Abstract

One of the best methods of gait analysis is to use analytical models. In this project, first, the normal human gait was simulated using a two-dimensional biped model with 7 segments, i.e., a HAT segment representing head, arms and trunk, and 6 segments representing thighs, shanks and feet of the two legs. The foot-ground contact was simulated using a five-point penetration contact model. The elastic impact and friction effects are considered in the ground reaction force modeling. Optimization of the normal human walking model provided constant coefficients for simple PD controllers' (driving torque) equations that could reasonably reproduce the normal kinematical pattern. Then, in the second phase, the walking with above-knee prosthesis was simulated using the same model. Resulting torques form simulation of normal gait were then applied intact joint of the amputee model with a prosthetic leg equipped with a kinematical driver controller for the ankle and either a hydraulic, elastic or constant friction controller for the knee joint. Result in simulation of normal gait cycle indicate that the biped model of the present study effectively mimics the general characteristics of the human gait and validate from biomechanical point of view. Design optimization of the prosthetic joints was used to achieve the closet knee flexion and ankle plantar flexion pattern to that of the normal gait. Kinematical curve of amputee model for the optimum mechanical properties indicate that the prosthetic leg reasonably reproduces the kinematics of the normal gait under normal joint driving torques. It was concluded that a hydraulic knee controller could provide a better performance in reproducing the normal gait kinematics. Ankle plantar flexion is sensitive to change of stiffness, specially in the stance phase. The pattern of the ground reaction force is similar to those of the normal gait. Considering the result of changes in the knee mechanical properties it is evident that the decrease of damping coefficient and coulomb friction constant moment and increase of stiffness in the knee controllers have a considerable effect on knee flexion pattern specially during the stance phase.

Keywords: Gait, Walking kinematic, Dynamic modeling, Foot contact model, Optimization, knee controller, Above-knee prosthesis