Master/Bachelor Thesis - Semester Project

Pathological gait generation for rat robot with spine-based damage control

Background

Quadruped robots exhibit excellent mobility across various complex terrains [1]. This capability is attributed to their ability to select suitable footholds for different terrains to accomplish tasks [2]. However, if a limb suffers an irreparable failure during movement, the robot's ability to choose footholds is severely effected, leading to significant differences in the motion of its two sides, as illustrated in the figure. In this case, the robot generally needs to employ damage control mechanisms to continue performing its predefined tasks [3]. Currently, damage control is primarily applied to hexapod robots and is rarely used in quadruped robots. This is because, under damage conditions, the direction and dynamic balance of a quadruped robot's movement are easily disrupted, making task execution challenging.

In the natural world, animal locomotion involves not only quadrupedal movement but also the influence of the spine on movement direction and balance [4]. Based on this, our research will explore damage control in quadruped robots using a rat robot equipped with a flexible spine. The goal is to generate pathological gaits when a limb suffers irreparable damage, enabling the robot to continue completing its tasks.

Your Tasks

In this thesis, your task will involve acquiring advanced knowledge of robotic control and then designing a spine-based pathological gait for a rat robot. Specifically, you will:

1. Learn the fundamental principles and applications of controlling quadruped robots.
2. Reproduce the results from existing research on robot gait.
3. Select one of the proposed ideas (reinforcement learning method or model-based control) and investigate a novel algorithm for damage control of the rat robot.

Requirements

High self-motivation; Over Six month working time; Related experiences or knowledge; Python programming experiences.

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Reference

[1] Lee, J., Hwangbo, J., Wellhausen, L., Koltun, V. and Hutter, M., 2020. Learning quadrupedal locomotion over challenging terrain. *Science robotics*, *5*(47), p.eabc5986.

[2] Chai, H., Li, Y., Song, R., Zhang, G., Zhang, Q., Liu, S., Hou, J., Xin, Y., Yuan, M., Zhang, G. and Yang, Z., 2022. A survey of the development of quadruped robots: Joint configuration, dynamic locomotion control method and mobile manipulation approach. *Biomimetic Intelligence and Robotics*, *2*(1), p.100029.

[3] Mailer, C., Nitschke, G. and Raw, L., 2021, June. Evolving gaits for damage control in a hexapod robot. In *Proceedings of the Genetic and Evolutionary Computation Conference* (pp. 146-153).

[4] Bing, Z., Rohregger, A., Walter, F., Huang, Y., Lucas, P., Morin, F.O., Huang, K. and Knoll, A., 2023. Lateral flexion of a compliant spine improves motor performance in a bioinspired mouse robot. *Science Robotics*, *8*(85), p.eadg7165.