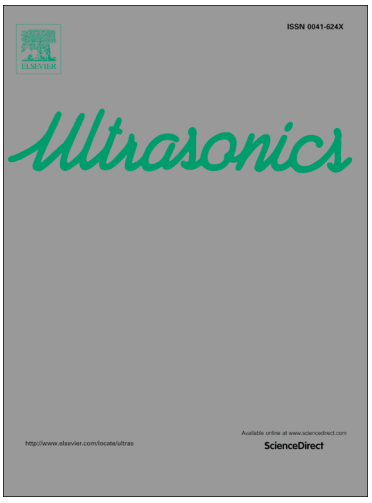

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PII: S0041-624X(17)30884-3
DOI: https://doi.org/10.1016/j.ultras.2017.11.019
Reference: ULTRAS 5665

To appear in: *Ultrasonics*

Received Date: 16 October 2017
Revised Date: 24 November 2017
Accepted Date: 29 November 2017

Please cite this article as: Z. Jiang, L. Wang, J. Jin, A Novel Robotic Arm Driven by Sandwich Piezoelectric Transducers, *Ultrasonics* (2017), doi: https://doi.org/10.1016/j.ultras.2017.11.019

A Novel Robotic Arm Driven by Sandwich Piezoelectric Transducers

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Abstract

In this work, a novel robotic arm driven by sandwich piezoelectric transducers is proposed. The proposed robotic arm is composed of three arms and four joints. Each arm consists of a sandwich piezoelectric transducer and an H-shaped hollow frame. The sandwich piezoelectric transducer utilizes frictional force to drive the joints on its both sides to rotate simultaneously. The joint between two arms can be driven to rotate in two perpendicular directions by two sandwich piezoelectric transducers. The rotation of joints results in the arm motion. Utilizing the finite element method, the optimized geometrical parameters of the sandwiched piezoelectric transducer are obtained, and the operating principle is demonstrated. A prototype of the robotic arm is also fabricated and assembled, it is 573 g in weight and 412 mm in length, and the maximum rotation angle of each joint is 160º. The mechanical characteristics of the robotic arm prototype are investigated by experiments. The results indicate that, when the excitation frequency of one sandwich piezoelectric transducer is 37.4 kHz, the arms on its two sides rotate in opposite directions with an average rotational velocity of 320 deg/s at 330 V_{pp}, a resolution of 100 μrad at 230 V_{pp}, and a startup and shutdown response time of 40 ms and 30 ms at 230 V_{pp}, respectively.

Keywords: robotic arm, sandwich piezoelectric transducer, experimental investigation

1. Introduction

With the increasing demand for achieving dexterous motion, robotics arms are required to move with multi-degrees-of-freedom (multi-DOF). Electromagnetic motors are generally combined together as a unit to achieve multi-DOF motion [1], Due to the facts that the electromagnetic motor only generates one-degree-of-freedom rotation and reduction devices are indispensable, this kind of driving unit is comparably large and hard to be miniaturized. Currently, most robotic arms that applied to the aerospace [2], industrial manufacture [3], and underwater tasks [4-8], are designed to operate with multi-DOF motions. Especially for the aerospace and underwater explorations, the weight and size of the robotic arms must be limited. Thus, traditional electromagnetic motors cannot fully meet the aforementioned demands. As the piezoelectric actuating concept is proposed, many types of piezoelectric ultrasonic motors have been developed and shown the potential to replace electromagnetic motors in many practical applications due to the merits of compact and simple structure [9-11], fast response [12, 13], no electromagnetic interference, and high precision positioning [14, 15].

Aimed at developing a multi-DOF robotic arm with small size and compact structure, some multi-DOF ultrasonic motors have been developed [16]. Of all the designs proposed, the most-received type is an ultrasonic motor with a single stator and a ball-shaped rotor. Takemura *et*