University at Buffalo, Computer Science and Engineering

CSE 468/568: Robot Algorithms

Homework 1: Kinematics

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This is the first assignment of the class and carries 5% of your total grade. It is due on 3rd March (Monday) before class. Please start early. I **WILL NOT** encourage any postponements if you do not have a valid reason, and have not informed me of it well in advance.
Please also take time to review the graduate/undergraduate handbooks. It is UB policy to give an **F** grade if any form of plagiarism is detected. Please do not put yourself in this situation. These assignments are fairly straight forward, and are meant to enhance your understanding of the material in class. If you start early, it should be easy.

Kinematics of Marvin

You are given Marvin, a not-so-paranoid android robot whose configuration and dimensions are as shown in Figure 1. Marvin is outfitted with two fixed standard wheels aligned with the robot chassis but imbalanced, and asymmetric. Its left wheel is smaller than the right one. The diameter of the left wheel is r meters while the diameter of its right wheel is $2r$ meters. Further, it is asymmetric with its center of gravity(P) closer to its left wheel than its right wheel. P is at a distance l meters away from the left wheel and $2l$ meters away from the right wheel.

1. Derive the linear and angular velocities of Marvin in the robot frame assuming that $\dot{\phi}_l$ is the angular velocity of the left wheel and $\dot{\phi}_r$ is the angular velocity of the right wheel.
2. Let us assume that $l = 1m$ and $r = 1m$. Calculate $\dot{\phi}_l$ and $\dot{\phi}_r$ of Marvin at which it maintains a robot velocity of $3m/s$ along a straight line.

Marvin with sensors

Realizing that you cannot do anything with Marvin without sensors, you outfit it with two cameras as shown in Figure 2. However, this now moves the center of gravity of Marvin $1m$ further up the body to point P_2 as shown.

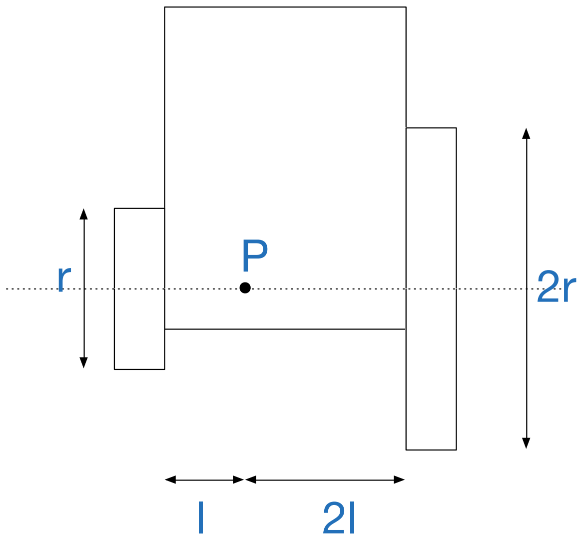

Figure 1: Marvin, the paranoid android

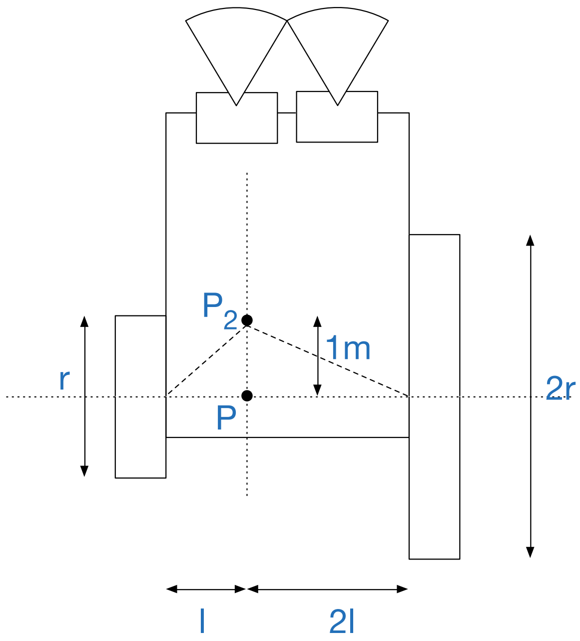

Figure 2: Marvin outfitted with sensors

1. Derive the linear and angular velocities of Marvin in its frame, given its change in center of gravity, in terms of the angular velocities of the wheels ($\dot{\phi}_l$ and $\dot{\phi}_r$)
2. Re-calculate $\dot{\phi}_l$ and $\dot{\phi}_r$ to maintain a linear robot velocity of $3m/s$ along a straight line.

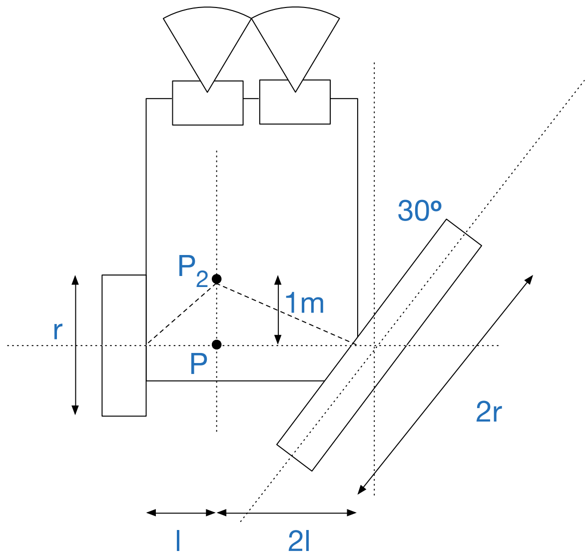

Figure 3: Marvin with right wheel mis-aligned

Marvin with injury

As we are driving Marvin along, its right wheel hits a pothole causing the wheel to lose alignment. The right wheel is now rotated 30· in the clockwise direction as shown in Figure 3.

1. Derive the linear and angular velocities of Marvin in the robot frame given the new orientation of the right wheel, in terms of the angular velocities of the wheels ($\dot{\phi}_l$ and $\dot{\phi}_r$)
2. Re-calculate $\dot{\phi}_l$ and $\dot{\phi}_r$ to maintain a linear robot velocity of $3m/s$ along a straight line.

Extra credit

1. Analytically, derive how the linear and angular velocities in robot frame are related with a fully functional Marvin with and without sensors.
2. Analytically, derive how the linear and angular velocities in robot frame are related with a fully functional Marvin with sensors, and an injured Marvin.