Industry Projects Submission 1

ME 639 - Introduction to Robotics

IIT Gandhinagar

Group Name: The Usual Suspects

Names of Group Members: Srujan Pandya | Navneet Kaur | Jaydeep Ramnani

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.

Joint Impedance Control for an existing Exoskeleton

Statement of Our Understanding of the Project (in 200-300 words)

We are provided with an existing exoskeleton for the lower extremity rehabilitation whose parameters are assumed to be given and the dynamics can be calculated from the given parameters. Instead of the position control, we are supposed to utilise the joint impedance control approach, which relates the torque applied by the actuator to the angular position of the joint. Controlling the joint impedance helps control the external factors that act as a force of resistance to the external motion of the gait execution.

The position control approach helps the exoskeleton follow the desired trajectory; however, there will be a difference in the actual motion when the patient either resists or favours the pre-defined motion derived in the initial approach. We are supposed to encompass this difference and design the control system with a different approach i.e. joint impedance control. In this approach, we have to precisely control the velocity, amplitude and joint angles. Sensors attached to the patient would be required for the locomotion parameters and then the predictive analysis of the movement needs to be done.

The entire mechanism should be made of lightweight links with motors attached to it which will control the input torques. Ideally, the system should also sense the intent of the patient to move and eliminate the need to push/pull in order to recreate human walking. In the case of the 1-DOF rotational system, the patient effort can be quantified through an external torque at the joint and the dynamics (and controls) will subsequently follow. For a 2-DOF system, the translational motion should be controlled from the ankle/heel area to step forward, while the rotational motion will be controlled by the joints. A detailed study of the swing phase and the stance phase will also be required.

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

An ideal approach would include an initial CAD drawing for visualisation purposes, followed by modeling of a control system and a suitable selection of the joint parameters. The next step would be to code the control system with the specific desired trajectory (walking, standing march, etc). The last step would be the comparison between the desired trajectory and the actual trajectory from the gait analysis, along with the limitations, if any.

Tools: MATLAB, Python, Fusion 360 (only for visualisation purposes)

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

1. The demographic details of the individual are provided.
2. The model is individual specific or works within a small range of patient height and bodyweight.
3. The control system and the results of the gait analysis of the existing exoskeleton is known to us.

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

1. Are CAD diagrams mandatory? Or will the codes for the control/robotic system be enough?
2. Will the company be providing any information about the dynamics or controls of the existing system?
3. What are the details available about the patient? Or what is the range of the patient's required parameters (bodyweight, height)?

Expected list of Deliverables (check all that apply)

- ☑ ~~A brief explanation of the concept (including type of robot, number of links and joints, and other such details~~
- ☑ ~~Figures/drawings/sketches showing the concept~~
- ☐ Relevant equations of the robotics solution
- ☑ ~~Codes incorporating the solution~~
- ☑ ~~Representative plots/or other representative results from the codes~~
- ☐ CAD drawings
- ☐ Explanation of the solution and the results

- ☐ Statement about limitations and future recommendations
- ☐ Others (list as many as needed)
  - ☐ _____
  - ☐ _____
  - ☐ _____

A Highly Tentative Sketch of the Problem and Expected Solution