Extraction of Behavior Primitives for Understanding Human Standing-up Motion

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Recently, maintenance of QOL (Quality of Life) in the aging society is becoming an important issue especially in developed countries, and the concept of care prevention was introduced in Japan so that the people should train themselves for being healthy to maintain the motion function and to keep independent living.

In this research, human standing-up motion has been focused. The motion is considered to be very important because it is the start point of many daily actions. Thus, machines or methods to train elderly people are really needed nowadays. However, the way how a person stands up is not known precisely. In this paper, in order to understand the motion, "behavior primitive" is defined as a muscle coordination which constructs human motion and each behavior primitive has a specific role toward motion. Therefore, objectives of our research are to understand the mechanism of human standing-up motion by extracting behavior primitives and to analyze difference between healthy elderly people and elderly people who have physical problems.

An integrated simulation method was developed to elucidate the role of muscles coordination toward the motion. Experiments were made to one healthy young man to measure body data during the standing-up motion, such as muscle activations (EMG), joint torques, and body trajectory. Those observed actual data were used for the simulation. The method is consists of two parts. One part is to decompose observed muscles patterns into coordinated muscle patterns by "synergy analysis", and the other part consists of two neural networks: one is for building a mapping between muscles and joint torques, and the other is for building the one between joint torques and body trajectory. The structure of the neural networks in standing-up motion simulation is shown in figure 1. In addition, data from elderly people were obtained by experiments and divided them into two groups: one group includes elderly healthy persons and the other includes those who have physical problem. Behavior primitives were also extracted from both groups, and similarity was calculated between each behavior primitive to find difference between two groups of elderly persons.

From our study, it is implied that human standing-up motion can be divided into two behavior primitives. The first behavior primitive moves their center of gravity forward and upward, and the other keeps body posture stable by their ankles. Also, it is suggested that while there are not much difference in the first behavior primitive among two groups of elderly people, there is significant difference in the second behavior primitive. Thus, it can be estimated that elderly persons who are physically injured have difficulties in controlling their posture stably.

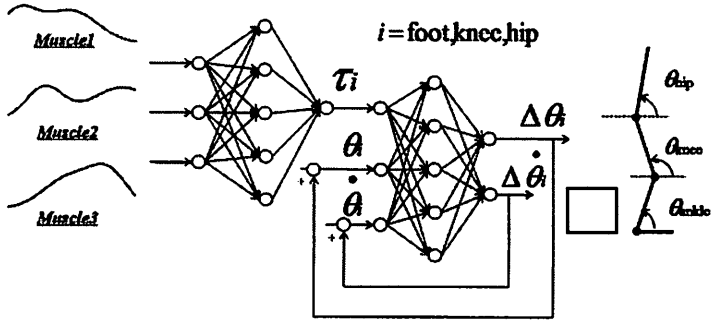

Figure 1. The structure of the neural networks in standing-up motion simulation