Autonomous Docking for the TurtleBot3

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Introduction

By 2030, the proportion of the population aged 65 years or older in the US is predicted to rise to a record 20%[1]. Because of this massive increase, and the correspondingly fewer numbers of younger adults to care for retirees, robots are increasingly being turned to as an avenue to assist the elderly in various activities of daily living (ADLs). The robot TurtleBot3 is a prime platform from which to perform research into methods of assisting the elderly, due to its relative inexpensiveness, ease of use, and highly adaptable configuration. The TurtleBot3, however, lacks the ability to charge itself.

Purpose

- Construct a docking station the TurtleBot3 can dock with and charge from with minimal supervision for potentially weeks at a time
- Create the code to direct the TurtleBot3 to the docking station when the TurtleBot3 requires charging

Requirements

- 4 contact pins on the docking station for the main battery, another pin for a second battery, and a common ground pin. Combined that means 6 contact pins total.
- Precision sensors designed to detect the docking station on top of existing sensors and navigation systems
- The reliability to continue working for long periods of time without supervision
- High safety standards for the electrical parts to minimize hazards
- The ability to access the electronics inside the docking station

TurtleBot3

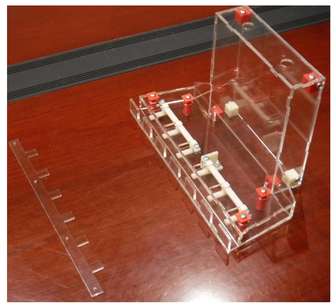
Superstructure of the robot: Contains a tablet (represented by a hard drive here) and an Astra camera

The core structure of the robot. Within this structure are all the circuit boards, wires, and motors needed for the robot to work

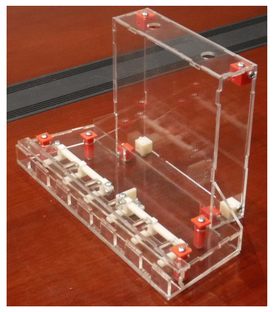
The robot side pin holder is seen in front of the robot. For use this component is attached to the bottom of the robot

Prototype Docking Station

Lacks all electrical components



Position 1: The robot side pin holder, seen to the left of the picture, ready to dock with the station. During an actual docking it would be attached to the bottom of the robot.



Position 2: The robot side pins are now “connected” with their counterparts on the docking station

Components

- Customized TurtleBot3 with 4.5” diameter wheels
- ROS based programming
- 14.8v, 4 cell, lithium battery
- 15-24 volt, 1 cell, Li-polymer battery

Limitations

- Docking station must be capable of being easily relocated
- Space was required inside the docking station for up to 2 adapters and wires to connect the pins to the adapters and then an external power source

Design Notes

- The design of this system was heavily inspired by the design of the TurtleBot2’s docking station and Roomba technology
- For materials, we decided to use primarily acrylic parts cut out with a laser jet and then glued together for the majority of the structure. This was supplemented with various 3-D parts when acrylic could not be used, and to allow for the back and bottom plates to be removed.

Results

- The mechanical components of the docking station have been designed and fabricated, with some limited testing
- The electrical components still need more time to finalize, especially the sensors
- In terms of programming, the framework of the program to send the robot to the docking station was designed, but the code for the final approach to the docking station has not been created

Conclusions

- The addition of precision sensors and the code required to fully utilize them is necessary to the docking station’s ability to act as a robust charging station
- This design was intended for a customized TurtleBot3, not the standardized model. As such this design can only be used as a charging station for this specific robot layout.

