ME5402/EE5106R ADVANCED ROBOTICS

Part II: Dynamics

Mini Project II

Instructions:

1. Put your name and matriculation number on the cover page, and submit the hardcopy of your answer to Dr. Shuzhi Sam Ge (Room E4-05-28) or to my mail box in the ECE general office, by **21 April, 2017**. Submit the original codes of the simulation via IVLE with the file name as your registration number.

   Example: If your registration number is HT093376M then the file names must be HT093376M.rar.

2. Students are supposed to work in group of two or three. While the work is group and encourage collaboration, each student must have his/her own individual contribution and effort and should be clearly stated in his/her **individual report**. Identical reports will be subject to penalty and or disciplinary actions of the university.

3. Please submit the Groupings to me next Monday.

Background:

Increase in life expectancy and population aging has contributed to the rise of the number of elderly individuals living with an age-related disability or a chronic disease. Meanwhile, we face a significant shortage of nursing professionals. This acute need provides significant opportunities for roboticists and AI researchers to develop assistive technology that can improve the quality of life of our senior population, and help caregivers become more effective in their activities. Different from traditional robots, which are considered task-driven machines, designed to physically interact with the surrounding environment and to automate dirty, dull, and dangerous task, social robots are designed for completely different environments and application scenario – those that involve physical or affective interaction with human beings by following social behaviors and rules attached to its role. The potential for application of social robots is aplenty. By introducing social robot in home, we are able to promote wellness to make people lead a quality lifestyle.

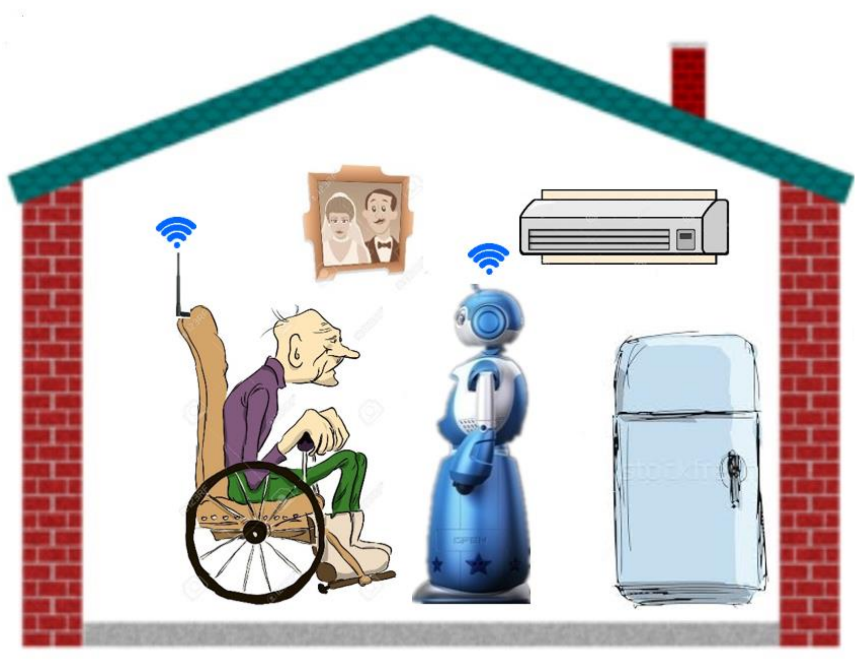

Figure 1: Social Robot companying elders

Scenario:

In this project, we consider the modeling and control of the social robot Adam developed in Social Robotics Lab, NUS, as shown in Figure 2. Adam has the ability to serve the elders, provide companionship and other special events as well as to give information intuitively through multiple interactive channels

For the modeling and control, each robotic arm is considered to be identical with two links and each link is assumed to be cylinders with zero radiuses and the mass of each link is assumed to be lumped in the middle of the link. For each arm, the lengths of both links are 0.25m, the lumped masses of both links are 2.3kg, and the inertias of both links that passing through the center of mass are 0.03kgm$_2$.

