A Neurofuzzy Knowledge Based Architecture for Robotic Hand Manipulation Forces Learning

Ebrahim Mattar, College of Engineering, University of Bahrain, Sakheer, Kingdom of Bahrain

ABSTRACT

Optimal distribution of forces for manipulation by a robot hand, is a hard computational issue, specifically once a whole hand grasp is needed. It becomes a complicated issue, once a robotic hand is equipped with human like deformable sensory touching materials. For computing optimal set of manipulation forces, grip transform and inverse hand Jacobian play major roles for such purposes. This manuscript is discussing a Neurofuzzy learning technique for learning optimal force distribution by a dextrous hand. For learning purposes, optimal set of forces patterns were gathered in advanced using optimization formulation technique. After that, to let a Neurofuzzy system to learn the nonlinear kinematics-dynamics relations needed for force distribution. This is done by considering the computational requirements for the inverse hand Jacobian, in addition to the interaction between hand fingers and the object. Training patterns clustering, and generation of the fuzzy initial memberships, and updated shape of memberships, are considered as vital information to build upon for more reasoning of fuzzy interrelation. The technique is novel in a sense, that the adopted Neurofuzzy architecture was transparent in terms of revealing the learned hand optimal forces if then rules.

Keywords: Force Closure, Jacobian Inverse, Manipulation, Multilayers Neurofuzzy Architecture, Robotics Hands

1. INTRODUCTION

1.1. Previous Research Outcomes

Articulated robotics hands are becoming complicated and being used for wide spectrum of use everywhere and for different applications. However, an essential concern for such dexterous hands, is how to mix forces and moments, and the selection of best forces, either for grasping or even over a course of manipulation, specifically, once a whole hand grasp is needed. In addition, it becomes a complicated issue, once a robotics hand is equipped with human like deformable sensory touching materials. While artificial neural networks have been employed extensively in robotics and automation systems and for robot arms, in particular ANN have been used for approximating the mapping between object posture and the corresponding finger joint displacements. There have been substantial number of research articles concerning employment of Neuro-fuzzy for dexterous robot hand control. Example of

DOI: 10.4018/ijimr.2013040102
such is the research that has been the one presented by Wohlke, where the conception of the control system was based on the combination of a neural network approach for the adaptation of grasp parameters and a fuzzy logic approach for the correction of parameters values given to a conventional controller. Zsiros et al., have also discussed a practical application of generalized neural networks for a dexterous hand moved by shape memory alloys, where the robot hand was controlled by a generalized neural network. Li-Ren and Taipei in, have discussed the use of a digital signal processor for fuzzy control of robot hands. In their approach, they presented “fuzzy control” of a multi-fingered robot hand using a (DSP). DSP has been employed to implement a fuzzy control methodology of the seventeen joints which are controlled simultaneously. Doersam, et al. have also suggested a fuzzy logic approach for an on-line grasp-force-adaptation. This can be used for the control of a robot hand. A decision making logic that expresses a priori knowledge about the force behavior inside the friction cones has been used. Caihua and Youlun have presented an employment of intelligent learning based techniques for a multifinger grasp force planning which has been based on Neural Network. A technique through which an evolution strategy (genetic optimization) was employed for learning dexterous hand manipulation strategies has been presented by Fuentes and Nelson. They have suggested a genetic-based technique for optimizing a robot hand grasp configurations to meet defined manipulation requirements. Fischer et al. have studied controlling an object’s posture and forces between an object and its environment. They advised an object-pose controller with feedback from an object pose sensor suits for multi-finger gripper control. Due to joints dynamic nonlinearity, an effective, easy-adaptable joint controller was employed. The adaptable joint controller was based on fuzzy and neural-network algorithms. Here an exact analytical model for such a case was not utilized. In terms of recurrent ANN, Fok and J. Wang, has also proposed a two recurrent neural networks for grasping force optimization. The system was trained to learned several optimized force distributions. Tascillo et al. in have proposed a system with an efficient first grasp for a wheelchair robotic hand. The grasping pressure sensing was hence determined and learned, while combining advantages of ANN and fuzzy system into a hybrid control algorithm. Lia, et al. in, have proposed an anatomic and experimentally ANN for modeling force coordination in static multi-finger tasks. The goal of the study was to construct and test a neural network model that incorporates available knowledge about the finger functioning. In reference to this, examples of which are Fok and Wang, and Dorsam, et al. In addition, Martin et al. have also formulated the task of grasping force optimization, as an optimization problem. This was based on the smooth manifold of linearly constrained positive definite matrices for which there are known globally exponentially convergent solutions via gradient flows. Schemes involving second derivative information for quadratic convergence are also studied. Several forms of constrained gradient flows are developed for point contact and soft-finger contact friction models. “The physical meaning of terms and the cost index used for the gradient flows was discussed in the context of grasping force optimization”, Martin et al. In terms of contact uncertainties, Zheng and Qian have presented and analyzed mechanism for coping with the grasping uncertainties in force-closure stated and reflected our approach to handling these uncertainties in force-closure analysis. Uncertainty was measured by the possible reduction rate (κ) of friction coefficients, while the radius of contact (ρ) regions is used to quantify the latter uncertainty. The actual contact point may deviate from the desired position but not farther than (ρ′), the supremum of (ρ), without loss of force-closure, indicates the grasp tolerance to contact position uncertainty. They proposed three new problems in force-closure: whether a grasp with given (κ) and (ρ) achieves force closure, what value (ρ′) equals if (κ) is given, and how (ρ′) varies versus (κ). To facilitate their solu-
Evolutionary Robotics 1
www.igi-global.com/chapter/evolutionary-robotics/69692?camid=4v1a