Future Work

- The work necessary to make the docking station fully operational is mostly electrical in nature, with some programming involved. Thus, persons with electrical background and/or programming backgrounds should be recruited to work on finalizing the docking station.
- In future projects where precision sensor usage is deemed necessary, someone with experience mounting and using sensors should be recruited early on for the project. This allows more time to create the sensors in parallel to the mechanical design process.
- Also in future projects, researchers should look at what manufacturing methods and capabilities are available to them before choosing one, both for the purpose of identifying cheap, easy, and fast methods as well as ensuring they design for manufacturing their product

Acknowledgments

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Docking Station Design

Sensor Shelf

This is a shelf for holding to be determined sensors and/or sensor beacons

The Main Compartment

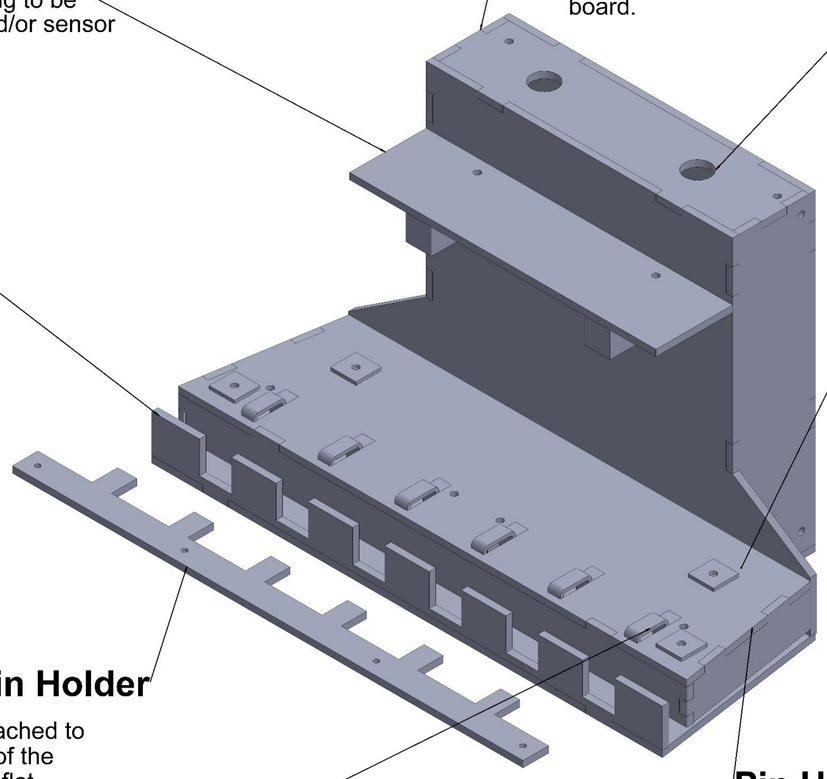
The biggest part of the docking station, the main compartment is designed to house up to two adapters or one adapter and a circuit board.

Wire Holes

Wires exit the docking station here to connect to a source of power.

Spring Cap

The squares visible in this drawing are caps, designed to prevent the pin holder from coming off the docking station vertically. Each one is attached by a screw to a pillar underneath. The pillars serves as a location to put the springs around to keep the springs in the right orientation (A top view of this is directly below) and keep the pin holder in the right orientation.



The Wall

The wall is designed so that the wheels of the robot cannot get through the gaps in it. This requires the robot to approach the way we want it to (with the wheels on either side of the docking station) to make contact with the pins, reducing the likelihood of the wrong pins connecting and short circuiting the robot.

Inner circle represents the pillar

outer circle represents the spring

Robot Side Pin Holder

This part is attached to the underside of the robot, and has flat, metallic pins attached to the underside. These will be soldered to wires that will connect to the rest of the robot

Pins

These metallic contacts are where electricity will be transferred to the robot. They are fixed to the pin holder and connected by wires to the rest of the station

Pin Holder

This is the component upon which the pins are mounted. Beneath this component are springs to ensure the pins have a good connection with their counterparts on the robot by pressing the pin holder, and thus the pins, upwards.

References

US Census Bureau. (2018, March 13). Older People Projected to Outnumber Children for First Time in U.S. History. Retrieved from https://www.census.gov/newsroom/press-releases/2018/cb18-41-population-projections.html