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Energy Efficient Autonomous Lower Limb Exoskeleton for Human Motion Enhancement

Authors : Nazim Mir-Nasiri, Hudyjaya Siswoyo Jo

Abstract : The paper describes conceptual design, control strategies, and partial simulation for a new fully autonomous lower limb wearable exoskeleton system for human motion enhancement that can support its weight and increase strength and endurance. Various problems still remain to be solved where the most important is the creation of a power and cost efficient system that will allow an exoskeleton to operate for extended period without batteries being frequently recharged. The designed exoskeleton is enabling to decouple the weight/mass carrying function of the system from the forward motion function which reduces the power and size of propulsion motors and thus the overall weight, cost of the system. The decoupling takes place by blocking the motion at knee joint by placing passive air cylinder across the joint. The cylinder is actuated when the knee angle has reached the minimum allowed value to bend. The value of the minimum bending angle depends on usual walk style of the subject. The mechanism of the exoskeleton features a seat to rest the subject’s body weight at the moment of blocking the knee joint motion. The mechanical structure of each leg has six degrees of freedom: four at the hip, one at the knee, and one at the ankle. Exoskeleton legs are attached to subject legs by using flexible cuffs. The operation of all actuators depends on the amount of pressure felt by the feet pressure sensors and knee angle sensor. The sensor readings depend on actual posture of the subject and can be classified in three distinct cases: subject stands on one leg, subject stands still on both legs and subject stands on both legs but transit its weight from one leg to other. This exoskeleton is power efficient because electrical motors are smaller in size and did not participate in supporting the weight like in all other existing exoskeleton designs.

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