Fusing Prior Analytical Knowledge into Neural Network for Tactile Information Representation

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***Abstract*—Soft magnetic sensors provide considerable merits for tactile perception, such as high precision, simple wiring, and easy expansion to large sensing areas. However, current magnetic sensors basically rely on data-driven methods, difficult to establish the relationship for the two-stage conversion (i.e., from magnetic signals to spatial displacements, then to force signals). In this study, a soft magnetic sensor is designed with magnetic powder and hyper-elastic rubber for multi-dimensional tactile perception. Besides, prior analytical knowledge is extracted to analyze the two-stage conversion according to magnetic dipole model and dynamic Young's modulus. Furthermore, a neural- network-based model is proposed to fuse the prior knowledge for precise tactile perception. Extensive analysis in terms of different magnet numbers are conducted in COMSOL environments. The results demonstrate the proposed method's high accuracy with relative errors of 0.10% and 0.53% for normal and tangential compressions, respectively. This fact also indicates the great potential of our method to various applications of tactile perception.**

***Index Terms*—Soft magnetic sensors, tactile perception, magnetic dipoles, dynamic Young's modulus, prior analytical knowl- edge**