Eli Branstetter

M.ENG ROBOTICS AND INTELLIGENT AUTONOMOUS SYSTEMS
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Senior Capstone - Low Water Silicon Wafer Cleaning - 1st in Department

Project Goals

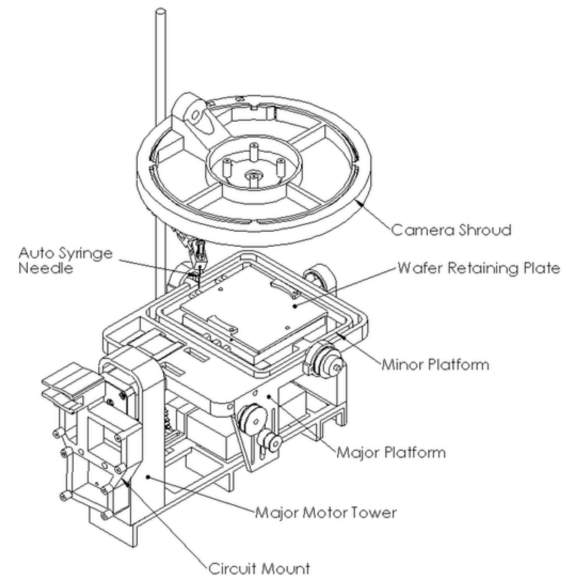
This project aimed to develop a proof-of-concept device for researching single-droplet cleaning of silicon wafers. Unlike traditional methods that clean entire surfaces, this approach targets only areas with detected contaminants—offering a promising route to significantly reduce water consumption in semiconductor manufacturing, an industry that uses over 1 trillion liters of water annually. The system leverages the Leidenfrost Effect by heating wafers to 120 °C, creating a vapor layer that enables low-friction droplet motion while preventing direct contact with the wafer surface.

Physical Overview

The system consists of a two-axis tilting table actuated by stepper motors, with an overhead camera providing visual feedback. A computer-controlled syringe deposits droplets onto the wafer as needed. This setup enables precise control of droplet movement across the wafer surface for targeted cleaning.

Controls Overview

Cleaning starts with image capture to scale the wafer and detect contaminants using OpenCV. Coordinates are sent to a Traveling Salesman algorithm to plan an efficient droplet path. A droplet is then guided along this path using PID control with a Kalman filter. Real-time camera feedback corrects motion errors, while velocity predictions reduce overshoot. After 8 seconds or when enough contaminants are collected, the table tilts to remove the droplet and avoid redeposition. The process repeats until the wafer is clean. Image processing and control run in Python on a PC, which sends commands to the motors via an Arduino Uno.



My Role

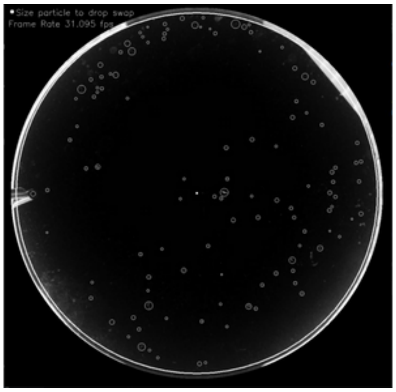
As Team Lead and Computer Vision Engineer, I worked across all phases of the project, focusing on droplet and particle detection. This involved tuning image processing techniques and modifying lighting and backgrounds for consistent performance. I also helped tune the PID and Kalman filter parameters to optimize system response and constructed the proto-board.

Results

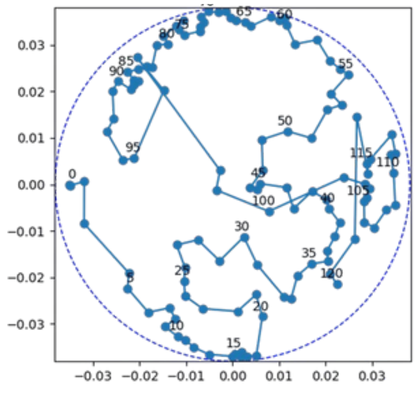
The system met all project objectives, achieving wafer cleaning using only 0.4 mL of water—compared to approximately 275 mL required by conventional methods. The project was awarded 1st place out of 50 Mechanical Engineering teams in our department.

