THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY | DEPARTMENT OF ELECTRONIC & COMPUTER ENGINEERING

Robotic Guide Dog: A Solution to the Lack of Guide Dogs in Societies (SL06a-22)

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Introduction

Niche

Visually impaired people use guide dogs to support their navigation both indoor and outdoor

Problem

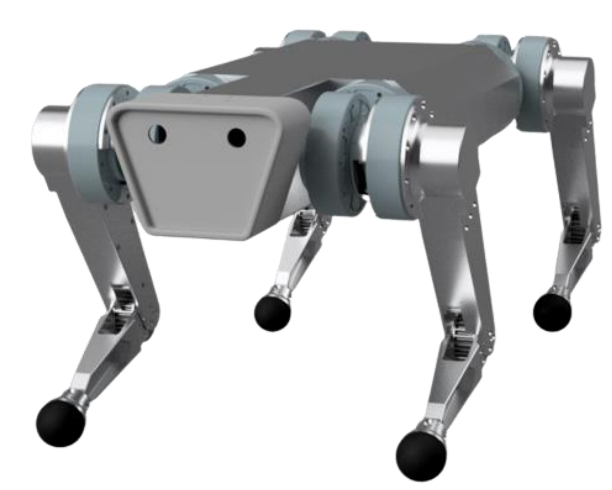
Guide dogs are very expensive and time consuming to train, with a short service life.

Solution

Robotic guide dogs offer mass production which lowers the unit cost and production time.

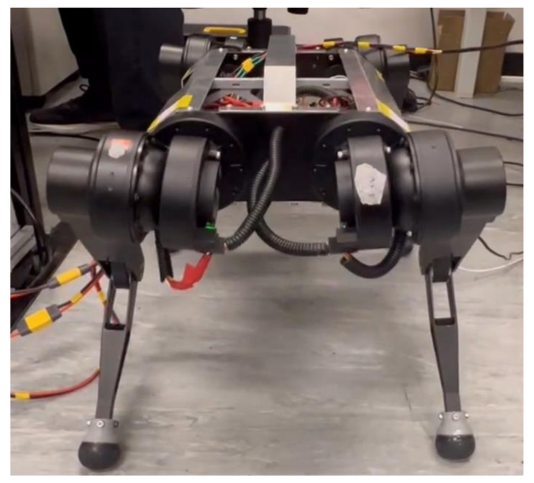
Result & Analysis

What we have done



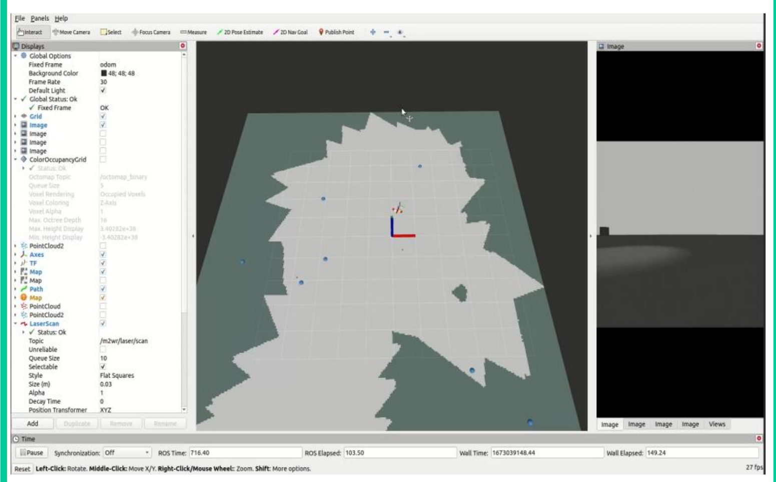
Bottom Layer

- ☑ Design a phototype dog
- ☑ Design a real size dog
- ☑ Power system of the dog



