The Effect of Prosthetic Arm Vibrotactile Indicators: An Active Haptic Sensing Study of the Effect of Vibration and Visual Stimuli on Perception Accuracy

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It is necessary to 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. Vibrotactile perception can help calibrate prosthetic, robotic, and motor assist arms to more accurately apply the force needed to haptically/tactically lift objects. This is also helpful for medical rehabilitation, invasive surgery, and gaming technology/steering wheel designing. This research analyzed the correlation between predicted and observed force applied to weights, the effect of vibration on haptic perception accuracy, male versus female perception, the magnitude estimation of vibration, and the effect of weight detection thresholds. A robotic system with a 3D-printed prosthetic arm was engineered and programmed to incorporate sensory feedback through vibration motors that directly connect to the user. As applied force increases, the intensity of the vibration motors simultaneously increase, allowing users to observe objects using vibrotactile perception. Furthermore, the arm can mimic the actions of a flex-sensor glove and use pattern recognition algorithms based on the input of the force applied to an object. Significant findings include: Most people underestimate the force needed to lift an object; 1.1 times the predicted value will alleviate this inaccuracy in prediction, the index finger applies the greatest force load while lifting, magnitude estimation for vibration is logarithmic, gender does not affect haptic perception accuracy, vibration detection thresholds are between 110%-190% of the reference, and vibration motors spaced 2.5 cm apart on the non-dominant forearm leads to the highest perception accuracy.