Force Sensing and Closed Loop Control of an Electromagnetic-based Haptic Interface

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Abstract—In this study, we integrate a force sensing element with the magnetic-based wearable haptic device. We design and develop the modified wearable haptic device. We build a single-input multi-output proportional-integral-derivative (PID) for controlling the value of magnetic force by tuning the input current to the electromagnetic coils. We design and build a state observer for estimate the value of magnetic force from magnetic field measurements. We test the accuracy of the magnetic force value in three cases open-loop case, state-observer case and the case of direct control. In order to measure the advantage of incorporating a force sensing element into our haptic system, we conduct a comparison study between the three cases during rendering 3D shapes. Participants experimentally demonstrate an average success rate -%, -% and -% in distinguishing between four shapes for the three cases , our statistical analysis shows that effect of using a force sensing element on the average success rate is statistically significant for 95% confidence level.

Index Terms—Closed loop, force sensing, proportional-integral-derivative.

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