Detents

In our second experiment, we investigated the concept of electromagnetic detents in a continuous slider control.

Methodology

A slider control was mounted on the table (Fig. 1). For each trial, we applied different electromagnetic fields to simulate various detent configurations. A participant could shift the sliding knob to the left and the right as long as she wanted. After that, she was asked to report the number of detents she felt. The experimenter entered the data accordingly. During the test, the participant was not allowed to look at the control to ensure that she only used her sense of touch. She performed ten trials while we randomize the number of simulated detents between two and five in each trial.

Results

On average, test persons made 1.46 mistakes in ten trials (SD = 1.51), with three participants detecting all detents. Four detents were recognized in all cases but one (3.7 % false rejects), followed by three and five detents (11.5 % and 11.1 % false rejects, respectively). In the configuration involving two detents, nearly one third (30.0 %) of the decisions was incorrect.

Discussion

Our test shows that alternating polarization of adjacent magnets yields a suitable way to simulate detents. A positively polarized electromagnet next to one or two negative ones creates a strong force towards the detent position. While recognition rates are quite high for three to five detents, many participants had major difficulties to recognize the two detents configuration. In this case, the detent positions are about 8.4 cm away from each other. Between the detents, their pulling force is too low to overcome the friction and to attract the sliding knob. Accordingly, two adjacent detents should not span more than two magnets in such a setup. In this user test, our proof-of-concept prototype is aligned with the table's electromagnets. To allow detents in any orientation on the table, the density of magnets should be increased. Alternatively, dynamic magnetic fields can be used to simulate a higher magnet resolution. However, this requires tracking the sliding knob in real-time.

CONCLUSION AND FUTURE WORK

We applied electromagnetic actuation to render physical effects in tangible tabletop controls. Our studies show that electromagnetic force can be mapped to simulated properties, such as varying weight, friction, spring resistance, and dynamic detents. In future work, we will refine the hardware setup to achieve a higher output resolution. Furthermore, we intend to design and evaluate various applications that make use of dynamic physical effects in tabletop tangibles.

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