18 Oct 23

Engineering Student Innovation Fund Application

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Project Description:

This project started over a year ago as Tiaan Spies (BU Robotics and Autonomous Systems M.S, 2023) and I were walking out of the Photonics Building after our Intro to Robotics class. We decided we would build a robot arm to play chess as a way to practice the skills we were learning in our degree program. As the design took shape, we quickly realized that our inexpensive, programmable robot arm had much more potential than just playing chess. Made out of recycled paper towel rolls, 3D printed components, and cheap off-the-shelf electronics it was an accessible platform for anyone trying to learn or teach robotics.

By the time Tiaan left Boston in late August of this year, we had a working Version 1.0, which we affectionately named CARL ("Creative Arm for Robotic Learning"). So far, CARL can:

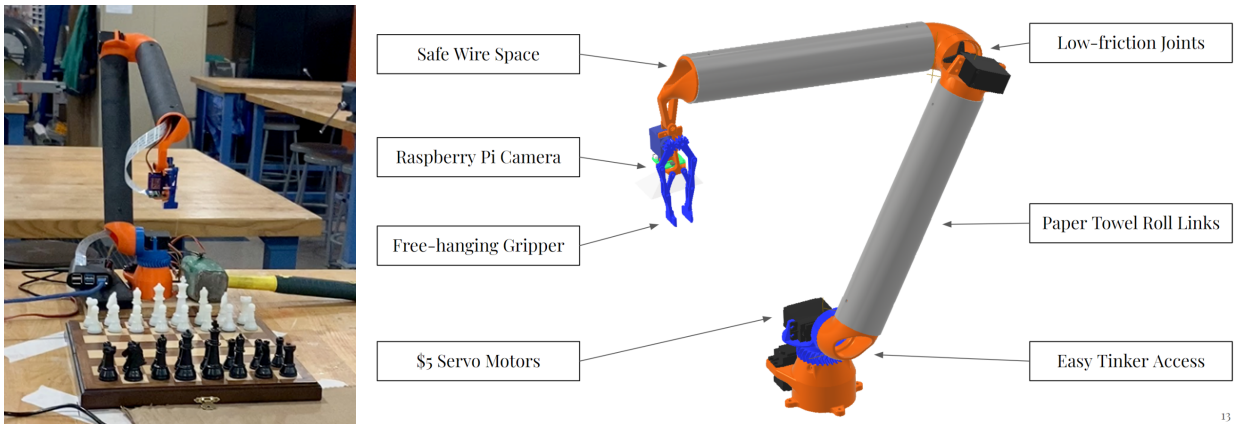
- Use the gripper-mounted camera and a basic machine learning and computer vision techniques to identify which piece has moved on a board, and leverage the stockfish chess engine to determine the best move in response
- Path plan, solve inverse kinematics, and actuate to anywhere in a ~8 cubic-foot workspace based an input goal location, given either as an x,y,z coordinate or a chess board square
- Grip, lift, move, and set down chess pieces with a ~50% success rate

The impetus for this application is that most of the electronic components belonged to Tiaan, and so CARL 1.0 went with him to Connecticut. I hope to still accomplish the specific objectives below, and need to purchase new electronics in order to build a version 2.0.

Objectives:

- Implement IKFast, an inverse kinematics library that only runs on Linux, in order to speed up the inverse kinematics solver from ~2 min per move to a more manageable ~2 sec per move
- Upgrade the three joint motors from $5 servos, to ~$20 motors with encoders so that I can implement closed-loop velocity control as opposed to the current open-loop position control. This will improve accuracy from 1 cm to the roughly ~2 mm accuracy needed for small pieces.
- Upgrade the current monocam vision to stereo vision with two cameras in order to minimize the issues we've run into with glare and piece overlap
- Put all the pieces together to finally play a physical, real-time chess game against CARL!

Media:



Left: CARL set up in the SILab; Right: labeled CAD model of CARL

Video of CARL block demo:
https://drive.google.com/file/d/1uz9qLOAQAT_SkbHkqDkfapOeZ2GBj-LL/view?usp=sharing

Video of CARL attempting to move actual chess pieces:
https://drive.google.com/file/d/14qmjkFrUPWNP2_dfGTUp_FXrw1m8HgJS/view?usp=sharing

BOM and Budget:

Raspberry Pi	$169	https://www.amazon.com/iRasptek-Raspberry-8GB-RAM-Starter/dp/B0BY711V7Y/ref=sr_1_4?crid=3IL5AWJDKUKM&keywords=raspberry+pi+5&qid=1697661089&sprefix=raspb%2Caps%2C101&sr=8-4&ufe=app_do%3Aamzn1.fos.f5122f16-c3e8-4386-bf32-63e904010ad0
Servo PWM Driver	$10	
2 Raspberry Pi Cameras with extension cable	$28	https://www.amazon.com/Arducam-Octoprint-Monitor-Extension-Raspberry/dp/B07SN8HB1R/ref=sr_1_2_sspa?crid=SJFZ5G7Q3YRN&keywords=raspberry%2Bpi%2Bcamera&qid=1697661661&sprefix=rasberry%2Bpi%2Bcamera%2Caps%2C94&sr=8-2-spons&sp_csd=d2lkZ2V0TmFtZT1zcF9hdGY&th=1
3 Joint Motors	$60	https://www.amazon.com/LewanSoul-Connectors-Equipped-Position-Temperature/dp/B081CTX6DM/ref=sr_1_19_sspa?crid=3OKHJI8XVRC07&keywords=hiwonder%2Bservo&qid=1698966559&sprefix=hiwonder%2Bservo%2Caps%2C98&sr=8-19-spons&sp_csd=d2lkZ2V0TmFtZT1zcF9tdGY&th=1
Buck Converter 10A	$10	
12V Power Supply	$20	
TOTAL	$297	