The Effect of Shape, Weight, and Diameter on Haptic Perception: An Active Haptic Sensing Study of the Predicted and Actual Grip Forces and their Impacts on Weight Detection Thresholds

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It is necessary to better understand human haptics because of the explosion of multi-sensory interfaces and growing need for devices that utilize weight perception to decide force required for object handling. Using the difference of the predicted and observed exerted force values, prosthetic and motor assist arms can be accurately calibrated to apply the force needed to tactically lift objects. This is also helpful for medical rehabilitation of stroke patients, invasive surgery, and steering wheel designing. This research analyzed: the correlation between predicted and observed force applied to weights, the effect of object shape (cylindrical/rectangular) and diametric properties to human haptic perception, the variance of force load between fingers, and the effect of weight detection thresholds. Two sets of weights (cylindrical and rectangular) with 3 small and 3 large diameter weights and a sensor-embedded glove were created to measure applied force. Subjects perceived each weight 3 times: first, they lifted the object as a personal reference for its weight; second, they applied their estimation for the predicted force needed to lift the weight; and finally, they lifted the weight again (observed). 5,040 pieces of data were obtained. One of the major findings was that most people underestimate the force needed to lift an object; 1.1 times the predicted value will alleviate this inaccuracy in prediction. It was also noted that the index finger applies the greatest force load while lifting. Additionally, it was observed that more force was applied when lifting a cylindrical shape than a rectangular prism.

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