Ambert Yang Sawaya
Mechanical Engineering Portfolio

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Research

CAIR Lab Wireless Haptic Robot*
Boston University Fall 2020 – Spring 2021

Goal: Create wireless haptic modules to assist with haptic sketching (Dr. Rebecca Khurshid CAIR Lab at BU).

Contribution: CAD designed and assembled circuitry for probing module.

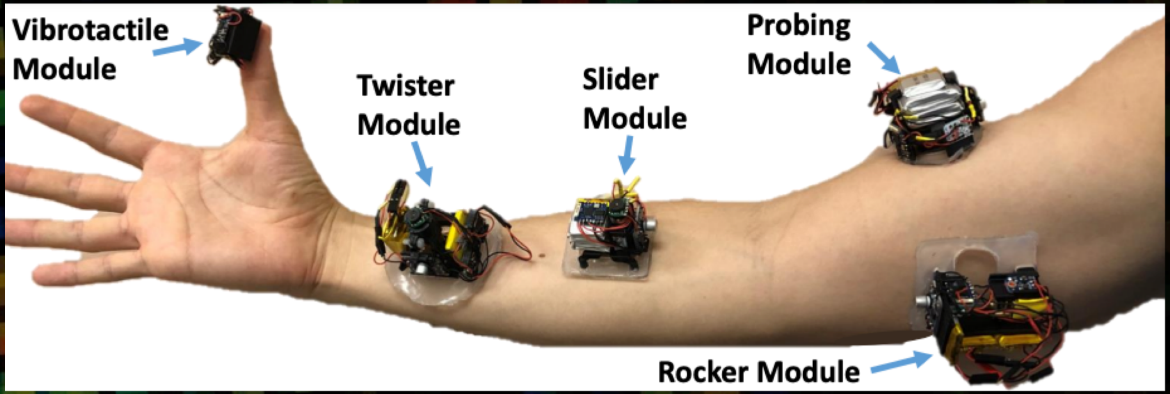
Skills Used: Python, Arduino, electric circuits, and SolidWorks.

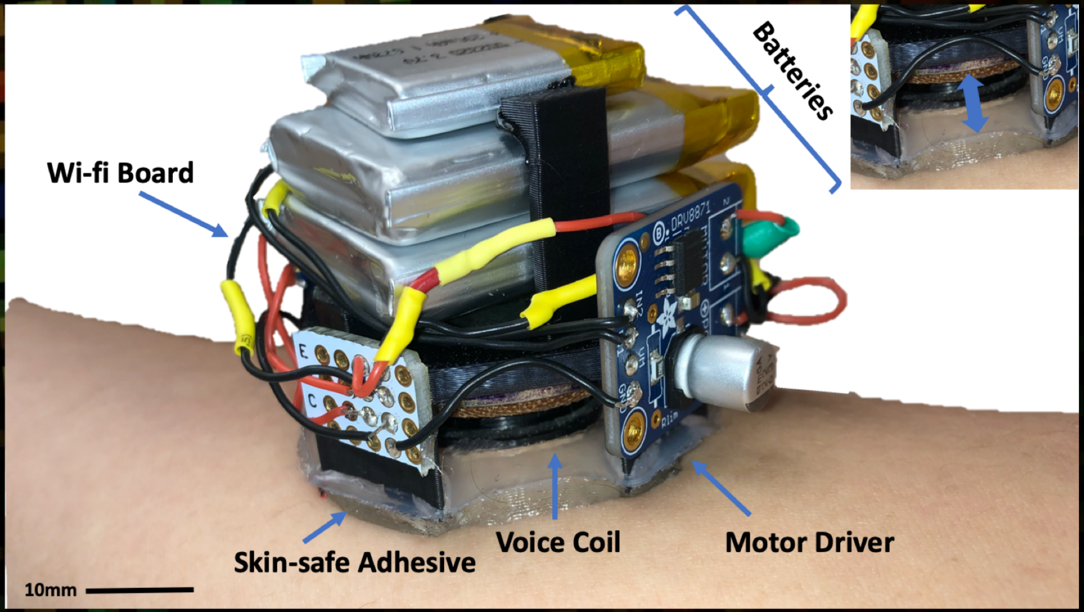
Skills Gained: Soldering, Dremel, curing silicon based adhesive, writing published literature, 3D printing.

