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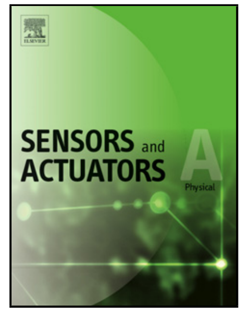

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Pose Estimation and Calibration using Nonlinear Capacitance Sensor Models for Micro/Nano Positioning

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Abstract

This paper presents a technique to perform pose estimation of planar three degrees of freedom (DOF) motions using two-plate capacitive sensors. These sensors are commonly utilised to measure linear motion, however their capacitance response becomes nonlinear and errors can be introduced with the introduction of angular motions. This paper focusses on the development of a methodology to invert a nonlinear model which maps the pose of the end effector of a planar positioner to the capacitances of each sensor, in effect providing pose estimates from capacitance measurements. Strategies for the calibration of model parameters, for cases where full reference or only yaw sensor measurements are available, are extensively explored. The points evaluated through the proposed method are shown to outperform the best affine transformation when trained with a full reference, and improved performance is also observed when the single reference is employed.

Keywords: micro-nano positioning, coupled 3DOF motion, capacitive sensor, nonlinearity, calibration

1 Introduction

High precision positioning with nanometre scale resolution is seen as a key enabling technology for many developments in numerous scientific and engineering disciplines; with diverse applications in microscopy, manufacturing, and manipulation [1–4]. To establish these highly precise positioning capabilities, high stiffness compliant mechanisms, often driven using Piezoelectric Actuators (PEAs), may be employed. However, such systems would typically suffer from hysteresis and drift, and are difficult to model, resulting in inaccuracy in the output position. Consequently, significant research efforts in this field have been devoted to the design of feedforward and feedback control strategies [5–9].

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