Middle Layer

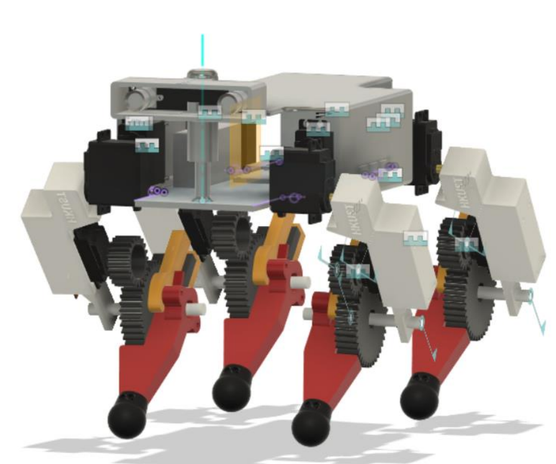
- ☑ Communication between the motors and PC using RS485
- ☑ Using IK and Gait generation to drive the robotic dog



Top Layer

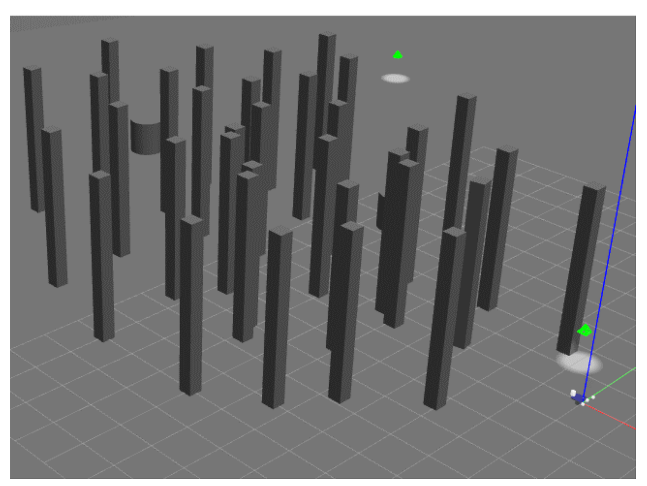
- ☑ Build 3D map online
- ☑ Navigation in a static & dynamic environment
- ☑ Voice and gesture module

What can be improved



Controller

- ☒ The posture and gait of the robot dog is not very stable
- ☒ Battery drains very quickly

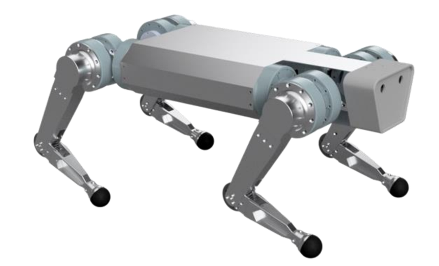


System Design

- ☒ Modules are not merged
- ☒ Some of the part only tested in the simulator due to the time

Methodology

Mechanical design

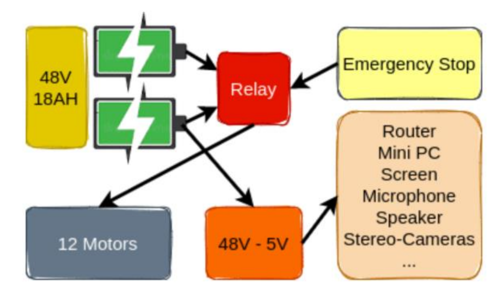


Our project was divided into two different sub-tasks for our team to parallelly achieve each member's goal with a full set of equipment. The two tasks represent the design and coding of two quadruped robots.

One is the 12 D.O.F. servo-controlled prototype with 3D-printed parts for early development. And the other is the large scaled legged robot like the MIT cheetah to achieve main objective of helping people with visual impairment.

Also, the project uses a drawbar as an intuitive alternative for the interaction between the user and the guiding dog robot. The drawbar has been optimized and refined in shape and is used to connect the robot with the user.