*Our paper was accepted to the *IEEE World Haptics Conference 2021.*

Modular Haptic Feedback for Rapid Prototyping of Tactile Displays

Ramón E. Sánchez Cruz*[1], Mela C. Coffey*[1], Ambert Yang Sawaya[1], and Rebecca P. Khurshid[2]





Abstract—This work presents the foundations of a novel haptic toolkit, consisting of a set of modules that seeks to enable designers to easily and quickly produce new tactile prototypes. The modules are re-attachable, wearable, wireless, customizable, and can be placed on different parts of the body. This paper first discusses a series of design decisions that were made when producing these modules. The paper then presents a set of five modules that were created using the decided upon design techniques. The five haptic modules presented produce the three most common tactile feedback modalities: vibrotactile, skin-stretch, and probing. Each module haptic cue parameters can be customized and controlled wirelessly through an off-board computer. The modules can be used either in isolation or in groups for haptic sketching to rapidly iterate through tactile displays.

Projects

Actuated Gravity Balanced Neck Brace
Columbia University Spring 2022

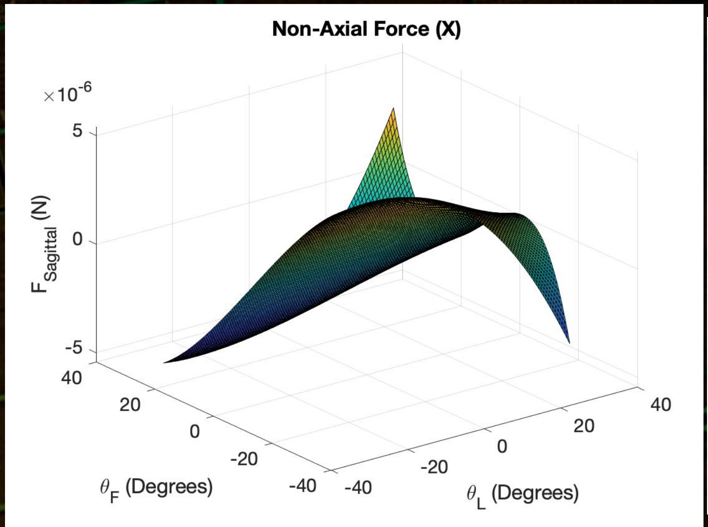
Goal: A continuation of the gravity balanced mechanism with springs (slide 8), but with a configuration that cancels out the non-axial force, an aspect left unaddressed by the previous mechanism. Modifications include an equilateral triangle configuration and prismatic actuators negate forces on the head.

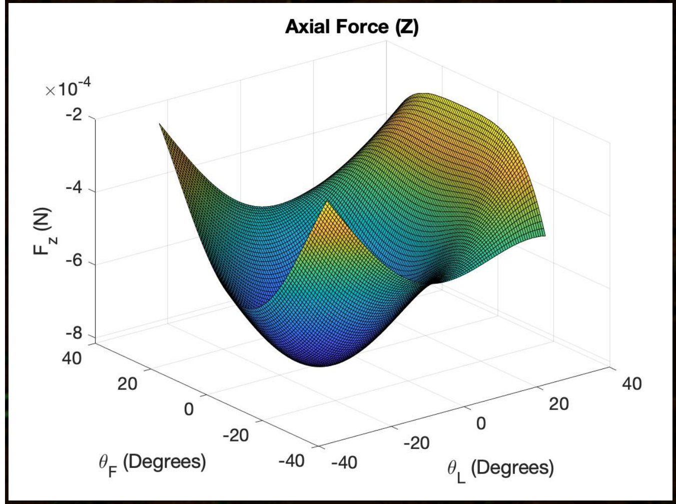
Contribution: Calculated magnitude of axial and non-axial forces on the head and plotted them over a range of lateral and flexion/extension bending angles. Solved for a zero vector using a Jacobian to find appropriate forces the actuators will apply.

