Legged Robotics

HW #5

Problem 1 – 5 pts.

What is the minimum duty factor for a stable walking of a multi-legged robot? Why? Explain your answer.

Problem 2 – 15 pts.

a) Using the equation below, for a given foot velocity of $u(t)$, find the duty factor β which provides the maximum speed/velocity of the robot $v(t)$. What do you conclude? Describe your answer.

$$u(t) = \frac{\beta(t)}{1-\beta(t)} v(t)$$

b) Using MATLAB, plot a graph for the equation above with horizontal axis of $v(t)$ and vertical axis of $u(t)$. Change $\beta(t)$ from $\beta = 0\ to\ \beta = 1$ with intervals of 0.05 all in a single plot. What do you conclude from your plot? Describe your answer.

Problem 3 – 20 pts.

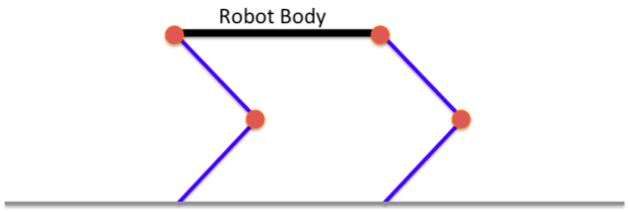
For a n-legged walking robot, plan a foot trajectory to follow a **sinusoidal** trajectory (sinusoidal function wrt ground in the form of $y = A \cdot sin(\omega x)$ where y is the vertical movement and x is the horizontal movement). Consider a foot average horizontal velocity of $0.16\ m/sec$ with respect to the ground while the body moves with an average constant velocity of $0.04\ m/sec$ with respect to the ground. Also, consider stride length of $0.16\ m$ for the foot. Show the position and velocity graphs corresponding to the foot trajectory. If you think something is missing or not given, simply make your own assumption and clarify that in your solution.

What you need to submit for this problem is the six graphs shown in the lecture. Use MATLAB. You are not supposed to come up with joint angles and velocities since the leg configuration of the robot is not specified.

Problem 4 – 60 pts. + 30 pts. EC.

Design a quadruped walking robot, with 2-DOF planar legs, to have a constant walking velocity of 0.1 m/s. For simplicity, design planar 2-DOF legs for the robot as shown below. You are the designer! Therefore, choose the size of the robot and legs based on your design insight.

a) Gait Planning: Plan a regular forward wave gait with a duty factor of 0.75 and show the gait in the form of the kinematics phase diagram. (5 pts.)
b) Foot Trajectory Planning: Come up with a smooth continuous foot trajectory in which the foot lifts up and touches down vertically. For example, you cannot use the sinusoidal trajectory because it does not lift up / touch down vertically. Show position and velocity plots for the foot tip of each leg during one complete walking cycle time. (15 pts.)
c) Joint Angles: Calculate the positions of all joints for one complete walking cycle time and show the results in 6 plots: one plot per leg – each plot/leg includes three joints. (15 pts.)
d) Joint Velocities: Calculate the angular velocities of all joints for one complete walking cycle time and show the results in 6 plots: one plot per leg – each plot/leg includes three joints. (15 pts.)
e) A simulation (video) of a leg in swing phase with your designed parameters. (10 pts.)
f) **Extra Credit (30 pts.)**: A simulation (video) of the whole robot walking. Hint: you **MUST Synchronize** the motion of swing and supporting legs during one complete walking cycle to get a correct and smooth/continuous motion for the body!



Side view of the quadruped robot with planar 2-DOF legs

Good Luck!