Trajectory Planning for Robots

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**SHINE** Summer High School Intensive in Next-Generation Engineering

Introduction

- The **Computational Learning and Motor Control Lab** focuses its research on human movements such as walking and manipulation. This summer, I worked in the CLMC lab where I learned **trajectory planning** that will allow robotic maneuvers to be performed smoothly, thus allowing natural movement that are easier to control.
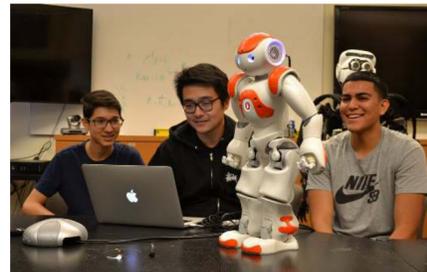
Luigi, Harry, and I (Left to right)

Overview of Professor's Research

- Many tools are used to generate motions such as **optimization theory**, **reinforcement learning**, and **control theory**. Researchers implement their findings onto various robots such as the Sarcos Master Arm and and the NAO small humanoid
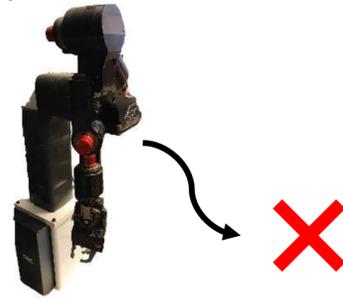

NAO Small Humanoid

Sarcos Master Arm

Project Objective and Results

My objective was to compute the **parameters** of the trajectory to create a **smooth** and **natural motion.**

To complete this project I was introduced to the concepts of
- Calculus
- Matrix Math
- Programming

I learned how to program in **MATLAB**, a computational tool and programming language used for:
- Linear **Algebra**
- Implementing **Algorithms**
- Data **Visualization**

For my project, I wrote code for minimum jerk trajectory planning that produced a smooth:
- **Position** trajectory (x)
- **Velocity** trajectory (xd)
- **Acceleration** trajectory (xdd)

$$x = c_0 + c_1*t + c_2*t^2 + c_3*t^3 + c_4*t^4 + c_5*t^5;$$
$$xd = c_1 + c_2*2*t + c_3*3*t^2 + c_4*4*t^3 + c_5*5*t^4;$$
$$xdd = c_2*2 + c_3*6*t + c_4*12*t^2 + c_5*20*t^3;$$
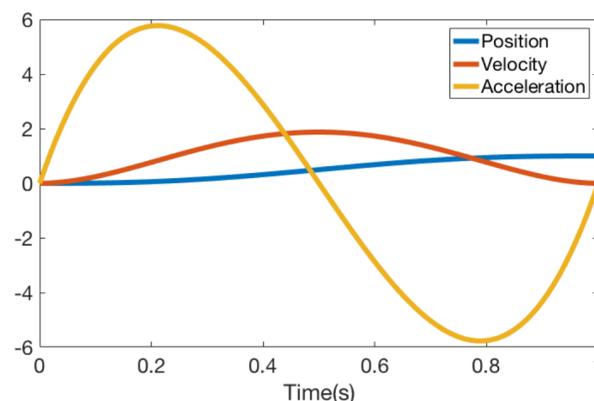
Important Skills Learned

My SHINE experience really opened my eyes to:

- the **realities** of robotic programming

- to **question** if I wanted to pursue it in college and as a career

However, this actually:

- **strengthened** my passion to continue my effort in becoming a programmer

- provided me with **knowledge** needed to stand out in college applications

```
%Scalar%
traj_length = round((tau - start_time)/delta_t) + 1;

%Vector%
time = zeros(traj_length,1);
X = zeros(traj_length,1);
Xd = zeros(traj_length,1);
Xdd = zeros(traj_length,1);

for t=start_time:delta_t:tau
[ x, xd, xdd ] = computesstateattime( c0, c1, c2, c3, c4 ,c5, t );
rowindex = round((t - start_time)/delta_t) + 1;
time(rowindex,1) = t;
X(rowindex,1)= x;
Xd(rowindex,1) = xd;
Xdd(rowindex,1) = xdd;
end
```

Code I wrote that Computes State At Time

There are many ideas and concepts I would like to share with my classmates:
- think about problems **with out having the solution in mind**
- in order to focus their attention on the methods used to solve the problem

This will allow them to:
- master their skills in the **methodology**
- **avoid discouragement** if they don't get the out come they want.

Advice for Future SHINE Students

To all the future SHINE students who will participate in the CLMC lab, I advise you to:
- Not get discouraged if you don't understand the many abstract concepts
- Take the MATLAB training seriously
- Not be afraid to ask questions when you truly don't understand something
- And finally, always try to look up your questions online before consulting your mentor

Acknowledgements