Course: Machine Learning
"Morphological Adaptability in Robots through Reinforcement Learning: Integration of Supervised and Unsupervised Techniques for Navigation and Recognition in Unknown Terrain."

Team members:
Victor Moo, K. Valeria Villanueva, Angel Huerta, Joshua Zamora, Esteban Valencia.
Group: IRC 9B

Introduction

The Mini Pupper is an open-source robot that will serve as the base model for this project. Using a combination of reinforcement, supervised, and unsupervised learning, the robot will learn and adapt to navigate various terrains effectively, being capable to identify those terrains and objects to design paths in real time. [1]

Description of the problem

The problem addressed in this project focuses on the limited adaptability and performance of robotic systems in navigation and unknown terrain recognition. These conventional robotic systems usually are programmed to operate in specific well-defined environments. However, they are uncapable to operate when exposed to unpredictable terrains with many variations; also, they lack of real-time adaptability to optimize their movements based on the environment in which they are exposed.
These limitations become critical when robots are deployed in the field to perform tasks that could be challenging for humans because of a hazardous environment or simply unreachable because of safety concerns. In these contexts, it is crucial to incorporate autonomous adaptation to robots. For the scope of this project, there will be a particular focus in achieving this autonomous behavior based on techniques in Reinforcement Learning, Supervised Learning and Unsupervised learning.

Objective

The project aims to enhance the adaptability and performance of the Mini Pupper as a base model for a 4-legged robot, through the implementation of Machine Learning algorithms. The robot will be simulated using GazeboSIM and ROS 2 on Ubuntu 22.04; it is expected to autonomously navigate and adapt to various unknown terrains, optimizing its movements and behaviors through continuous learning.

Reinforcement Learning:

- This is the main learning process of the robot, it will learn to navigate by interacting with the environment, receiving feedback, and optimizing its actions to maximize the rewards.
- Application of deep reinforcement learning algorithms to train the robot in a simulated environment.

Supervised Learning:

- Utilization of labeled datasets representing different terrains to train the robot to recognize and adapt to various surface types.
- Application of classification algorithms to enable the robot, in real-time, terrain identification.

Unsupervised Learning:

- Exploration of clustering techniques to categorize unlabeled data and detect patterns or anomalies in the terrain data.

Expected results

Is expected that the robot would be able to recognize different terrains based on the integration of supervised and unsupervised

learning, being capable of recognizing and adapt its movements according to the specific characteristics of the terrains. Also, the robot should demonstrate improved navigation skills, effectively moving and adapting to different terrains based on the learned behaviors.

References

[1] MangDang, "Mini Pupper," https://minipupperdocs.readthedocs.io/en/latest/guide/HowToOrder.html. [Accessed: 2 Oct. 2023].