NORTHROP GRUMMAN
ENGINEERING & SCIENCE STUDENT DESIGN SHOWCASE
FLORIDA TECH

COBOT

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Abstract

This project aims to develop a system where a robot arm can interact seamlessly with humans during a game of chess. Robots often behave unpredictably in human environments, which can lead to confusion or injury. With this project, we will use computer vision and familiar interfaces to demonstrate how a robotic system can be designed with human factors in mind.

System Overview

COBOT: Collaborative robot (or chess robot) – a modified version of the AR3 from Annin Robotics

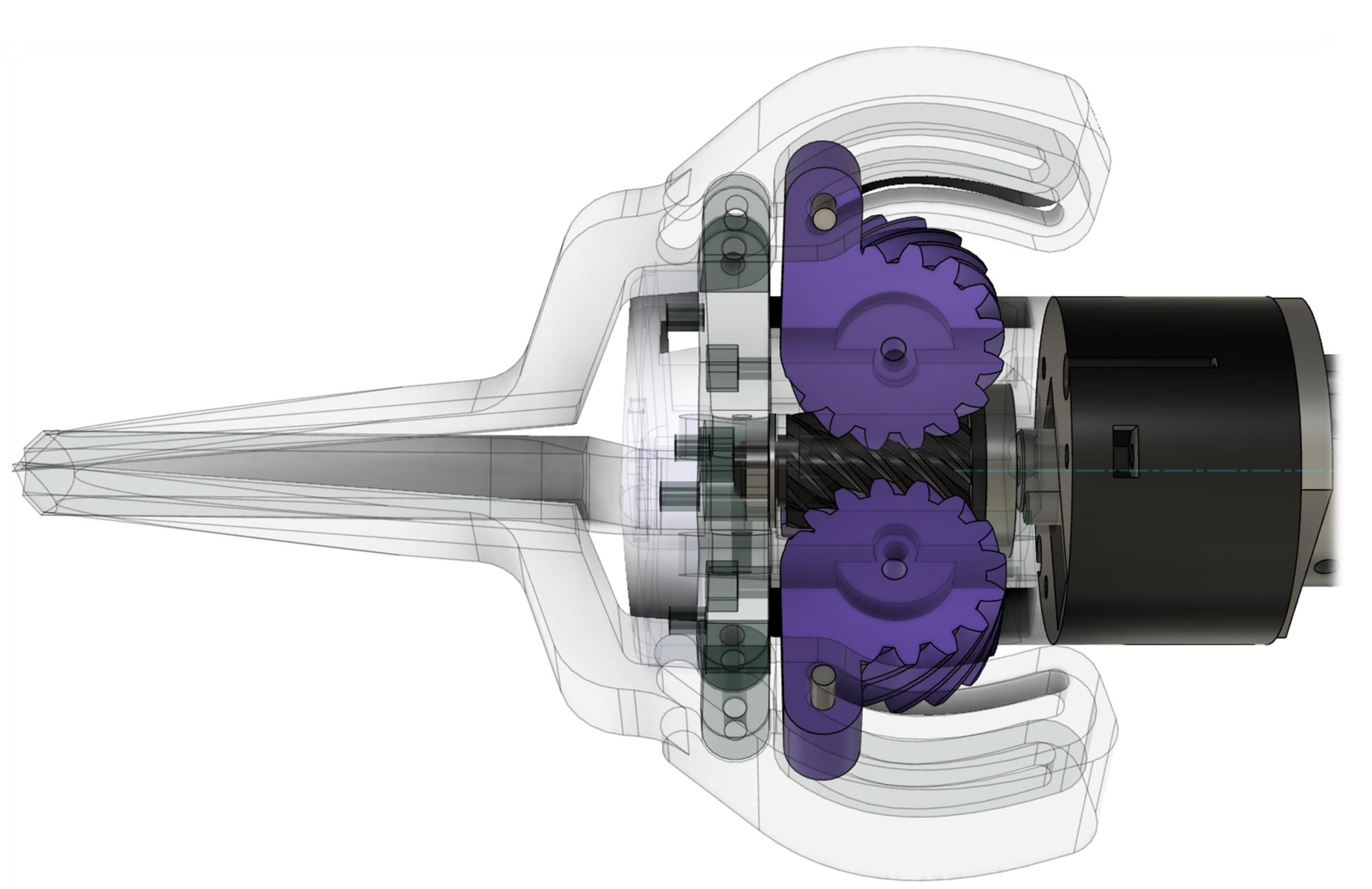
ROS2: The Robot Operating System is used to coordinate software and plan motion

