Reductive Mapping for Sequential Patterns of Humanoid Body Motion

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1. Introduction

Since a humanoid robot takes the morphology of human, users will intuitively expect that they can freely manipulate the humanoid extremities when try to control as pilots. However, it is not realized with simple devices because it is difficult to simultaneously issue multiple control inputs to the whole body. It is useful for motion pattern generation to get mapping functions bidirectionally between a large number of control inputs for a humanoid robot and a small number of control inputs that a user can intentionally operate. For the purpose of generation of voluntary movement of humanoid extremities, we present a dimensionality reduction algorithm of hierarchical NLPCA neural networks that forms low dimensional variables out of multivariate inputs of joint angles.

2. Dimensionality Reduction Method for Humanoid Motion Pattern

Our approach takes humanoid motion patterns as a set of state points in joint angle space. Each joint angle has nonlinear correlation each other when the humanoid robot takes action. By applying nonlinear principal component analysis (NLPCA) in that space, low dimensional internal representation can be obtained that provide multivariate inputs for the whole body.

In order to suppress the bias and improve the convergency when two or more motion patterns are learned, we arrange several NLPCA neural networks hierarchically by each level as shown in Fig. 1. This hierarchical NLPCA works as a system for bidirectional conversion between low dimensional variables and multivariate variables.

3. Internal Representation of Multiple Motion Patterns

We first make the NLPCA reduce a unique motion pattern “walk”. This experimental result described that appearance of periodic motion pattern can be generated by fluctuation of only one control variable with an appropriate nonlinear basis. Moreover, we found that such a basis can be acquired through a simple learning algorithm.

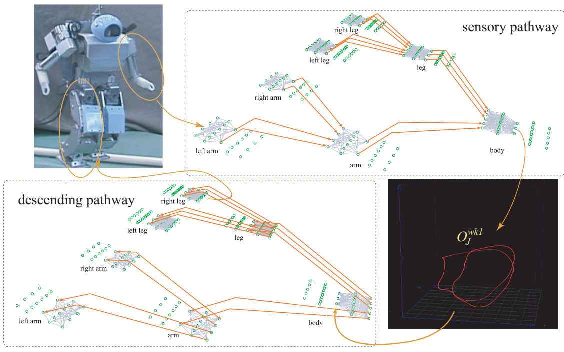

Figure 1: A design of hierarchical NLPCA neural networks. Two pathways are separately illustrated based on the difference of the functional aspects. The arc implies the flow of the signal transfer.

Then the problem is to find such variables for not only single motion pattern but also multiple motion patterns. Here, we assume that the original variety of motion pattern is to be regenerated by adding perturbation terms of the second or more principal components to the first principal component that represents approximate external appearance of the humanoid robot. This intuitive structure has advantages for robot control. The experimental result is shown that, though the hierarchical NLPCA must produce 9 motion patterns with 3 dimensional internal representations, the reproducibility was rather precise.

4. Conclusion

Dimensionality reduction of humanoid motion patterns is a problem of finding low dimensional manifold in the high dimensional space of joint angles. We used NLPCA to overcome the nonlinearity of the manifold and the NLPCA resulted in finding 3 dimensional space out of given 9 motion patterns on the 20 DOF humanoid robot.