Hardware design

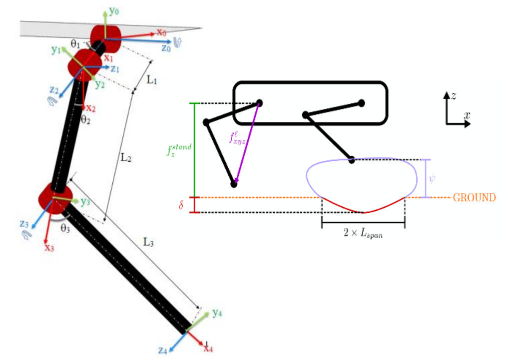


The hardware and embedded design for the R.G.D project involves several key components that create a functional and effective system. Two of the most important components are the power management system and the communication system.

The power system is designed to provide reliable and consistent power to all the components, while also incorporating an emergency stop feature to ensure the safety of users.

The communication system uses RS485 protocol to control all the motors in the robot for its robust and reliable nature. The system is based on a custom-designed Printed Circuit Board (PCB) that uses a CH348 chip to support USB to 8 RS485 ports.

Controller design

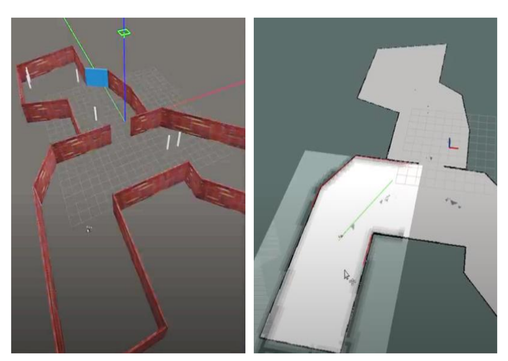


The goal of our control system is to convert the series of velocity/position commands of the whole robot in real life Cartesian coordinate system to each motor's position based on the updated information from the sensors. And it is divided in to two parts, inverse kinematics and gait generation.

First step is deriving the Inverse Kinematics for each leg, and then to describe the IK for the body itself. The approach used here considers a world frame *w*, which is the robot centroid's base position, and a body frame *b*, describing the robot's pose relative to the world frame.

Second step is the gait generation. The Bezier Gait deployed in this project uses an open-loop trajectory generator, which resets when the desired stride period is completed. The basic adaptation of the Bezier curve generator gives 2D foot coordinates over time: horizontal and vertical.

Algorithm design

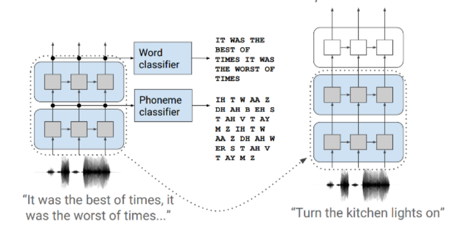


To facilitate efficient algorithm development, we have setup a simulation environment using Gazebo software. We create two simulation worlds for developing and evaluation of the navigation system, namely canteen-static and canteen-dynamic. In this project, two navigation methods are implemented for a simulated canteen environment: static navigation and dynamic navigation.

Static navigation employs an online map generated from pre-developed SLAM systems like laser-based SLAM and visual SLAM. These systems produce 2D occupancy grid maps or 3D point cloud maps, which are then transformed into 2D maps. This approach is suitable for environments with static obstacles only, as it doesn't account for dynamic obstacles.

Dynamic navigation, on the other hand, operates in an open area and uses a map-less method to navigate around dynamic obstacles like moving pedestrians. The project adopts the ROS navigation stack's global planner and local planner but encounters challenges when avoiding dynamic obstacles. To address this CADRL is implemented who accepts dynamic object observations and generates movement commands for the robot agent.

Human-Robot Interaction



The goal of human-robot interaction system is to enable seamless communication between the user and the robot. We are going to implementing two key components of the system: a voice interaction system and a hand gesture recognition system.

To implement the voice interaction system, we used an end-to-end spoken language model that can interpret natural language input and generate appropriate responses. Such that the user do not need to remember any commands.

To implement the hand gesture recognition system, we train our own model using the extracted landmark of the hand. The user can define his/her preferred gesture for some common commands, such as "stop" or "turn left".