CSCE-452-500 Project#2

Tropical Storm Ofo:
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Project Summary

For project 2, our team improved upon the previous version of our digital painting robot. Now, along with an improved forward kinematics system, our robot can also paint using inverse kinematics, with the mouse location as the target position. This report briefly summarizes the improved forward and inverse kinematics systems.

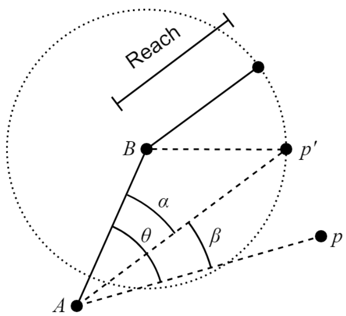
Forward Kinematics

For the first version of our project, we did not implement linear algebra in our forward kinematics system. Instead, we used variables and calculated rotations discretely per variable. This solution produced code that was long and difficult to read. However, our new version of the project has an improved forward kinematics system in which actual matrix multiplications occur. This results in code that is easier to read (and therefore maintain). Furthermore, it does not negatively affect the user's perceived result.

Inverse Kinematics

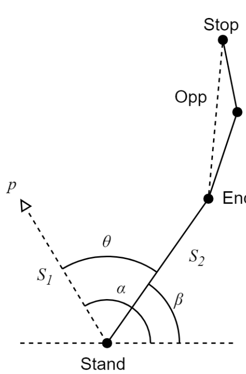
In order to rotate the end effector to the goal point our program first checks whether the point is in the reach of the end effector. If the goal is not in the reach, the program will then check if the goal is within the possible reach of all subsequent arms. Then the joint angles can be solved according to the following diagram.

The goal is to first rotate the outer arm by β, which is the minimal movement to bring p into range, and then recursively apply this for each subsequent arm. This can be solved through the following:



$$\begin{aligned}
\theta =& \text{Angle between } (A, B) \text{ and } (A, p) \\
\alpha =& \text{Angle between } (A, B) \text{ and } (A, p') \\
\cos(\alpha) =& \frac{-(\text{reach})^2 + |AB|^2 + |Ap'|^2}{2|AB||Ap'|} \\
\cos(\theta) =& \frac{(A, B) \cdot (A, p')}{|AB||Ap'|} \\
\beta =& \theta - \alpha
\end{aligned}$$

In order to prevent issues with some configurations, the following solution ensures that the goal can always be reached:



Solve for theta using law of cosines:

$$\cos(\theta) = \frac{-\text{opp}^2 + S_1^2 + S_2^2}{2S_1S_2} \tag{1}$$

Then re-apply the previous algorithm.