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Engineering Portfolio

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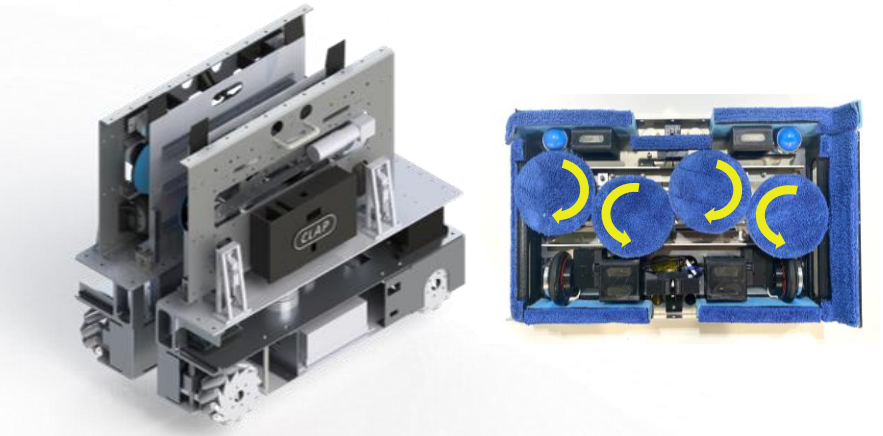
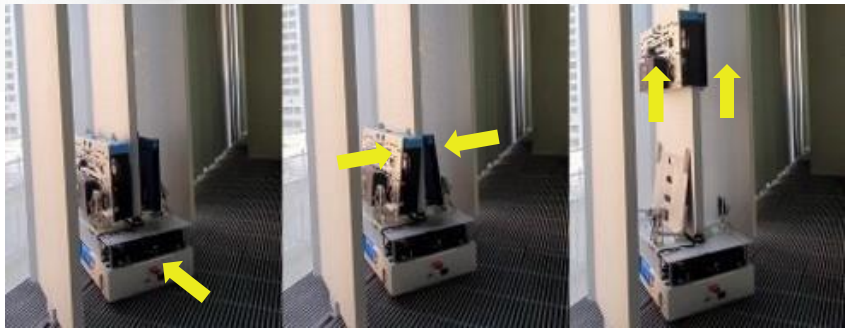
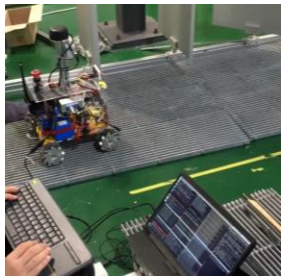
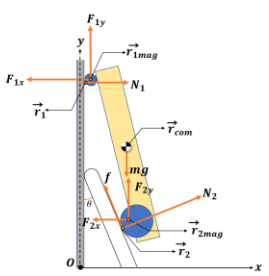
CLAP | Climbing and Cleaning Robot

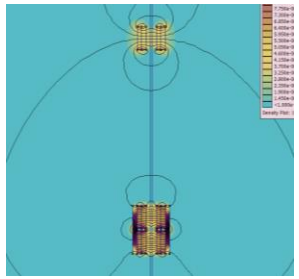
SolidWorks, AutoCAD, 3D Printing, Laser Cutting, Machining, Python











Objective

- To invent a robotic system to autonomously clean ~20,000 louvers (rotating thin walls of aluminum) in a new building for a company, in a team of 5 engineering interns

Technical Details

Mechanical Design

- Designed and created frames, mechanisms, electronic cases, and sensor mounts for a pair of magnetic wall climbing robots and an omnidirectional mobile base
- Developed a ferromagnetic ramp mechanism to connect climbing robots to the mobile base for better reliability

Prototyping

- Utilized rapid prototyping techniques to build 4 stages of prototypes for the system
- Built a testbed and designed experiments to evaluate the climbing and cleaning ability of the robot

Simulation & Analysis

- Analyzed the stress using SolidWorks Simulation to restrict the deformation of the body frame to 0.1 mm
- Simulated the magnetic field with finite element analysis, increasing the magnetic force by 60%

