**Weekly Report – W1 Fall 2022**

**Topic remained**

1. Interaction force modeling between human body and robot arm
2. Raileigh Dissipation function (velocity dependent potential)

**Progress and Work done**

1. I have looked up multiple papers and books during last week about this topic, and this problem can be classified into the following main aspects, how to apply the interaction force into the governing equations of motion (dynamics) and how to model the force.

(1). Here I will list some classic examples to apply the force in the equation,

* *Handbook of Robotics*

: motor torque

: dissipative friction torque

: typical unknown external joint torque, where

, Cartesian collision wrench.

* *Estimation of human impedance and motion intention for constrained human–robot interaction*

: control force vector

: interaction force vector between human and body, where

: damper matrix of human

: stiffness matrix of human

: human motion intention

and can be time-varying or constant, is time-varying; damper and stiffness matrices domain the model of human arm, so mass is ignored.

* *Control of Generalized Contact Motion and Force in Physical Human-Robot Interaction*

: control torque

: joint torque resulting from contact interaction force

(2). Since we have known the basic format in part (1), now we have to confirm how to model the interaction force; in most papers, the interaction between human and robot can be seen as a mass-spring-damper system, we can write the interaction force in .

There are basically two methods to identify the damping and stiffness matrices, one is by physical experiments, another one is to use "human impedance learning" to obtain estimated matrices.

1. The damping energy is classified as potential energy due to the definition of Raileigh Dissipation Function, I have looked up some background knowledge of this, which has been shown below.

In physics, Rayleigh dissipation function, named after Lord Rayleigh, is a function used to handle the effects of velocity-proportional functional forces in Lagrange mechanics. If the frictional force on a particle with velocity can be written as , the Rayleigh dissipation function can be defined for a system of N particles as

The force of friction is negative the velocity gradient of the dissipation function, . The function is half the rate at which energy is being dissipated by the system through friction.

1. During last week, I also helped Miao with his program to do some validation and calibration.

**Plan**

1. As one of the papers has mentioned the reason for using the simplified version of interaction force ignoring the mass (or inertia) part, I think I should know more details about it, for example, how much difference between remaining and ignoring the term, under what circumstance we can make this assumption or simplification.
2. And I also need to find some reliable resources to identify the damping and stiffness of human body in terms of different parts.