Progress report

13/09/2018

I have read a lot of literature (comprehensive list can be found in ‘Lit Review’ with a corresponding spreadsheet). I have also created a kinematic simulation with PID control in LabVIEW.

* End Effector type robots provide therapy which is comparable or superior to conventional physiotherapy, provided that sufficient intensity of rehabilitation is provided (essentially, provide a lot of access, obtain good progress) [19].
* A number of high-level control strategies are described, but the strategy of interest for MyPAM currently is Assistive control. A useful glossary of control strategies is described in [13].
* Assistive Control is a high-level strategy in which a device provides the physical assistance to aid the patient in accomplishing a task [13, 11].
* It is important to provide “Assistance-as-needed” (otherwise known as faded guidance) to the user to ensure good progression (also to prevent slacking) [11].
* A deadband is commonly used to allow for the usual variability in human movement (nobody moves along a perfect trajectory). A compliant trajectory is also important to ensure that the user does not need to use or experience excess force.
* All of the literature I have read which describes both high-level control strategies and low-level implementations used support the argument that the application of force or position control is not enough to ensure appropriate and safe interaction between the human and the robot, which must be considered as a coupled mechanical system.
* Further to this, all of the low-level control implementations I have seen described use position and either force or torque. I have not seen any described which use only position.
* Impedance control or admittance control are most commonly used as the low-level strategy
* With Impedance control the motion of the limb is measured and the robot provides the corresponding force feedback.
* With Admittance control the force exerted by the user is measured and the robot generates the corresponding displacement
* Impedance control is implemented in MIT-Manus. Admittance control is implemented in iPAM and MEMOS for example.
* I have also found an interesting article which describes a planar 2DOF robot with a fuzzy logic control system.
* Myoelectric measurements have been used by a number of devices to estimate patient intent, but these measurements are usually very noisy. These usually use the EMG signals as a control input to estimate the joint torque.
* When testing, be aware that spontaneous recovery exists.
* From [14] (MIT-Manus extension) - “*For robots interacting with the human, the most important feature of the controller is that its stability is extremely robust to the uncertainties due to physical contact. The stability of most robot controllers is vulnerable when contacting objects with unknown dynamics. In contrast, dynamic interaction with highly variable and poorly characterized objects (to wit, neurologically impaired patients) will not de-stabilize the impedance controller above*”
* Low friction = backdrivable = very good = compliant.
* Mechanical Impedance = force/velocity

Next steps:

Add mass and inertia to the simulation.

Continue to explore low-level control strategies.

Revise DH, frame transformation. Learn how to implement Jacobian matrix for IK.