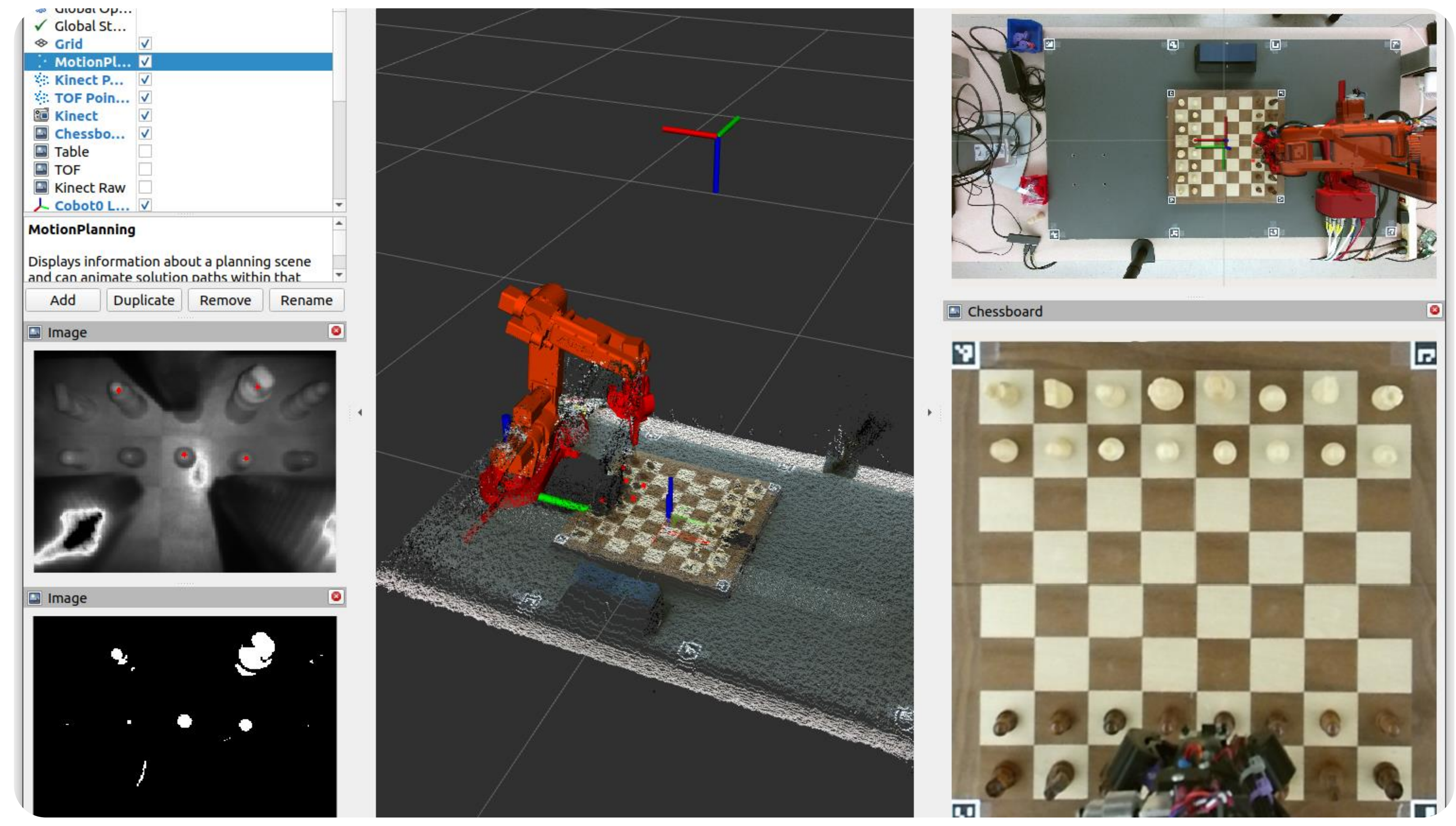
Computer Vision: An Xbox Kinect determines the physical locations of objects in the scene and identifies the pieces on the chessboard

Clock: A custom chess clock that communicates with the computer system over serial

Dashboard: A web-based dashboard with controls and live information

Gripper: A gripper designed to pick up chess pieces, with an inbuilt depth camera for visual servoing





Software Highlights

ROS2 (Humble): The Robot Operating System is a set of libraries that allow high-level composition of software components for robots

Cyclone DDS: An implementation of the Data Distribution Service that enables communication between components, even across networks

MoveIt2: A motion planning platform built on ROS2

COBOT Firmware: A custom firmware was written for the COBOT to take advantage of our hardware improvements and better integrate with MoveIt2

Pose Correction: An evolutionary algorithm is used to visually estimate drift in joint angles and correct them

OpenCV: Used to calculate the positions of objects seen by the Kinect and identify chess pieces with the gripper's depth camera

PyTorch: Neural networks were trained to classify chess pieces and identify obstacles above the board

Dashboard: A web-based frontend and backend communicate over WebSockets to relay data back and forth and interface with ROS

Chess Clock: Keeps track of time and signals robots when it is their turn

Standard Operation

A game is started via the dashboard. From now on, all future interactions with the COBOT are done through the chess clock, mirroring the experience with a human opponent. The player makes a move, presses the clock button, and the COBOT begins its turn. It uses the Kinect to ensure that the player's hand is clear, then proceeds to move its pieces. It presses the clock button and returns to a neutral position. During normal operation, the COBOT does not receive direct commands; instead, it watches the game state and intelligently takes its turn when it is safe to do so. This means that COBOTs can easily be swapped in and out of a game at any time while always behaving safely and predictably.

Future Work

Hardware Issues: Backlash in joints makes precise motion difficult. We enacted many workarounds for this, but a hardware fix is necessary to achieve true consistency.

Second COBOT: We had to cannibalize our second COBOT to fix issues with the main one. While our software scales elegantly to COBOT-vs-COBOT games, the second COBOT must first be rebuilt.