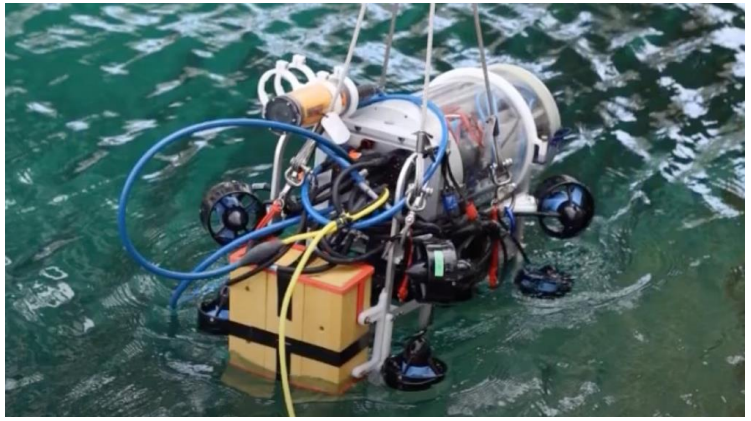
Results

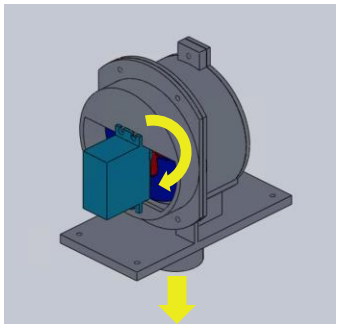
- A robotic system that navigates through narrow aisles and cleans each louver within 2 min, reducing the uncleaned portion from 30% to 0%
- Patent pending for a modular robotic system with ground navigating and wall climbing capabilities

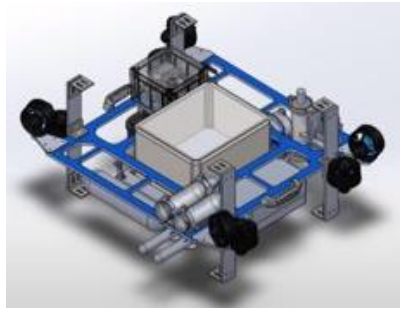
Link to video

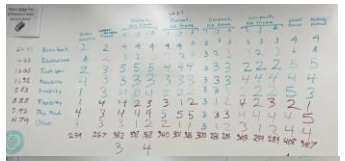
Cthulu | Autonomous Underwater Vehicle

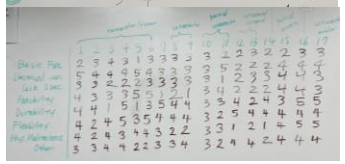
SolidWorks, 3D Printing, Waterjet Cutting, Machining, Python, OpenCV











Objective

- To develop autonomous underwater vehicles for RoboSub international competition, collaborating with 30+ members in Duke Robotics Club

Technical Details

Mechanical Design

- Designed the new robot to have improved versatility by doubling the space for additional actuators, increased maintainability by making the electronics case 20% more compact and its detaching time 50% shorter
- Developed a marker dropper mechanism for placing metallic balls on an underwater target with <5cm offset

Computer Vision

- Developing a Python and machine learning based computer vision software that preprocesses murky images and detect objects including gates and targets in real-time

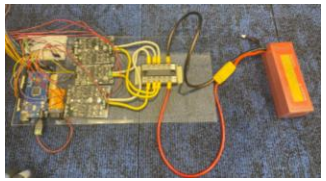
Results

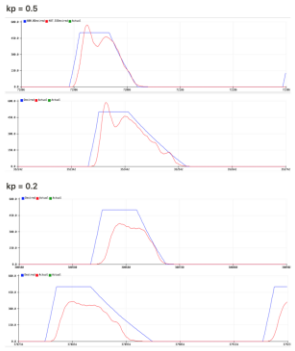
- Completed one version of the robot to be ready for pool tests and competition, new version of the robot ready to be assembled and tested
- Created design reports, skills videos, and an organized design documentation for all parts and assemblies for collaboration

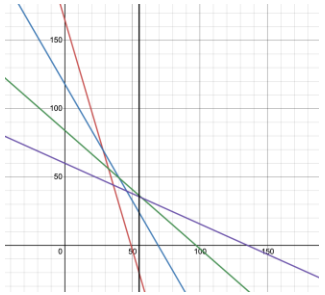
Link to video

TouChair | Touchpad Controlled Automatic Chair

Arduino, C++, Matlab, SolidWorks







Objective

- To conduct proof of concept for controlling a motorized chair with a touchpad
- To provide a working platform to test different aspects of human-machine interactions

Technical Details

Mechanical & Electrical Design

- Rapidly prototyped a mechanical structure with off the shelf components that can support up to 100kg
- Through dynamics analysis, selected motors and wheels to meet the velocity & acceleration requirements
- Selected motor controllers, a battery, and other electrical components to complete a working circuit

Control Software

- Simulated with Matlab to analyze the motor output given different control parameters for PID control
- Wrote C++ code to retrieve touchpad and motor encoder signals and smoothen them using filters
- Enabled smooth acceleration and movement through tests and utilization of dynamics and control theories

