Realtime Collision Avoidance for Mechanisms with Complex Geometries

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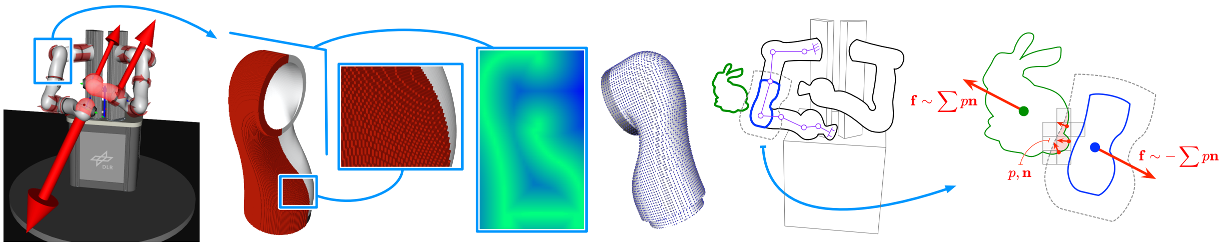

(a) (b) (c) (d)

Figure 1: (a) Virtual representation of the haptic interface HUG consisting of more than 14 robot links. Collision avoidance between the links and the environment can be performed in 1 kHz. Geometries do not have to be simplified and the framework is extensible to any mechanism. (b) Used data structures for mechanism links and environment objects: voxelized distance fields (left) and point-sampled representations (right). (c) After having configured the generic mechanism with its kinematic chain (purple) and geometries (green and dark blue), our system requires only the joint angles and information of the environment state. (d) The point normals ($\mathbf{n}$) multiplied by the penetration value (p) yield the repelling force ($\mathbf{f}$) applied to the links.

Abstract

This video presents a collision avoidance framework for mechanisms with complex geometries. The performance of the framework is showcased with the haptic interface HUG [3]. We are able to avoid contacts with the robot links and with moving objects in the environment in 1 kHz. The main contribution of our approach is its generic and extensible nature; it can be applied to any mechanism consisting of arbitrarily complex rigid bodies, in contrast to common solutions that use simplified models [2], [7]. In the preprocessing phase, first, the kinematic chain of the mechanism is described [1]. Second, we generate voxelized distance fields and point-sphere hierarchies for the geometry of each mechanism link and each object in the environment [6]. After that, our system requires only the joint angles and information of the environment state (e.g., object poses tracked by optical sensors) to compute collision avoidance forces. At runtime, each link is artificially dilated by a safety isosurface. If a point of an object goes through this surface, a normal force scaled by its penetration depth is computed and applied to the corresponding link. If humans are generically modeled as mechanisms and properly tracked, our system can also prevent collisions with them, ensuring save human-machine collaboration. Figure 1 illustrates the framework and its basic components. The multi-body collision computation architecture was first developed for virtual maintenance simulations with haptic feedback [5], [4], and thereafter extended to collision avoidance of mechanisms. A first prototype was previously published in [8].

Index Terms: Computing methodologies—Artificial intelligence—Planning and scheduling—Robotic planning; Computing methodologies—Computer graphics—Animation—Collision detection; Human-centered computing—Human computer interaction—Interaction paradigms—Collaborative interaction; Human-centered computing—Human computer interaction—Interaction devices—Haptic devices

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