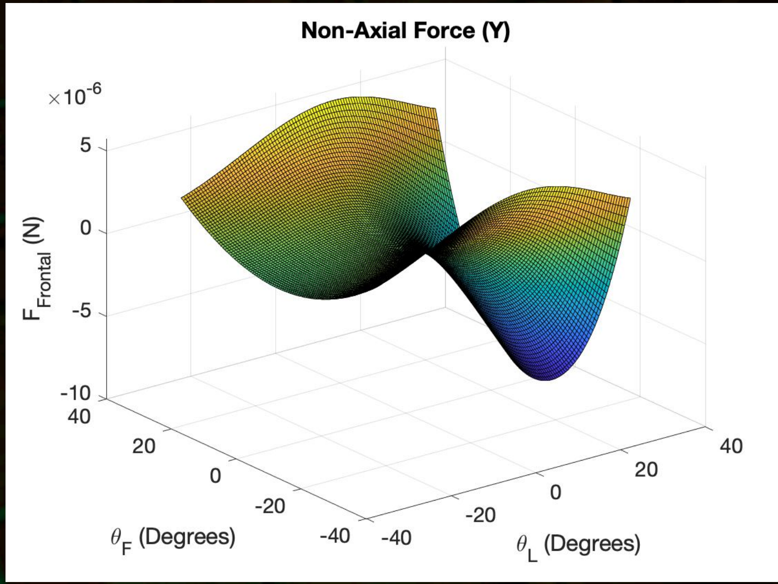
Skills Used: Linear algebra, MATLAB

Skills Gained: Proper use of Jacobians, better understanding of Space and Body rotation matrices.

Figures: Bottom right: CAD Model of new device. Plots: Show that with application of the actuators, we can successfully minimize the forces on the head to 10^{-4} to 10^{-6}.







Replication of a Machine Learning Application
Columbia University Spring 2022

Goal: Replicated the artificial neural network (ANN) in Robinson et al.'s 2017 paper titled "A Machine Learning Approach to Modeling Human Migration" using Python's Keras library.

Contribution: Took IRS Migration Data from 2004-2014, cleaned and relabeled it, then trained an ANN using '04-'08 data, and validated model by training it with '09-'13 data and predicted '14's data. Relative error was 1.4%.

Skills Used: Numerical Methods, data cleaning, and Python

Skills Gained: How to use Keras's library to build an ANN.

Relevant Results: Bottom left: Relative Error, Bottom Right: Convergence of Authors' loss function (CPC) over different epochs.

A Machine Learning Approach to Modeling Human Migration

Caleb Robinson and **Bistra Dilkina**
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arXiv:1711.05462v1 [cs.SI] 15 Nov 2017

Abstract

Human migration is a type of human mobility, where a trip involves a person moving with the intention of changing their home location. Predicting human migration as accurately as possible is important in city planning applications, international trade, spread of infectious diseases, conservation planning, and public policy development. Traditional human mobility models, such as gravity models or the more recent radiation model, predict human mobility flows based on population and distance features only. These models have been validated on commuting flows, a different type of human mobility, and are mainly used in modeling scenarios where large amounts of prior ground truth mobility data are not available. One downside of these models is that they have a fixed form and are therefore not able to capture more complicated migration dynamics. We propose machine learning models that are able to incorporate any number of exogenous features, to predict origin/destination human migration flows. Our machine learning models outperform traditional human mobility models on a variety of evaluation metrics, both in the task of predicting migrations between US counties as well as international migrations. In general, predictive machine learning models of human migration will provide a flexible base with which to model human migration under different what-if conditions, such as potential sea level rise or population growth scenarios.