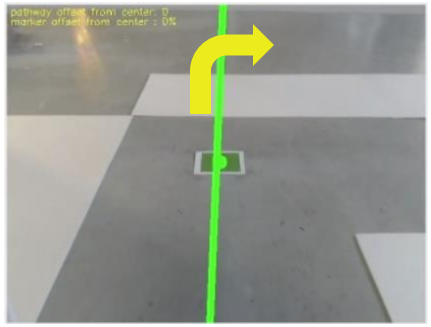
Results

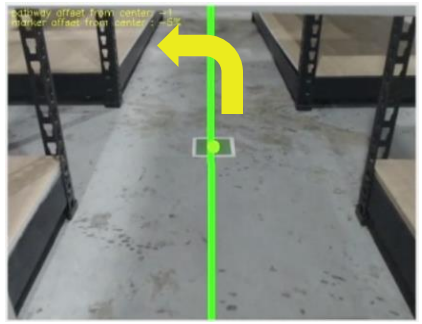
- A fully working electromechanical system that works with a human input retrieved through a touchpad
- A mechanical structure that can be attached to most of the office chairs and with a payload of 100kg

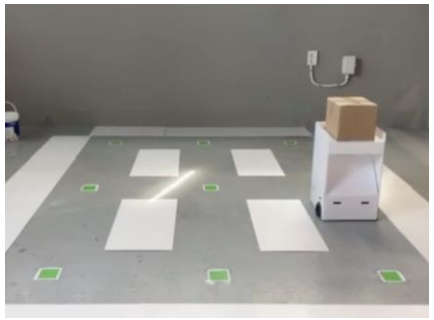
Link to video

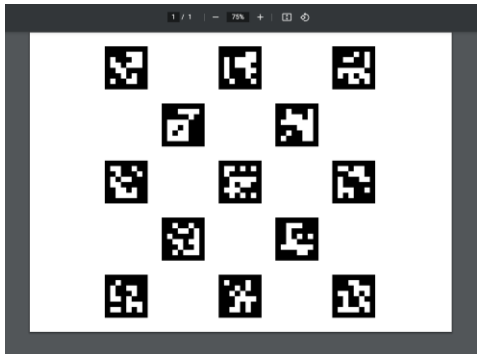
MiniCoCo | Autonomous Mobile Robotic System

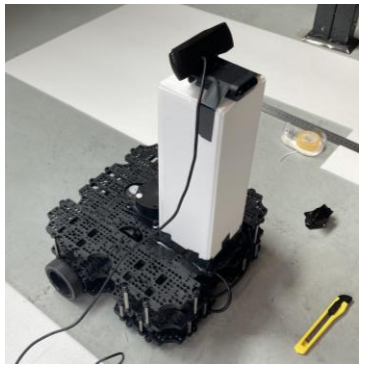
Robot Operating System, Linux, Python, OpenCV











Objective

- To develop and test a self-navigation software of mobile robots for logistics automation

Technical Details

Programming

- Implemented features including self-navigation and streaming the robot's point of view to the user
- Minimized the risk of path overlaps between robots with an algorithm that treats every aisle as one way
- Reduced the printing preparation time for the software team by over 90% by creating a Python package to automatically generate PDF of Aruco Markers

Computer Vision

- Used OpenCV library to create a computer vision software that locates the aisles and colored planar markers
- Recreated the lane detection algorithm for self-driving cars to ensure stability in environments with obstacles with various sizes and shapes

