CPSC 526: Computer Animation
Assignment 5

Due Fri March 20, 2015

1. (7 points) In this question you will be developing a 2D dynamics simulation of single-link pendulum and a multi-link pendulum using maximal coordinates, hinge constraints, and simple Euler integration. Each link of your pendulum should be 1 m long and have a mass of 1 kg. You can model it as a line segment or a narrow rectangular block. Use a default time step of 0.01 s. Email a link to the code to Michiel and arrange a time to demonstrate the results. A specific set of intermediate steps and results is given below. You are free to code this in your favourite language of choice. However, you should not use existing dynamics or physics-based simulation libraries. Feel free to post any questions to Piazza.
   (a) (2 points) Consider a one-link pendulum with no friction. Write out the full equations of motion using maximal coordinates, i.e., with equations for the unconstrained motion of the pendulum link and additional equations for the hinge constraint. Explicitly write out all terms, but structure it in the block form used in class. Then develop a simulation of the one-link no-friction pendulum, dropped from an angle of 45°. Animate the resulting pendulum and also animate a simple bar graph that illustrates the sum of the kinetic and potential energy. By default, the energy will slowly increase over time. First implement your method without constraint stabilization, and then add constraint stabilization (simple Baumgarte stabilization is recommended).
   (b) (1 point) Add frictional damping to the above simulation.
   (c) (2 points) Repeat part (i) for a four-link pendulum, although it is no longer necessary to write out the full equations of motion (although your code will still need to implement them!).
   (d) (1 point) Add frictional damping to the four link pendulum.
   (e) (1 point) Add a ground plane below the four link pendulum and use a penalty force method to apply an external force to the end of the bottom link such that it does not penetrate too far into the ground plane and instead slides along the surface. Use a smaller time step as needed. The ground plane can be frictionless or you can also experiment with adding friction.
   (f) (3 points) Optional: implement a 3D pendulum with point-to-point constraints between the links. You may wish to add some damping to the system.