1 Introduction

Models of human mobility in their different forms are important for many reasons. Models of human commuting can help reduce traffic congestion and pollution, and can be used to drive land use policy and development choices (De Montis et al. 2010). Models of human migration are equally important to policy makers as they can give broader estimates of how the population of an area will change in upcoming years, how labor markets might be affected (Dinkelman and Mariotti 2016), how infectious diseases spread (Balcan et al. 2009; Sorichetta et al. 2016), and how international trade will change (Fagiolo and Mastrorillo 2013). Much recent research focuses on modeling human commuting flows (Masucci et al. 2013; Lenormand, Bassolas, and Ramasco 2016); however little has focused on explicitly modeling human migration.

Human mobility has been traditionally modeled with the so-called gravity model, which posits that the probability of a trip between two locations decays directly as a function of the distance between them. This model was introduced in its modern form in 1946 (Zipf 1946) and has been used in many applications since (Schneider 1959; Lee 1966; Clark and Ballard 1980; Greenwood 1985; Letouzé et al. 2009; Noulas et al. 2012). More recently, the radiation model (Simini et al. 2012) has been shown to capture long range trips better than gravity based models, and is described as 'a universal model for mobility and migration patterns'. The radiation model posits that the probability of a trip will decay indirectly with distance and directly with the amount of intervening opportunities, a notion first proposed by Stouffer (Stouffer 1940). The radiation model has been extended several times since being proposed in 2012 (Masucci et al. 2013; Yang et al. 2014; Ren et al. 2014). In general, gravity models have been shown to be more capable of reproducing commuting flows, i.e. human mobility at small spatial scales (Lenormand, Bassolas, and Ramasco 2016), while radiation models have been shown to be better at reproducing migration flows, i.e. human mobility at larger spatial scales (Simini et al. 2012). Additionally, human migrations have been estimated by fitting generalized linear models derived from the gravity model (Cohen et al. 2008; Dennett and Wilson 2013). Both gravity and radiation models are analytical models with crafted functional forms and limited input data requirements. These models are focused on explaining human migration, rely on linear relationships between independent variables, and use hand crafted features for each zone. These approaches, while useful for explaining human migration, trade predictive power for interpretability. Data sources such as the World Bank and US Census provide many zone-based features that can be algorithmically combined in a non-linear manner by tree or neural network based models to best predict human migration. Our key contributions are as follows:

