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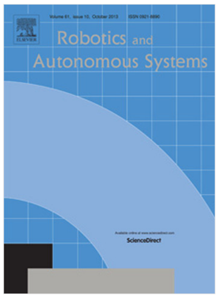


Complete design methodology of biomimetic safety device for cobots' prismatic joints

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# Complete design methodology of biomimetic safety device for cobots' prismatic joints

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*Abstract*—**Making robots collaborate safely with humans has created a new design paradigm involving the biomimetic mechanical behavior of robots' joints. However, few authors have contributed to the problems of safety in pure linear motion, i.e. a prismatic joint, in contrast to rotary motion. The contribution of this work is to present a new design that is capable of achieving, passively, an implementation of nonlinear elastic behavior for prismatic joints—the so-called Prismatic Compliant Joint (PCJ). This new device is based on the association of a six-bar mechanism with a linear spring. Hence, this structure generates a nonlinear stiffness behavior under a specified external force. The elastic characteristics of the PCJ are derived from a generic biological muscle mechanical behavior model and then customized according to the force-safety criteria of physical Human/Robot Interaction (pHRI) into a Hunt–Crossley contact model. A further investigation is carried out, via simulation, to verify the shock absorption capacity of the PCJ with a dummy head obstacle. In order to fit the PCJ response curve to the established safety measures, an optimization based on a genetic algorithm method is employed to tune the PCJ's intrinsic parameters subject to some chosen constraints.**

*Index Terms*—**Biomimetics, Mechanical design, Prismatic Compliant Joint, Safety, Passive Compliance**

## I. INTRODUCTION

In the last decade, interest in making safe collaborative robots (cobots) has increased along with the market demand, mainly for industrial and medical applications [1]. This has led to the introduction of compliant actuation solutions that can be classified into two main categories: Active Impedance Control (AIC) [2] [3] or Passive Compliance (PC) [3]. The active-compliance-based approach suffers from relatively low bandwidth because it involves an accumulative delay generated by the control loop components in response to a fast collision [4] [5]. On the other hand, PC is commonly composed of mechanical elements such as springs to absorb the kinetic energy of the link in collision; it is known that an elastic joint is capable of decoupling the next link's inertia from the base link. The PC approach does not utilize any sensor or actuator, which leads to a fast and reliable response [6]. A more accurate description of PC differentiates between semi-passive compliance, employed in Variable Stiffness Actuators

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