Abstract

The shoulder girdle plays an important role in the large pointing workspace that humans enjoy. The goal of this work was to characterize the human shoulder girdle motion in relation to the arm and recreate it with a humanoid shoulder girdle mechanism so as to ultimately improve the human-like motion of humanoids. The overall motion of the human shoulder girdle was characterized based on motion studies completed on test subjects during voluntary (natural/unforced) motion. The collected data from the experiments were used to develop surface fit equations that represent the position and orientation of the glenohumeral joint for a given humeral pointing direction. These equations completely quantify gross human shoulder motion relative to the humerus. The equations are presented along with goodness-of-fit results that indicate the equations well approximate the motion of the human glenohumeral joint. This is the first time the motion has been quantified for the entire workspace, and the equations provide a reference against which to compare the motion of candidate humanoid shoulder girdle mechanisms. A novel 2-degree-of-freedom parallel mechanism composed of two platforms, one leg with two revolute joints and two legs with spherical-prismatic-spherical joint combinations (1-RR, 2-SPS), is introduced and analyzed. The results from the data collection were used to find the optimal configuration for this mechanism to mimic human shoulder girdle motion. The results indicate that the optimized mechanism well approximates the motion of the human shoulder girdle, making it the first mechanism that replicates human shoulder girdle motion with minimal actuation. The methodology for incorporating the shoulder girdle mechanism into the shoulder-elbow complex is presented. The kinematic equations of motion for the complex were derived, and a qualitative analysis was completed that indicates the motion of the full system is similar to that of the human shoulder-elbow complex. The work presented here lays the groundwork for replicating complex human shoulder girdle motion with a relatively simple robotic system.