Industry Projects Submission 1

ME 639 - Introduction to Robotics

IIT Gandhinagar

Group Name: Coffee Bots

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We attest to abide by the stated collaboration policy: We understand that all sorts of collaboration are allowed, however, plagiarism will not be tolerated. If we use material from some other source (or from friends), we will cite them appropriately.

Controlling Exoskeleton Gait Trajectory

Statement of Our Understanding of the Project

Modeling human walking patterns to use in exoskeletons is required. The usual approach with most exoskeletons is to use a prerecorded pattern as a look-up table. Major challenges with these bots is walking pattern generation. There are various methods for planning walking patterns, depending on the application and structure of the exoskeleton. The basic necessity of this project is to execute the sufficient foot and ground clearance during the swing phase of gait. The swing phase of gait begins when the foot first leaves the ground and ends when the same foot touches the ground again. The swing phase makes up the other 40% of the gait cycle.

The current gait rehabilitation exoskeleton of TimeTooth Technologies does not take into account the weight shifting capabilities of the patients. Due to this, patients tend to scrub their feet on the ground. We need to implement closed loop control so that defined trajectory is followed even with weight shifting.

Also, given the link lengths, other exoskeleton parameters and locus of end effector trajectory, we need to apply inverse kinematics to find a solution (joint variables) that can be applied to make the exoskeleton follow defined gait.

Tentative Approach and Tools we May Need to Use (not more than 3-4 sentences):

We need to calculate the joint angles using the inverse kinematics approach, for that we'll need a tentative position and orientation of each of the joints during the static or moving configuration. It will be a closed loop problem with many iterations of ideal position. We'll need information about all the parts of the exoskeleton, to create an URDF model for simulation in Gazebo. We'll use ROS for software communication, writing codes in Python Script files and implementation in MATLAB. The human movements will be observed in real-time while walking with the exoskeleton due to a motion capture device. A real-time optimization technique and controller will be developed that uses motion data to calculate the desired cable tension values to be applied during human motion.

Key Assumptions Made in Approaching the Problem (in the enumerated list from)

1. The hip-joint is assumed to be a 2 Degree of Freedom joint.
2. At max, there will be 3- links(Hip-Joint, Knee-Joint, Ankle-Joint)
3. Here, we assume that the weight of the human is carried by the support at the back and the exoskeleton does not bear the weight of the human body.

Key Questions to Clarify the Requirement of the Project (in enumerated list form)

1. If we are implementing the solution in simulations, are we expected to develop fresh (new) ROS packages to simulate the model in Gazebo?
2. Is the Hip-joint a 3-DOF joint, if yes then do we have to calculate the equations of motion due to movement of this joint in the third direction?
3. Please explain the four terms in the statement in more detail:
    - Static Base
    - Moving Base
    - Translating
    - Hinged on the other side to single link inverted pendulum
4. Please explain the weight shifting problem mentioned in the problem statement.

Expected list of Deliverables (check all that apply)

- Relevant equations of the robotics solution
- Codes incorporating the solution
- Representative plots/or other representative results from the codes
- Explanation of the solution and the results
- Statement about limitations and future recommendations

- Others
    - Exoskeleton simulation files
    - Literature for identifying suitable cable-routing architecture for effective human-robot interaction.

A Highly Tentative Sketch of the Problem and Expected Solution

No sketch required for the solution as no changes in the already available exoskeleton.