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Research paper

A systems based experimental approach to tactile friction

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ABSTRACT

This work focuses on the friction in contacts where the human finger pad is one of the interacting surfaces. This 'tactile friction' requires a full understanding of the contact mechanics and the behaviour of human skin. The coefficient of friction cannot be considered as a property of the skin alone, but depends on the entire tribo-system. In this work, frictional forces were measured using a commercially available load cell. Parameters such as the hydration of the skin, the normal load on the contact and the roughness of the contacting surfaces were varied, whilst keeping the other parameters constant. The tests were performed under controlled environmental conditions. The total friction force is a combination of forces related to adhesion and to deformation.

A commonly made assumption is that, to describe the friction of human skin, the deformation component can be ignored and only the adhesive behaviour has to be taken into account. However, in this study it was found that the forces related to the (micro-scale) deformation of skin can have a significant contribution to the total friction force; this is valid both for dry conditions and in the presence of water, when hydration of the skin causes softening.

1. Introduction

The frictional behaviour of contacts in which the human finger pad is one of the interacting partners (often referred to as 'tactile friction') is of interest for a wide variety of applications. Examples include tactile perception, grip and haptic control when wearing disposable gloves for clinical use, as described by Burke et al. (1989) as well as the 'design for touch' of consumer products and packaging as discussed by Barnes et al. (2004).

A fair amount of literature is available describing the frictional behaviour of human skin. Two noteworthy overviews of results presented in literature are those by Sivamani et al. (2003) and Dowson (2009). Sivamani reports experimental values for the coefficient of friction μ ranging between 0.12 and 0.7, while Dowson reports significantly higher values, between 0.31 and 1.20. These values are obtained using a wide variety of test set-ups, ranging from small handheld devices (see e.g. Comaish et al., 1973 and Cua et al., 1990) to larger laboratory based set-ups (Sivamani et al., 2003; Asserin et al., 2000; Adams et al., 2007) that sometimes require more than one operator (Polliack and Scheinberg, 2006).

It needs to be noted that the coefficient of friction, as such, is not a material property but rather a system-parameter, meaning it depends on the combination of the two contacting materials, their surfaces and micro-geometry, any lubricants and the environmental conditions, as well as the operational conditions of the contact (Czichos, 1978). Thus, the large variation in values for the coefficient of friction that are reported in the literature is not surprising, considering the wide range of system properties under which they have been obtained.

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