Raw Image

Processed with Detections



Planned Path



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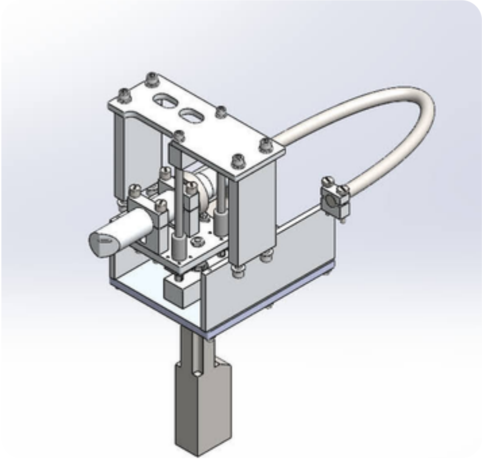
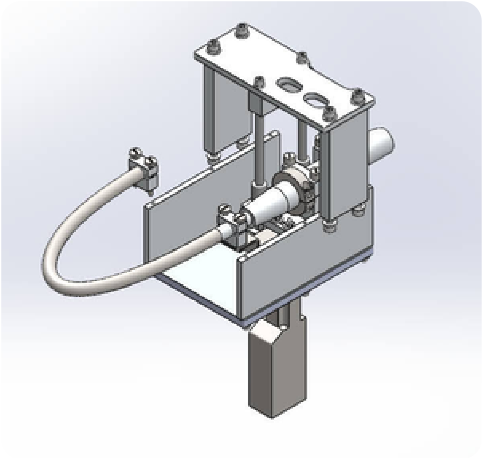
Label Printer - MiQ Partners





Task:

- Upgrade an existing label printing station to improve performance
- Utilize existing key components
- Improve rigidity

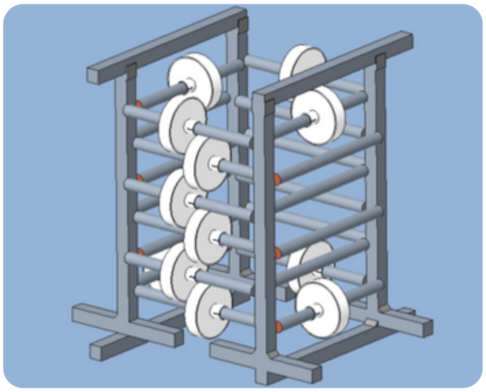
Methods:

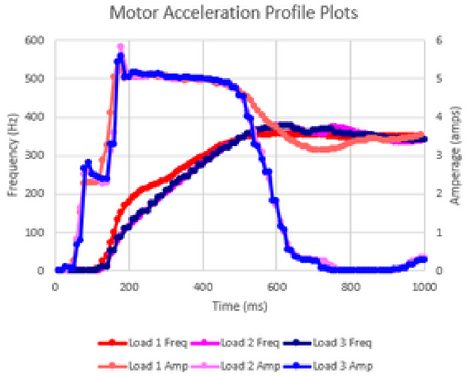
- Designed, spec'd components, and created detailed drawings for manufacturing release utilizing SOLIDWORKS
- Incorporated dual slides and top support for increased rigidity

Results:

- Improved label quality and reduced stoppages from every 5 to 10 minutes to daily cleaning

Motorized Drum Roller Testing - Regal Rexnord, Modsort Conveying Team





Task:

- Create and verify a motor load to simulate package load conditions for motor lifetime testing
- Collect and analyze motor acceleration profile data for system optimization

Methods:

- Calculated inertial characteristics of belt and package
- Designed a weighted drum to match calculated inertia
- Added to testing scripts using VBA and Ladder Logic programming
- Collected data for over 50 different load and acceleration profiles

Results:

- Proved a specific motor mode was more effective for sorting applications counter to team assumptions
- Guided motor parameters for life time cycle testing
- Created drum to simulate desired package load

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Bye Bye Birdie - UC Innovation Challenge, 2nd Place Winner

Idea

A turret with an ultrasonic speaker array to direct a concentrated beam of sound towards desired objects. Initial applications include bird area deterrence for agriculture or commercial facilities or personal audio devices. For bird deterrence, this solution would be a harm free, low impact solution which would provide easy install and scalability. Key project objectives include automatic recognition and targeting of desired objects, weather proofing, and ease of construction.

Key Skills

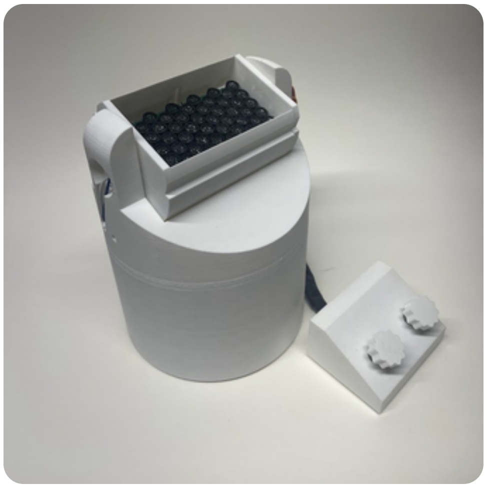
- Autodesk Fusion 360 CAD
- Raspberry Pi programming
  - Python
  - Tensor Flow Machine Learning
  - OpenCV Computer Vision
- 3D Printing
- Electrical System Design
- Arduino Programming

CEAS Tribunal Innovation Challenge

The initial two versions of this project were completed as part of UC Tribunal's Innovation Challenge. The challenge is a semester long competition between 20 student teams to create the best new entrepreneurial ideas and business models. My team won second place for our idea and working model. My role on the team was to create the mechanical design and I did most of the programming for V2. The challenge constrained the time and feature sets possible for the first two versions but I continued with V3 on my own to further develop my skills and learn about computer vision.

