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Detecting Embedded Objects Using Haptics with Applications in Artificial Palpation of Tumors

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In this paper, we describe a new method of measuring the stiffness of embedded objects. A tailor-made tactile probe equipped with a polyvinylidene fluoride-based (PVDF-based) piezoelectric sensor was used in the experimental tests. The structure of the probe is such that it deforms in specific ways when pressed against a large object. Two elastic materials, in the form of two concentric cylinders, with different moduli of elasticity compose the major structure of the sensor assembly. Young's modulus for a hidden object located inside a block is determined experimentally when the probe is applied to the outside of a rubberlike matrix. This matrix simulates the human organs (such as the breast). We propose a new analytical method that can be employed as a predictive tool for determining the stiffness and certain details of the geometry of embedded objects. In addition to the analytical method, a numerical approach is utilized in parallel, which is based on finite element analysis. The difference between the two theoretical methods is proven to be very small, and for all practical purposes, they can both be considered effective in our research. A reasonably good correspondence between the analytical and numerical approaches is obtained. The findings of this work have practical applications in detecting cancerous tumors in breast examination procedures.

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