepts for designing the hand of HRP-3 are:

i. Improve object manipulation.
ii. Dust proof and splash proof design.
iii. Gripper like functionality of the HRP-2 hand.
iv. Capability of achieving simple tasks using one.
v. Finger, such as operating a push type switch and.
vi. Pulling the trigger of electrical driver.

Figure 8: Multi-fingered hand

Application tasks performed by HRP-3P are still limited. It is also difficult for HRP-2 and HRP-3P to do simple tasks such as operating a push type switch and pulling the trigger of electrical driver. Ultimately a multi-fingered hand is required to perform human tasks as well as a human.

To achieve this requirement, we also developed a multi-fingered hand, which can be attached to life-size humanoid robots. Our developed multi-fingered hand has 4 fingers with 17 joints, which consist of 13 active joints and 4 linked joints. As expected, our hand is applicable both for grasping and manipulating objects on a prototype level. However, it is still premature to adopt our developed multi-fingered hand into HRP-3 as a product model.

VII. CONCLUSION

This paper described the system for robots to perform dance motions acquired from human dancers. A system could generate the robot motions which satisfy the mechanical constraints and dynamics consistency. An approach to scaling human motion captures data to the capabilities of a humanoid robot. Joint and velocity limits were incorporated into the motion using local scaling algorithms, and the motion was processed to avoid artefacts due to the singularity within the workspace of the robot's shoulder. This paper also describes how motion of three-fingered hand in HRP-3P is take place and motion of multi-fingered hand in HRP-3 as well.

In conclusion, the effectiveness of the motion control proposed in this paper and the motion systems are experimentally supported. All humanoid robots are not the same. All robots have some limitations and some advantages.

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