1. We develop the first general machine learning formulation of the human migration prediction problem.
2. We develop a pipeline for training machine learning models to tackle this problem that includes procedures to deal with dataset imbalance, hyperparameter tuning, and performance evaluation.
3. We develop a custom loss function for training artificial neural networks that is more suitable for the migration prediction task.
4. We compare the performance of machine learning models

```
In [11]:
#calculate mean relative error between prediction and validation data

rel_error_array = []
for i in np.arange(len(y_val)):
    rel_error = abs(y_val[i]-prediction[i])/y_val[i]
    rel_error_array.append(rel_error)

np.mean(rel_error_array, axis=0)

Out[11]: array([0.01457665], dtype=float32)
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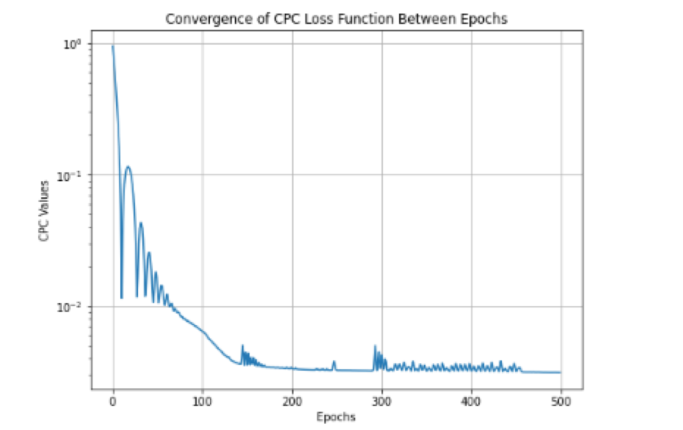


Gravity Balanced Neck Brace Design
Columbia University Spring 2022

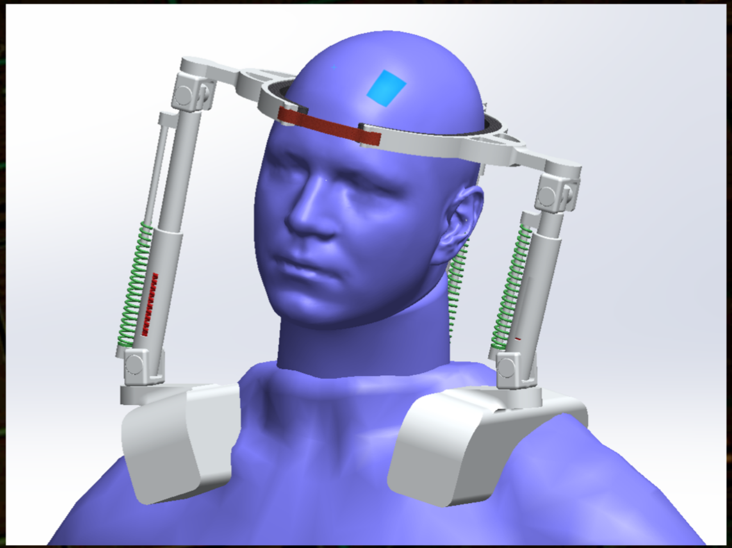
Goal: Created a neck brace where the weight of the head on the neck is minimized to zero, allowing the user to achieve lateral bending & flexion and extension with minimal force.

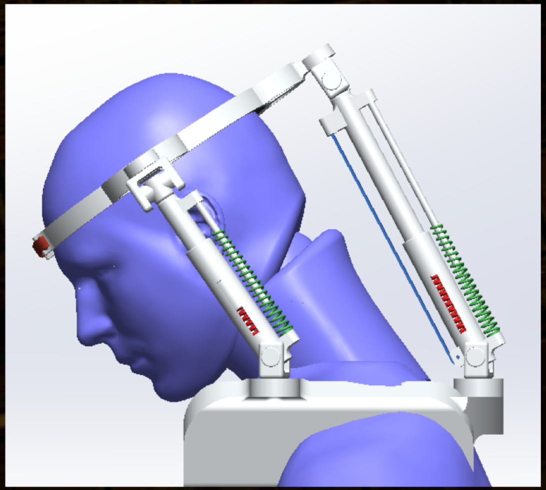
Contribution: Derived dynamics using MATLAB and plotted angles vs. force applied. Also determined the appropriate spring coefficients.

