1 How does Spot actually work?

Mode	Gaits	GAIT	CHARACTERISTICS	BEST FOR
STANDARD MODE	Operational gaits	Walk	Dynamically stable movement	Walking around
		Stairs	Slows Spot's speed and pitches robot to better see stairs while descending	Climbing or descending stairs
		Amble	Stable gait where one foot touches down at a time	Mobility demos, less stable
		Crawl	Three feet touch the ground at all times	Walking on uneven terrain, most stable
DEMO MODE	Demo gaits (less stable)	Hop	Raises and lowers one front and opposite hind foot together for five counts	Mobility demos, less stable
		Jog	Raises and lowers one front and opposite hind foot together	Mobility demos, less stable

TUNABLE PERCEPTION

Obstacle Avoidance	Helps Spot maintain a minimum distance from obstacles • In normal environments, obstacle avoidance should be kept on • In certain environments (such as outdoor areas with tall grass or foliage) Spot's performance may be improved by turning obstacle avoidance off
Walk on Grated Floors	Improves Spot's performance on grated flooring • To be turned on when Spot traverses on grated flooring • May also help Spot navigate flooring that has a very repetitive pattern
Ground Height Detection	Helps Spot navigate over obstacles approximately 12" or less in height • In normal environments, ground height detection should be kept on • When turned off, Spot is essentially blind, navigating only by contact • In certain environments (such as outdoor areas with tall grass or foliage) Spot's performance may be improved by turning ground height detection off
Stair/ Surface Edge Avoidance	Keeps Spot from navigating too close to edges • In normal environments, edge avoidance should be kept on • In certain environments (such as outdoor areas with tall grass or foliage) Spot's performance may be improved by turning ground height detection off
Plan Around Obstacles	Spot allows extra margin around obstacles when using touch to go • In normal environments, edge avoidance should be kept on

Spot has the user specify gaits before hand. Using the wrong gait for the task means spot can fall.

2 Paper Notes

2.1 Automatic Gait Pattern Selection for Legged Robots

- Model the robot as a single rigid body along with n_l mass-less legs.

2.1.1 Problem Description:

- $\tau = [r, \Theta]^T$
  - Where $r \in \mathbb{R}^3$ is Center of Mass(CoM) position
  - $\Theta \in \mathbb{R}^3$ is yaw, pitch, and roll angles
-

2.2 Gait and Trajectory Optimization for Legged Systems Through Phase-Based End-Effector Parameterization

2.2.1 Related Work

Commonality with the following Dynamics models are that they all predefine some motion before hand.

- *Linear Inverted Pendulum model* (LIP) which only optimizes over the Center of Mass position.
  - By modeling the robot as an inverted pendulum, the position of the Center of Pressure (CoP) or Zero-Moment Point(ZMP) can be used as a substitute for contact forces, and is used to control the motion of the Center of Mass.
  - Fast and pretty effective.
  - BUT this method uses predefined footholds.
- Another common model in Trajectory Optimization is the *Centroidal Dynamics* model.
  - Projects the effects of all link motions onto 6-dimensional base.
  - the input that drives this system are the contact forces, as opposed to the Center of Pressure in the Linear Inverted Pendulum or the joint torques in the full rigid-body dynamics.

2.3 A Robust Quadruped Walking Gait for Traversing Rough Terrain

2.3.1 Things to Note:

- "Obviously, a robust balancing controller is the prerequisite for legged locomotion, and it is usually characterized by a special control variable, for instance, the locations of the center-of-gravity (COG) in static walking, or the zero-moment-point (ZMP) in dynamic walking. "
- In this paper we address how to generate a robust COG trajectory for a quadrupedal walking robot, and how to convert this plan into an appropriate joint-space walking pattern.
- They adjust the COG trajectory continuously in response to the current movement of the feet of the robot, in smooth twice differentially way.