# Introduction

Quadrupedal robots or legged robots research is a popular research direction in the field of Robotics. Characterized by their animal-like figure, quadrupedal robots are considered to have excellent talent of traversing challenging environments, such as stairs, rocky terrain, and cluttered spaces. In contrast to wheeled robots, which are typically constrained to pre-designed, artificial and predominantly level terrains, legged robots demonstrate greater adaptability, enabling their deployment in intricate and high-risk environments. This applications encompass tasks such as research and rescuemissions, military operations and exploration of challenging and uneven terrains.

However, unlike directions such as Unmanned Arieal Vehicle (UAV), robot manipulators or wheeled robots whose robot dynamic model and control algorithms have reached a nearly SOTA extend, legged robots are still facing challenges coming from complex dynamic model and control, which greatly limits the development of legged robot’s traversability. Furthermore, wheeled robots or manipulators have established a mature industrial market, whereas there is still a large gap for legged robots to realize commercialization for practical use, due to several technical limits such as battery life, manufacturing costs, and versatility.

Characterized by the advantage of learning complex control policy in an End-to-End way, Deep Reinforcement Learning method holds the promise in training legged robots and have been used successfully in various research and application domains. Besides, Deep RL method gain several advantages over conventional control methods (such as MPC). After training, robots can show their stronger ability in generating complex locomotion patterns (walking, running, crawling…) and a good performance while generalizing to different tasks and situations.

The primary objective of this research project is to enhance the traversability of legged robots when operating in challenging terrains. Specifically, I seek to accomplish this goal through the implementation of Deep Reinforcement Learning on a lightweight legged robot platform known as DOGZILLA. Furthermore, the training and learning of control policy obeys a“Sim-to-Real” idea. The idea is implemented by firstly training and testing algorithms in a simulation environment. When control policy or ability reached a satisfying level, it will be transferred to real robot and conduct real-world testing. In this way we can assure the training safety and improve learning efficiency.

This paper is structured into the following sections: Section 2 provides a review of related literature, Section 3 presents the research methodology, Section 4 discusses the findings, and Section 5 offers conclusions and recommendations.

## Motivations

**What contributions have done by previous researchers? – See literature Review**

Deep RL method is not a very new and fancy method for robot dog training. Hundreds of works have proved its advantage over conventional control algorithms. Regardless of how magical and effort-saving this training procedure is, the after-trained robot dog can easily generate several gait patterns, without manually setting parameter. What’s more important is that, you can’t believe how robust and versatile the robot dog is after a millions of training. For example, you must have watched the robot-walking-on-ice video, or the robot-getting-a-kick video, these are the results being trained via RL or DRL methods. For other examples, you should notice that in this research area, the DRL method is so popular and useful that many world-wise top institutions like ETH and KAIST have demonstrated many many perfect works *(ETH 2020 — Learning Quadrupedal Locomotion over Challenging Terrain)*. In conclusion, too many fantastic works have been done.

**Why I want to do it still?**

Honestly speaking, just like those works mentioned, I want to handle this skill to train robot dogs via DRL and accomplish many fancies works too. I want to know how to configure RL training simulation environment. I want to know how I can train and tune the training outcome. I want to know how to deploy all those learned policies onto my real robot dog. I also want to know how I can evaluate the performance: is it runnable? Does it work in walking on flat, slope, through cluttered terrain, grass and stairs? What’s the evaluation criteria? How those people evaluate its performance? Apart from all of these, I also want to check if this general training method works well on my tiny, little robot dog. Can a control policy acquired by simulation dog (such as *Unitree* or *Anymal*) be silky connected to my robot dog? What problems can occur and how I can fill the gap between this sim-to-real transfer puzzle?

In conclusion, my motivation of doing this project is both research-based (wanting to check if it works from a simulation model to a DOGZILLA) and confirmation-based/technical-based (simply wanting to go through this exciting journey towards handling DRL-training skill)

**What importance does my project have?**

Like I said before, the value or contribution of my project has two aspects: First, my project will reimplement the typical RL-training procedure and expect to achieve a good real-world outcome. In this way, my project will prove the validity and importance of this method for robot dog training. To conclude, this aspect is a technical/confirmative aspect. I only need to repeat this technique and confirm it works. Second, my project explores the possibility of implementing this general method to a specific and never-being-tried robot platform. What’s more. If it works, I can further prove the effectiveness of this method to any types of robot dog.

**Appendix: PLES**

A well-researched consideration of any Professional, Legal, Ethical, and Social Issues pertinent to the project. (e.g. codes of conduct (BCS), codes of practice, standards,

computer law, ethical decision making, intellectual property, social aspects, copyright, data protection, and so on).

**Appendix: Project Management**

This section should include:

o A timetable for the whole year, inc. semester 1 and 2, agreed with your supervisor

and specifying activities, deliverables and deadlines.

o An analysis of the risks for the project together with appropriate mitigation plans,

i.e. not due to illness.

# Literature Review

**Requirements Analysis or Research Methodology**