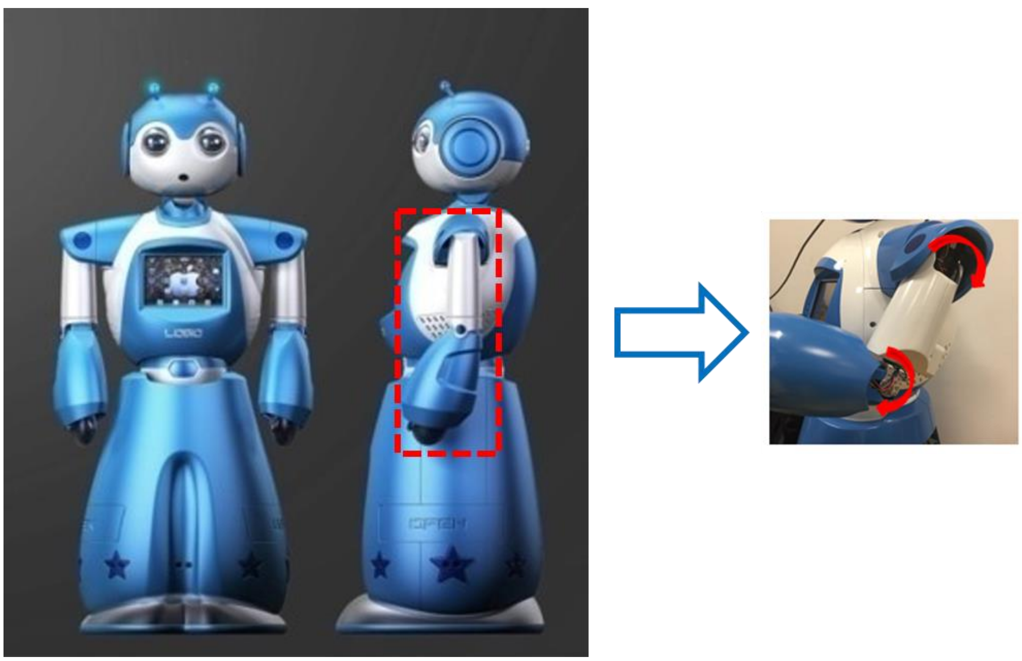

Figure 2: Social Robot Adam in Social Robotics Lab (SRL), NUS

Note:

1. You are free to present your work in any environment, such as C++, python and ADAMS, of your choice.
2. You are free to make any assumptions needed, but with proper explanation.

List of Projects:

For the robotic arm depicted in Figure 2, please accomplish the following tasks (each group member choose one sub project):

Project 2-1: Modeling and Animation of Robotic Arm

1. Do literature review on social robot design and virtual robot simulation.

2. Develop the D-H model of the robotic arm in Figure 2, and derive the Lagrange-Euler equations.

3. Design a CAD model for Adam and his working circumstances using any software or tools of your preference such as Utility 3D, Solid works, etc, use the kinematic and dynamic equation to guide your design.

4. Design a simple control to make each joint of the virtual robotic arm in Figure 2 to achieve simple social service tasks such as serving drinks, cleaning tables, interaction with elders and etc.

5. Optional: Discuss the design considerations to ensure a smooth and safe operation of social robots. Please clarify the ideas with necessary visual aids. List the problems that you identified, and you are encouraged to propose any new or novel methods to solve them.

Project 2-2: Interaction Control of the Robotic Arm

1. Do literature search on interaction control of the robotic arm.

2. Develop the D-H model of the robotic arm in Figure 2, and derive the Lagrange-Euler equations.

3. Design impedance control for the robotic arm and discuss the effect of different selection of impedance parameters on the interaction performance.

4. Design Hybrid Force/ Position Control for the robotic arm

5. Do a simulation study to demonstrate the interaction control performance of the robotic arm using any software or tools of your preference, such as MATLAB, MRDS, Visual Studio, ADAMS, SolidWorks, etc.

6. Optional: Adam is supposed to perform handshaking with humans for guest reception, please formulate and model the problem of the robotic handshaking and choose proper interaction control methods as solutions. Discuss the results and limitation.

Project 2-3: Constrained Control of the Robotic Arm

1. Do literature review on the constrained tracking control of the robotic arm.

2. Derive the Lagrange-Euler equations for the robotic arm and design a PD or PID control to guarantee each joint of the robotic arm in Figure 2 tracks any given desired trajectory.

3. Design constrained control to make each joint of the robotic arm track any given desired trajectory with limited tracking error. (Hint: you may refer to [1] for one of the possible controls. You are encouraged to develop the control with other methods with necessary theoretical verification.)

4. Do a simulation study to demonstrate the constrained and PD/PID control performance of the robotic arm, using any software or tools of your preference, such as MATLAB, MRDS, Visual Studio, ADAMS, SolidWorks, etc and compare the results.

5. Optional: Design of adaptive neural network control for the robotic arm to handle uncertain parameters in the dynamics. Use simulation to demonstrate the performance. (Hint: you may refer to [2])

Reference

[1] Tee K P, Ge S S, Tay E H. Barrier Lyapunov functions for the control of output-constrained nonlinear systems[J]. Automatica, 2009, 45(4): 918-927.

[2] S.S. Ge, T.H. Lee and C.J. Harris, Adaptive Neural Network Control of Robotic Manipulators, World Scientific, London, December 1998.