Spot

Spot is a commercial zoomorphic robot manufactured by Boston Dynamics designed to be used in a wide range of applications - an article by RumbleRum titled “Boston Dynamics Dog Robot ‘Spot’ Has Been Employed By Norwegian Oil Company To Detect Gas Leaks” reports an application in which Spot assumes the role of an autonomous industrial robot whose job is to look for potentially life-threatening gas leaks within a complex environment.

Spot as a base product allows basic gaiting and full vision of surroundings. The basic package comes with five monochromatic cameras [2] that overall produce 360 degrees of vision that allow motion controllers running on the onboard computer to not only react to unexpected obstacles but also plan motion predictively - this is done via simultaneous localization and mapping (SLAM) algorithms. Although the details on the types of actuators used is proprietary, by observing that Spot can perform dog-like, natural gaits, jump and absorb the impact upon landing on the ground, and react to external forces that push it to the side, there are certainly embedded force sensors that feed into reactive controllers.

A variety of sensors can be added to Spot by attaching modules as payloads [3], allowing expandability of applications. For example, Spot can be a social robot in the sense that it can replace the role of a therapy dog - in this case, a full color camera or heart rate monitor module can be utilized to better effectively guage a human’s mental state and inform internal algorithms to plan Spot’s nurturing behavior. Conversely, Spot can be a teleoperated robot for hazardous situations. An external robot arm and grasping end effector can be attached, enabling a human to remotely control Spot to walk into a dangerous environment and pick up objects. In the case of Norwegian Oil Company, an atmospheric sensor was attached to the payload interface of Spot, allowing the detection of anomalies in the air indicative of a gas leak [1]. Additionally, since Spot was programmed to autonomously patrol the entire worksite, this saves on human labor.

The advent of autonomous patrolling agents such as Spot gives high-risk industries a cost-effective and thorough method to increase safety. It is no surprise that many industrial tragedies occur because of human error and incompetence, not to mention errors in badly-maintained system sensors and controllers. Spot provides an external and independent way to check the integrity of a system.

Spot’s monochromatic vision system may pose an issue due to the loss of color data. In an instance where a certain environment may have similar-looking textures, color data is key to distinguishing features such as the foreground and the background, information that is required for predictive and reactive motion planning. Moreover, since Spot’s main form of travel is gaiting, fixed cameras on the body are subject to shaking and distortion. Perhaps this issue can be remedied via stabilization algorithms that fuse inertial sensor readings.

Technical issues that result from the complexity of Spot can hinder its productivity. With 12 actuators, any one of them can break from unexpected backdriving. Another issue can be onboard power distribution. The constant forces required to hold Spot up and computation of onboard CPU/GPUs translate to high power consumption. Plus, Spot needs to be compact in size which constrains the size of the battery.

Although Spot physically does not present a threat to a human, the modules attached to its payload can. For example, if Spot was tasked to cut up fruits, monochromatic cameras may detect a human hand as a fruit. In that case, some reactive behavior such as scream detection via microphone must be implemented to act as an emergency stop. In general, the objective of Spot must be cautiously designed to not permit greedy and irrational behavior. Moreover, the payload interface must implement a verification protocol that guards against third-party modules that enable dangerous actions - the modules must be electronically verified by Boston Dynamics.

Works Cited

[1] Hanif, Maheen, *Boston Dynamics Dog Robot 'Spot' Has Been Employed By Norwegian Oil Company To Detect Gas Leaks*, RumbleRum, 2020, https://www.rumblerum.com/boston-dynamics-robot-dog-spot-norwegian-oil-company-gas-leaks/

[2] Boston Dynamics, *About Spot*, accessed Jan 2022, https://dev.bostondynamics.com/docs/concepts/about_spot

[3] Boston Dynamics, *Spot*, accessed Jan 2022, https://www.bostondynamics.com/products/spot