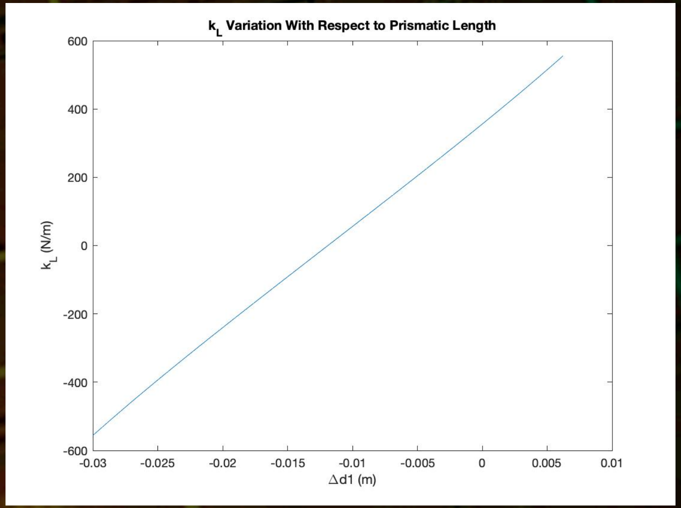
Skills Used: MATLAB, Dynamics, Linear Algebra.

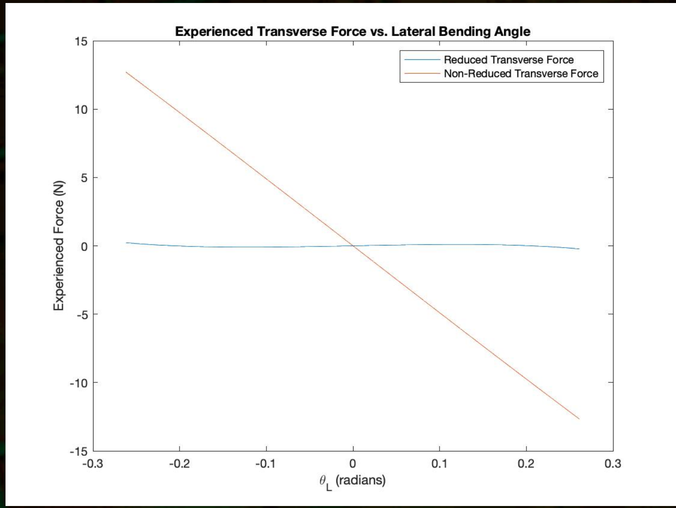
Skills Gained: Simulating a closed chain mechanism.

Bottom plots: Left is the spring constant for the chains at the temples to achieve gravity balanced lateral bending (K vs. change in link length). Right plot are the results before and after the spring is applied to the chain.









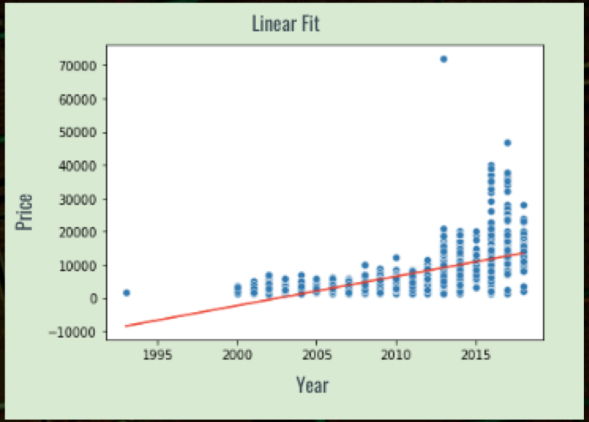
Craigslist Used Car Price Estimator
Columbia University Fall 2021

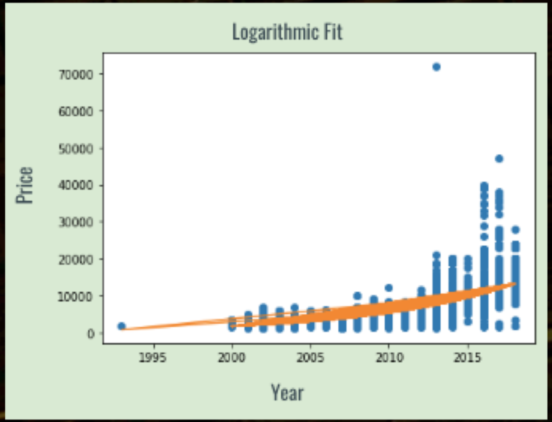
Goal: Use a dataset of all used cars listed on craigslist to provide an estimate price for a user's car.

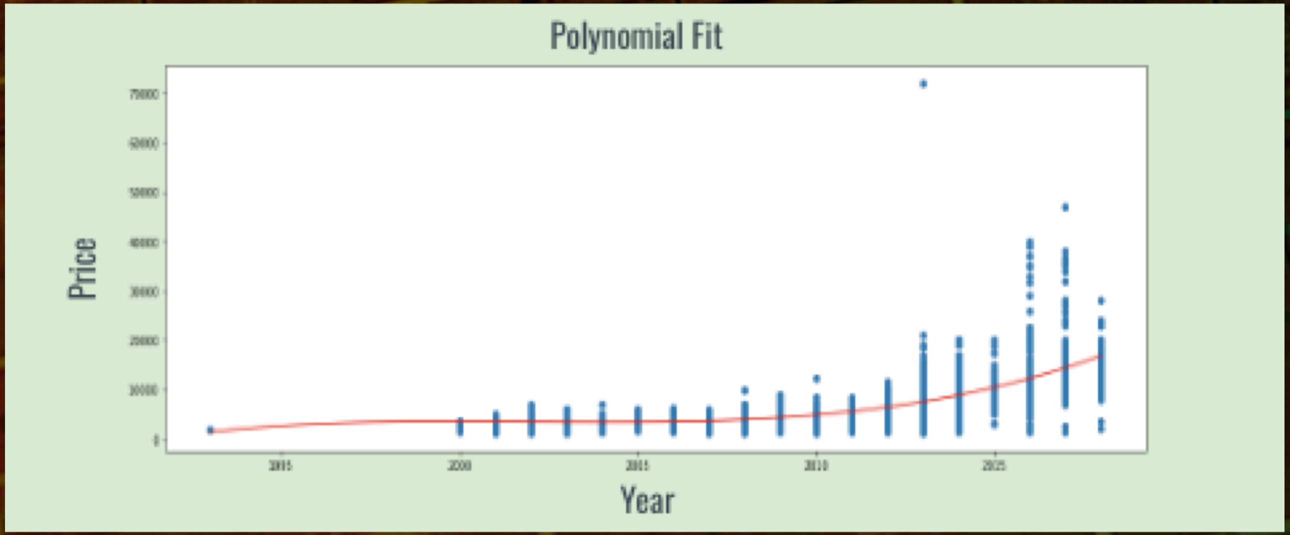
Contribution: Assisted in coding three regression models to see which one fit our data best.

Skills Used: Python, Statistics.

Skills Gained: Working with a large dataset (1.35GB), additional Python experience.





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Enter your car's manufacturer: ford
Enter your car's model: focus
Enter your car's odometer: 10000
Enter your car's year: 2018
Enter your car's condition (New/Excellent/Good/Fair/Salvage): excellent
Enter your city: los angeles
Enter your state (e.g. NY): ca
Enter your zipcode: 90005
```

```
Your car will cost approximately $16030.21
```