V1

The first iteration was a minimum viable prototype to test the speaker array and ensure the servos provided the necessary torque. This also allowed for programming of the Arduino controller before the second iteration was completed. An ultrasonic speaker array is used as higher frequency waves do not disperse as quickly as audible frequencies but can be modulated to create audible beam sound.



V2

The second version housed the major electrical components and introduced weatherproofing features. Due to time constraints during the challenge, it did not include a camera for object recognition and was operated manually using an Arduino and rotary dials.

V3

In the third version, the Arduino was replaced by a Raspberry Pi for camera integration and other refinements were made to improve weather proofing and movement performance. This version uses Tensor Flow Lite and OpenCV for object recognition and targeting. It is currently set up to recognize and target faces, which can be used for music or other audio delivery to a specific individual.

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Event Horizon Team Lead, FIRST Tech Challenge

FIRST Tech Challenge (FTC)

FTC is a robotics competition for high school students to promote interest in robotics. Four teams compete on a 10'x10' field with a 30 second autonomous period followed by two minutes of driver control. Game elements are assigned points and teams try to maximize points scored.

Key Skills

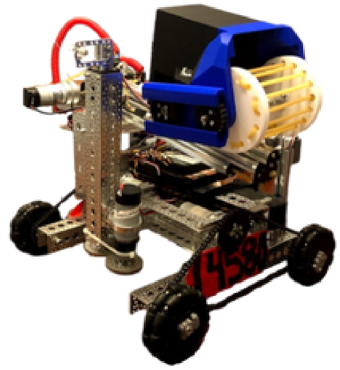
- Autodesk Fusion 360 CAD
- 3D Printing
- Java Programming
- Electrical System Design
- Timeline Management

Event Horizon Team Leader

I participated in FTC on Team Event Horizon, which was a neighborhood team formed after my FIRST Lego League team of 6 years aged up into FTC. Being a new team we did not have experienced members who knew the rules and systems of the competition. While other team's lead workshops, learning and overcoming the challenges of a new competition was a difficult task, particularly as the team leader. With my role, I was responsible for designing our robot in Fusion 360 CAD, creating custom 3D printed parts, ensuring proper documentation was maintained, managing our timeline, and ensuring the robot followed all competition rules.

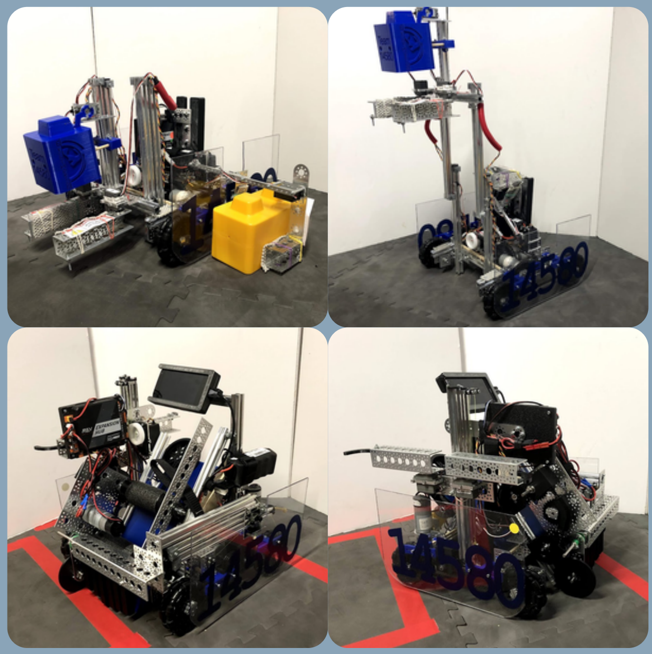
2018-2019 Season

During our first year the primary goal was to learn while setting ourselves up for success in future years. The primary game objectives were to pick up and place cubes and balls into elevated containers and lift the robot off of the ground at the end of the match. I designed a large 3D printed assembly, to house a motor and servo and store the game elements, which was attached to a telescoping arm. Even as a rookie team we performed well and made it to semifinals at our second tournament



2019-2020 Season

In the 2019-2020 season, robots were tasked with stacking LEGO style bricks as tall as possible. We once again used telescoping extrusion to create the linear motion we desired and we made many improvements to the robot's base design. We also vastly improved our design documentation practices and won a Mechanical Design Award in addition to tournament finals.



2020-2021 Season

While Covid-19 prevented in person meetings and tournaments our team was still able to persevere and compete virtually to demonstrate our foam ring tossing abilities. This robot used a variety of gear and chain systems to drive all required parts while maintaining a small form factor. We also implemented image recognition to find game elements during the autonomous phase. We won a Mechanical Design Award for our innovative designs and thorough documentation.