DESIGN OF A MICROCOMPUTER CONTROLLED KNEE JOINT FOR ABOVE-KNEE PROSTHESIS.

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Flexible control of the artificial knee joint of an above-knee prosthesis is the key issue of this project. To obtain enhanced patient safety and comfort, a conventional prosthesis is equipped with a control system. The actuator is a brake on the knee joint. Sensors measure the pressure under the prosthetic heel and metatarsal site, the knee angle and electro-myographic signals from hip muscles in contact with the socket. A digital control unit runs the control algorithm which yields the appropriate braking torque at each point of time. The control algorithm uses a finite state approach: for a number of distinct modes (level walking, ramps, stairs, sitting, etc.) a suitable control strategy is designed. EMG-signals provide the information needed to distinguish between the different modes. The level walking control algorithm is currently being developed and tested on prosthetic patients. A blocking of the knee joint during stance phase when knee flexion passes a threshold prevents undesired knee buckling. A damping of the extension and flexion movements of the knee during stance and swing phase is closed-loop controlled in gait time. Flexibility is brought into the design by adapting the desired knee angle pattern to varying initial conditions of the controlled phases.

ALIGNMENT OF A SINGLE-AXIS PASSIVE KNEE: NUMERICAL PREDICTION OF THE EFFECTS ON GAIT

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An inverse dynamics technique was used to numerically predict the movement of walking with a passive, single-axis right knee. Starting from an initial movement, the solution was found by successive iterations while minimizing a general criterion of walking. For the initial movement, a measured walking pattern with the right knee immobilized was chosen. The optimization criterion consisted of a fatigue criterion, mostly depending on the calculated joint moments of force, with additional constraints describing the passive properties of the right knee. The investigated alignment-parameter was the backward displacement d of the knee-axis relative to the original location. The computed results were compared to what is known from prosthetic practise. During single stance no flexion occurs. According to what would be expected, the maximal flexion decreases when the knee is placed more backwards. When the predicted step-parameters for the passive knee are compared with the data of the stiff knee, it is seen that the symmetry increases for the step time but decreases for the step length. As expected, it will cost more energy (according to the fatigue criterion) to walk with a passive knee. With increasing d, the energy cost decreases, since less energy is needed to stabilize the knee joint with the hip musculature during stance.

SIMULATION OF ABOVE-KNEE AMPUTEES SWING PHASE

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To give to the above-knee amputees a gait as similar as for normal persons, it is a prerequisite to study the effects of changes in the geometric and inertial features of the prosthesis, on the control torque during the swing phase. Therefore, we had studied a mathematical model, taking into account these mechanical properties, and carry out an experimental apparatus for comparison. Preliminary experimental results show a good agreement with various other published studies: (i) positive torque in flexion of the prosthetic leg, (ii) negative in extention, (iii) increasing in respect to the mass and the moment of inertia, (iv) variation with the position of the center of inertia of the prosthesis. Using, as input : (i) the mechanical characteristics of the prosthesis, (ii) the data (velocities and accelerations) from the experiment, the model enables a comparison of respective contributions, during the swing phase, of inertial, gravity, and damping, effects. Both experimental apparatus and model provide accurate informations upon the swing phase of the prosthesis. This study is of great interest to (i) the mechanical design of artificial legs, (ii) create the corresponding subroutines to act on the knee, for various activities of the amputee.