Results of models and user interface.

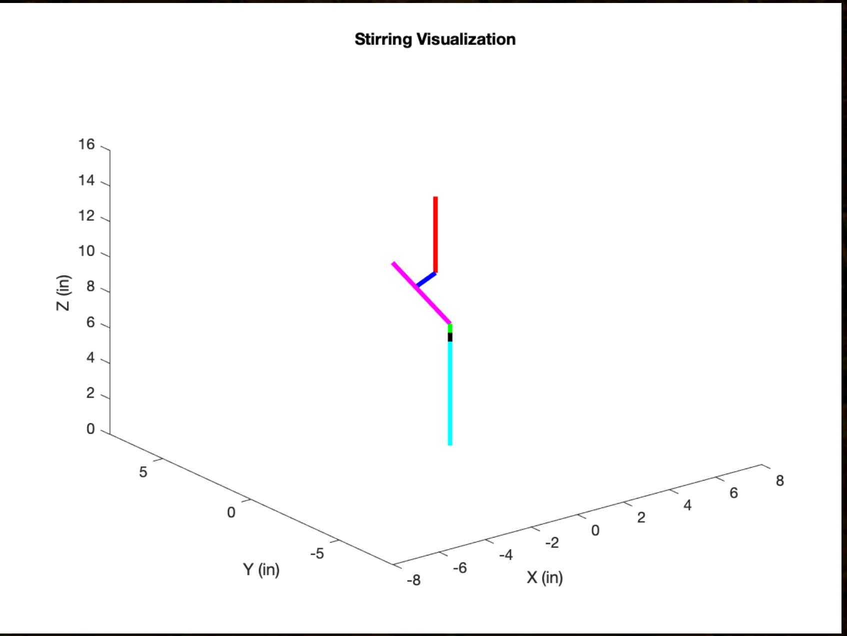
Cooking Robot: ChefServo
Columbia University Fall 2021

