The New Dexterity Adaptive, Humanlike Robot Hand

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***Abstract*— In this paper, we present the New Dexterity adaptive, tendon-driven, human-like robot hand. The particular hand is the first attempt towards industrialization of a tendon-driven, underactuated, anthropomorphic design with structural compliance in the form of elastic fingerpads and distal flexure joints. The accompanying video demonstrates the robot hand's ability to execute efficiently robust grasping and dexterous, in-hand manipulation tasks, using a range of everyday objects.**

I. Introduction

Replicating the dexterity of the human hand has been one of the biggest challenges that roboticists have faced. Several attempts have been made to create multi-fingered, anthropomorphic, dexterous robot hands using fully-actuated, rigid designs that require expensive components, complex control algorithms and sophisticated sensing to interact with the objects surrounding them or the environment. Bicchi has argued that simplified designs may provide an affordable dexterity leading to hands of low complexity that are intuitive to use [1]. In this paper, we propose an under-actuated, tendon-driven, compliant, humanlike robot hand that is capable of executing both robust grasps and dexterous, in-hand manipulation tasks under a wide range of environmental uncertainties (e.g., object pose uncertainties).

II. The New Dexterity Adaptive Robot Hand

The New Dexterity adaptive, humanlike robot hand consists of 15 degrees of freedom (DOF) actuated with 5 motors. The hand was developed using computer numerical control (CNC) machined aluminum parts, 3D printed parts (using Stereolithography and Fuse Deposition Modeling), and the Hybrid Deposition Manufacturing (HDM) technique that allows the integration of rigid parts into elastomer structures by employing appropriate molds [2]. The robot hand has been designed so as to be anthropomorphic, following the directions provided in [3]. The index, middle, ring, and pinky fingers consist of two spring loaded pin joints (metacarpophalangeal joint and proximal interphalangeal joint) and one flexure joint (distal interphalangeal joint) based on an elastomer material, while the thumb consists of two spring loaded pin joints. The fingerpads and the flexure joints are all made out of urethane rubber (SmoothOn PMC 780) and the palm pad is made out of silicone rubber (SmoothOn Dragonskin 10). The index, middle, and thumb are independently driven using a dedicated actuator for each, while the ring and pinky fingers are coupled together through a single-bar whiffletree differential that is connected to a dedicated actuator (the four actuators are Robotis Dynamixel XH430-V350-R). An additional motor (Faulhaber DC) with a custom made worm gear gearbox was used for the thumb base, offering a non-backdrivable thumb opposition. The PCB board located at the back of the hand houses a microcontroller to control the hand, a motor driver to control the thumb opposition motor, and appropriate tactile sensor connectors. The length, breadth, and thickness of the hand are 27 cm, 10 cm, and 8.5 cm respectively, while the total weight is 1.09 kg.

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III. Experimental Validation

In order to experimentally validate the efficiency of the proposed adaptive, humanlike robot hand we have created 3 different prototypes that have been mounted on two different dual robot arm hand systems. The first pair of arms uses the Universal Robots UR5 and UR10, while the second pair uses two Schunk LWA 4P robot arms. The grasping experiments were conducted using a wide range of everyday objects. The dexterity of the proposed hand was experimentally validated through the execution of a wide range of complex tasks, including bi-manual tasks and in-hand manipulation.

IV. Video

The accompanying video showcases the capabilities of the New Dexterity adaptive, humanlike robot hand. The HD version of the ICRA 2019 video, as well as more videos of the hand involving different types of tasks, can be found at the following URL:

www.newdexterity.org/adaptiverobothands

V. Authors' Contributions

Geng Gao, Anany Dwivedi, and Nathan Elangovan contributed to the modelling, design and development of the New Dexterity adaptive, humanlike robot hand and worked on the preparation of the experimental paradigms. Yige Cao and Lucy Young prepared the telemanipulation demo. The hand was developed in collaboration with industrial partners. Minas Liarokapis led the whole project.

References

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