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Roughness Discrimination Using Bioinspired Tactile Sensors

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Abstract : Surface texture discrimination using artificial tactile sensors has attracted increasing attentions in the past decade as it can endow technical and robot systems with a key missing ability. However, as a major component of texture, roughness has rarely been explored. This paper presents an approach for tactile surface roughness discrimination, which includes two parts: (1) design and fabrication of a bioinspired artificial fingertip, and (2) tactile signal processing for tactile surface roughness discrimination. The bioinspired fingertip is comprised of two polydimethylsiloxane (PDMS) layers, a polymethyl methacrylate (PMMA) bar, and two perpendicular polyvinylidene difluoride (PVDF) film sensors. This artificial fingertip mimics human fingertips in three aspects: (1) Elastic properties of epidermis and dermis in human skin are replicated by the two PDMS layers with different stiffness, (2) The PMMA bar serves the role analogous to that of a bone, and (3) PVDF film sensors emulate Meissner's corpuscles in terms of both location and response to the vibratory stimuli. Various extracted features and classification algorithms including support vector machines (SVM) and k-nearest neighbors (kNN) are examined for tactile surface roughness discrimination. Eight standard rough surfaces with roughness values (Ra) of 50 μm, 25 μm, 12.5 μm, 6.3 μm 3.2 μm, 1.6 μm, 0.8 μm, and 0.4 μm are explored. The highest classification accuracy of (82.6 ± 10.8) % can be achieved using solely one PVDF film sensor with kNN (k = 9) classifier and the standard deviation feature.

Keywords : bioinspired fingertip, classifier, feature extraction, roughness discrimination
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