**Objective**

- Currently, the ways robots move are not as maneuverable for traveling in multiple directions.
- Our mission is to create a robot that can be more flexible, agile, and overall more maneuverable.
- The current goal is to start building a prototype for a self-balancing robot.

**Backgrounds**

- We are trying to create the possibilities for robots to stand on the spherical ball and define it a novel way to move.
- (limitations of current vehicles and robots)
- The future of the spherical driving robots is unlimited. The possible Goodyear car or some other driven machines
- We are trying to create the possibilities for robots to stand on the spherical ball and define it a novel way to move.

**System Modeling and Simulations**

We started by breaking down our systems into two separate mechanisms. We studied the model of a DC motor and analyzed its torque. Then we turned to analyze the classical inverted pendulum example to study the similarity between the example and our system. Lastly, we combined the two models together to obtain our final model.

Our final system model includes three main parts: robot body, motors and wheels, and spherical ball. We assume no slip condition, which means that when the motor rotates angle \( \Psi \) in clockwise direction and the body will be able to tilt angle \( \theta \) in the clockwise direction.

\[
E = \begin{bmatrix} \theta \\ \dot{\theta} \end{bmatrix} \quad (state \ variable \ \theta)
\]

\[
\dot{E} = \begin{bmatrix} 0 & 1 \\ -K_r & -K_r \end{bmatrix} E + \begin{bmatrix} 0 \\ r_1 \end{bmatrix} \quad \text{(modeling of an inverted pendulum on a cart)}
\]

\[
V = \begin{bmatrix} r_2 K \ \\
2 r_2 K \end{bmatrix} E + \begin{bmatrix} 0 \\ r_1 \end{bmatrix} \quad \text{(modeling of a DC motor)}
\]

The simulation on the left shows the transient response of the system without input voltage. One can see that any angle \( \theta > 0 \) will converge to 0. The simulation on the right shows the result of the controlled system. All angles will converge to 0.

**Final Deliverable**

The final deliverable is capable of balancing itself on a stationary sphere. By reading the angles from the IMU sensor, we were able to adjust the angle with the motor force calculated by the PID control model. The deliverable successfully met the requirements of what we tried to do so far.

**Future developments**

The project development and future implementation can be divided into three parts: the self-balancing robot on a sphere, the spherical drive robots, and the real industry application. In the future, we may make the robot control the movement of the spherical ball and also have the chance to put the load on the spherical robot and give it more functions.

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