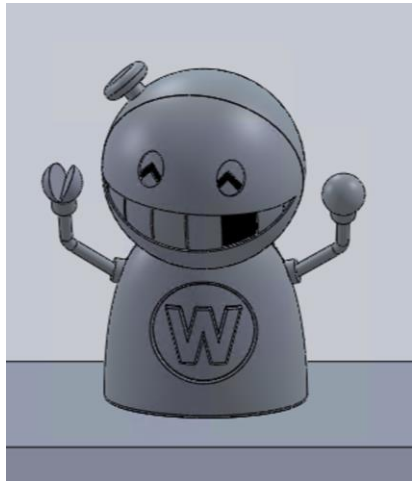
Results

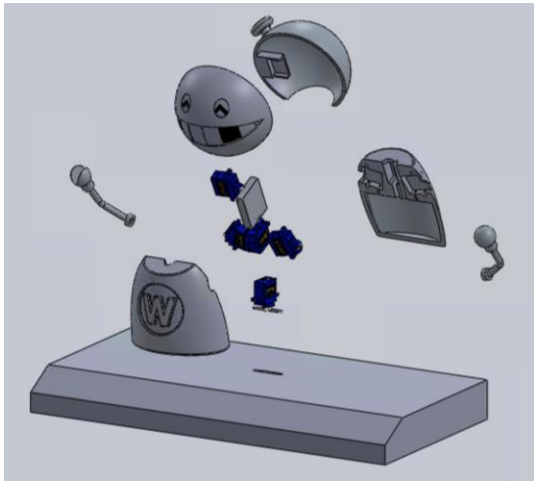
- Completed a ROS2 package for mobile robots to navigate within grid-like warehouses of any size, requiring no modifications of the warehouse
- Created a basis for software engineers to test navigation algorithms, higher-level computer vision software, and AWS server synchronization for fleet control, saving weeks of developing time

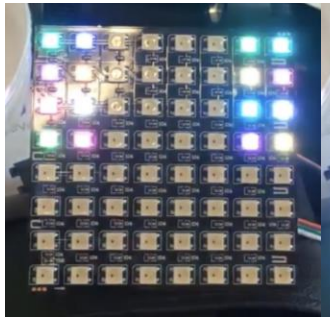
Link to video

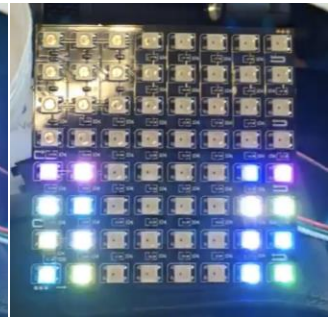
Concert-Bot | Music-Synced Robot Performer

SolidWorks, 3D Printing, Robot Operating System, C++, Python, Arduino *ongoing project









Objective

- To design an automated performer robot that generates dancing movements given user's music input

Technical Details

Mechanical Design

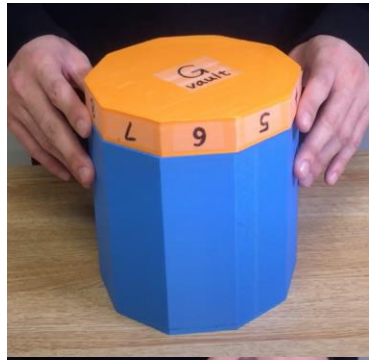
- Designed covers for a character figure using SolidWorks surface modeling

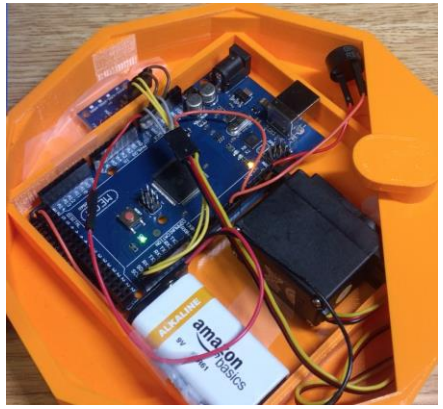
Programming

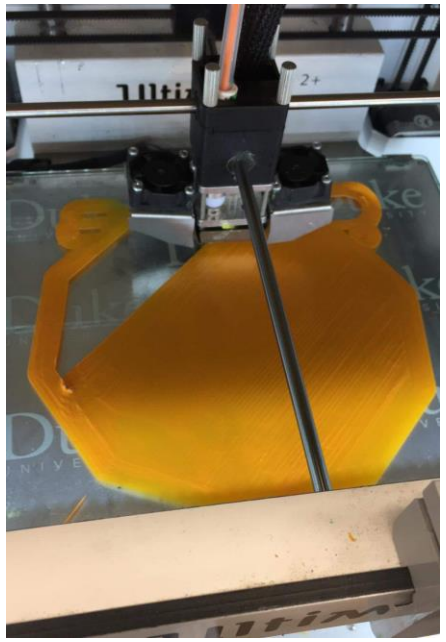
- Currently implementing Python and ROS2 based software for bpm detection, genre classification, and motion planning
- Currently implementing C++ based software for LED matrix control for displaying graphic output

G-Vault | Arduino-based Locker Project

SolidWorks, 3D Printing, C++, Arduino







Objective

- To create a vault that utilizes its own orientation for password input

Technical Details

Mechanical Design

- Designed using SolidWorks and 3D printed a vault with a single-servo locking mechanism and an electronics case

Programming

- Implemented algorithms in C++ for locking/unlocking, alerting the user for wrong password, and resetting the password
- Utilized IMU sensor values for password input of 0~9, *, and #

Results

- A working prototype and a demonstration video of a novel vault design

Link to video