Goals:

Use state of the art gait generation and motion planning to control Boston Dynamics Spot in Webots to walk on uneven terrain while being robust to various external pushes/forces. The evaluation of the system will be having Spot walk on unseen and technical terrain to reach a goal state, with added pushes at random times.

Roadmap

1.) Set up Webots sim in flat environment, use perfect sensors and actuators, and utilize MoveIt to have Spot walk around.

2.) Replace MoveIt with SOTA gait generation methods - (Alternate Method: Train multiple policies with RL, have high level controller to choose policy)

3.) Add noisy actuators and sensors to more resemble reality

4.) Replace flat world with uneven terrain

5.) Make gait generation methods robust to external forces (First on flat world)

Teammates

- Chris Beggs - Took UMich's DL course, (Slowly) going through Sergey Levine's Deep RL course, plus I'm going through literature about this stuff to prepare.

Stretch Goals/Things I could add

- Add obstacles to world and use SLAM
- Compare gait generation methods with Deep RL
- Various challenges on final project competition
- Socially Aware Motion Planning
- Add manipulator for object grasping

Motivation

I do want to work on a robot with joints/manipulators because it's an interesting problem. Robots like Spot are better equiped for technical terriain that cars are not able to reach. Also, smaller quadrepeds are able to achieve a better relationship with humans than cars. Plus I love dogs.

Timeline Risks

Mostly just some aspect of the project taking much longer than anticipated, like implementing some aspects of different papers, unexpected software issues, etc.

Related Work

- **Gait Generation:**
  - Discovery of Complex Behaviors through Contact-Invariant Optimization *Mordatch et al.*
  - Feature-Based Locomotion Controllers *Martin de Lasa et al.*
  - Fast and Flexible Multilegged Locomotion Using Learned Centroidal Dynamics (Source code included) *Kwon et al.* - http://calab.hanyang.ac.kr/papers/flexLoco.html

  - Gait and Trajectory Optimization by Self-Learning for Quadrupedal Robots with an Active Back Joint *Masuri et al.*
  - Automatic Gait Pattern Selection for Legged Robots, *Wang et al.*
  - Adaptation of Quadruped Gaits Using Surface Classification and Gait Optimization *Kim et al.*
  - A Robust Quadruped Walking Gait for Traversing Rough Terrain *Pongas et al.*
  - Robust Gait Synthesis Combining Constrained Optimization and Imitation Learning *Ding et al.*
  - Gait and Trajectory Optimization for Legged Systems Through Phase-Based End-Effector Parameterization *Winkler et al.*

- **SLAM**
  - ORB-SLAM3: An Accurate Open-Source Library for Visual, Visual-Inertial and Multi-Map SLAM
  - ORB-SLAM2: an Open-Source SLAM System for Monocular, Stereo and RGB-D Cameras