Hand function is quantified in different ways for clinical evaluation and object design. It is measured in the clinical environment to evaluate changes in function and levels of function with respect to the population. In design, it is used to understand what healthy hands can do so that objects can be made to fit the abilities. However, no hand function quantification method is currently applied to both evaluation and design, allowing for design of objects for individuals with reduced functional abilities in their hands.

The goals of the research were to: 1) develop a kinematics-based model of the 3D reachable space of the fingers of the hand, weighted by objective measures of functional ability; 2) assess the model's ability to evaluate levels of function between individuals with varying levels of hand function; and 3) demonstrate that the model could be applied to a design scenario to assist in designing handheld objects for groups of individuals, specifically groups with reduced functional abilities. These goals were addressed by three different research studies.

The first study presented the mathematical development of the weighted fingertip space (WFS) model and an initial evaluation of the model as applied to a theoretical 50th percentile male hand and nine healthy individuals. The WFS model transformed hand dimensions and finger joint ranges of motion into a three-dimensional representation of all of the points in space reachable by the fingertips. The reachable points were then weighted based on the number of ways each point could be reached, the range of fingertip pad orientations possible at each point, and the range of force application directions that could be applied at each point. The results showed that the model was capable of calculating and presenting the weighted functional space, and the theoretical 50th percentile male model showed similarities in size, shape, and weighting patterns to the models developed from the individuals. In addition, the models all showed distinct spatial patterns for each of the three weighting parameters. From this, it was shown that the WFS model could have potential application in both evaluation of function and design.

The second study examined the differences between WFS models of healthy and arthritic individuals to assess the model's ability to evaluate function for clinical purposes. Hand dimensions and ranges of motion were measured for 22 healthy and 21 arthritic individuals, and WFS models were calculated for each participant. In addition, the models from the individuals were combined to evaluate whether a universally reachable space existed for each group. The results showed that the model was capable of differentiating levels of function as the arthritic group showed lower functional values than the healthy group. Further, the group models showed that a universally reachable space existed for the healthy group, but not for the arthritic group. However, the arthritic group’s most reachable spaces overlapped with the universally reachable space of the healthy group.

The third study showed the WFS model's ability to aid in design by demonstrating that the model's 3D representation of functional weighting values could be mapped to the surface a 3D modeled handheld object and interpreted for a given task. The models developed in the second study were all mapped to the surfaces of cylinders of varying size representative of a handheld device, an auto-injector. The mappings of the model to the cylinders were used to evaluate the diameter of cylinder that best matched the abilities of the individuals. It was shown that for both the healthy and arthritic groups, the WFS models mapped the highest levels of functional weightings to the 40mm cylinder diameter. From this research, it was shown that the WFS model can be used to evaluate handheld object designs for groups of individuals based on objective hand function quantifications.