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A RELATION-LEARNING METHOD BETWEEN MOTIONS OF BOTH ARMS AIMING AT APPLICATION TO UPPER LIMB PROSTHESIS

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Abstract. *We proposed a relation-learning method by using Volterra neuron networks in order to represent cooperative relationships between motions of each part in a human body. Though it is considered that these relationships are associated with skillful motion, they are often nonlinear and cannot be formulated. A Volterra neuron network, which one of the authors has presented in previous work, can deal with nonlinear signal processing better than TDNN since each neuron has a Volterra filter used for nonlinear filtering. Then we assumed that the relation-learning method was applied to upper limb prosthesis for an above-elbow amputee. A difference from conventional myoelectric prosthesis is a motion generation method which the cooperative relationships is applied to. Conceptually the prosthesis does not take any surgery or training. Preliminary experiments were performed in order to check if Volterra neuron networks can learn several kinds of measured motions. Rotation angles of both arm's joints were used as signals of the neural networks. In the best result, average of the error margin rate was approximately 5.5%. From the results, it was shown that the relation-learning method by using a Volterra neuron network can be useful for representation of cooperative relationships between motions.*
Keywords: Bimanual coordination, Relation-learning, Volterra neuron network

1. **Introduction.** The Human body is a nonlinear dynamic system with a large amount of degrees of freedom. Motions of the human body have diversity. Relationships among motions of each part in the body is often nonlinear and very complicated. However, each part in the body does not work individually. A cooperative relationship can be found in the motions of the body. Especially, coordination between motions of both hands is called bimanual coordination [1-3]. Leonard and et al. have described that a neural network which maintains cooperative relationships probably exists in a human brain since his birth and that these relationships develop to realize skillful motion with his age [4,5]. It is considered that the cooperative relationships are associated with hidden principles of a human's skillful and flexible motions. If the coordination relationships can be represented, reasonable motions can be generated like humans according to a situation. Though the cooperative relationships cannot be formulated, artificial neural networks may be able to learn them since it can approximate arbitrary functions and has generalization capability [6,7].

It is difficult for artificial neural networks to learn coordination relationships between motions of each part in the body. One of the reasons is that the coordination relationships