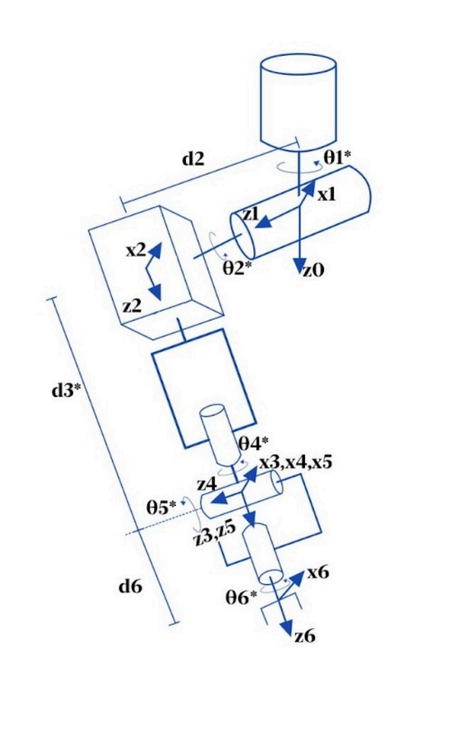
Goal: Create a novel cooking robot that automatically stirs.

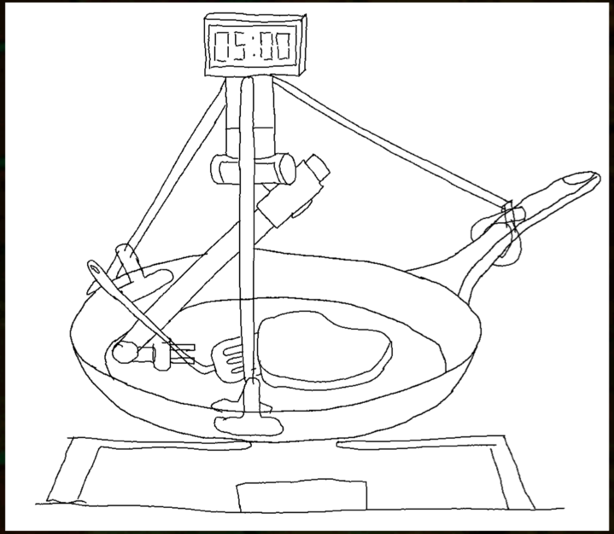
Contribution: Deriving Denavit-Hartenburg table as well as inverse and forward kinematics.

Skills Used: MATLAB, Robotic Kinematics

Skills Gained: A stronger understanding of robotic kinematics and workspace.







Soft Gripper
Boston University Spring 2021

Goal: Use thermoplastic elastomer (TPE), Arduino, and conductive fabric to make a lightweight fluid actuated gripper.

Contribution: Designed 4-fingered gripper, used conductive fabric and Arduino to keep track of capacitance, since it is correlated to space between fabric during actuation. Modeled inflation using FEA analysis on Abaqus.

Skills Used: Python, Arduino, Abaqus, SolidWorks, electric circuits

Skills Gained: Using an Arduino and Abaqus as well as CAD skills.