UTA College of Engineering

Checkers-Playing UR5 Co-Bot

CSE Senior Design

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Executive Summary

The UR5 collaborative robot (co-bot) belonging to the Computer Science and Engineering department at the University of Texas at Arlington currently does not showcase the collaborative nature of its ability to interact closely with humans. The co-bot has been programmed to perform an interactive game of Checkers, the strategy board game, against a human opponent safely and intelligently.

The purpose of the checkers-playing co-bot project is to present the co-bot to prospective College of Engineering students for marketing purposes as well as the opportunity to expose students to industrial automation technology. In addition to this, prospective students will gain exposure to different projects that computer science, software engineering, and computer engineering students get to work with.

Background

Our project aims to showcase how a robot arm can be programmed to play a game of Checkers. Although there is no demand for a checkers-playing robot today, there is a growing demand for engineers in the modern world, especially when it comes to computing technologies. With this project, we hope to ignite new and existing passions for technology and innovation in the students of tomorrow.

Through the use of computer vision, artificial intelligence and the UR5 co-bot, we have given the robot arm the ability to play a game of Checkers against a human player. We accomplished this by utilizing computer vision to analyze the current state of the board so that the co-bot can then use artificial intelligence to make an educated choice as to which move to play next.

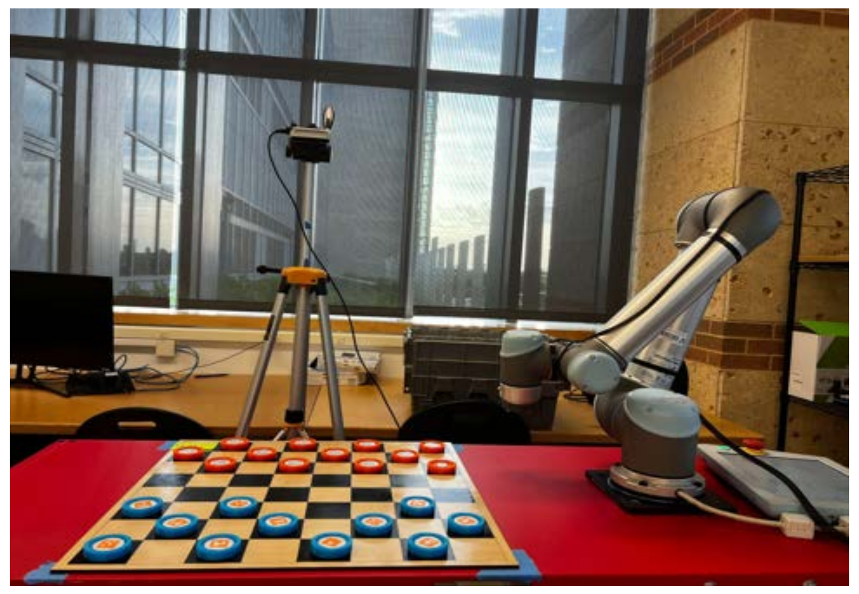

Figure 1. UR5 Playing Checkers

Experimental Setup

- **UR5 co-bot:** The robot is connected to the computer and utilizes the minimax algorithm to make game decisions.
- **Magnetic gripper:** Allows the robot arm to pick up pieces individually by turning on the electromagnet and placing the pieces by turning off the electromagnet.
- **Arduino and MOSFET module**: Turn the electromagnet on/off to pick up and drop the pieces. The MOSFET module drives the gripper and listens to the signal from the Arduino.

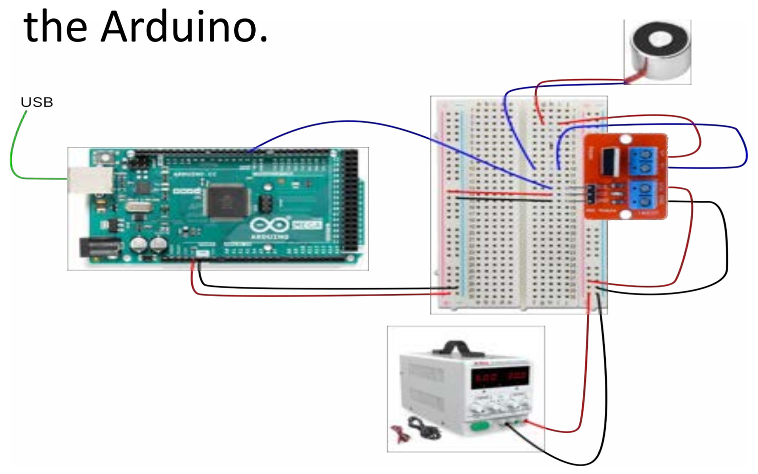

Figure 2. Electromagnet Circuit

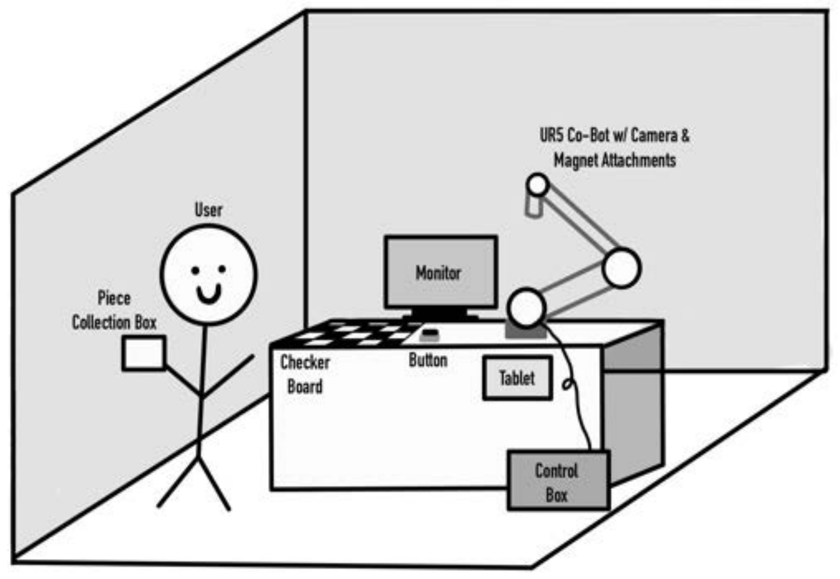

Figure 3. Conceptual Drawing of Gameplay

- **Checkers pieces**: ArUco markers are attached to the top of the 3D printed surface for the identification and detection by the camera.
- **RealSense camera:** The computer receives and processes the frames from the RealSense D435 camera for piece detection. The library used is OpenCV.

Experimental Test Plan

- First, the game script is run on the computer by the human player.
- This script will run until one of the players wins the game, or the human decides to quit early.
- The computer then utilizes the camera to assess the state of the board and will continue to do so throughout the game.
- The human player will be assigned the blue Checkers pieces and play first.

Figure 5. AruCo Markers on Checkers pieces

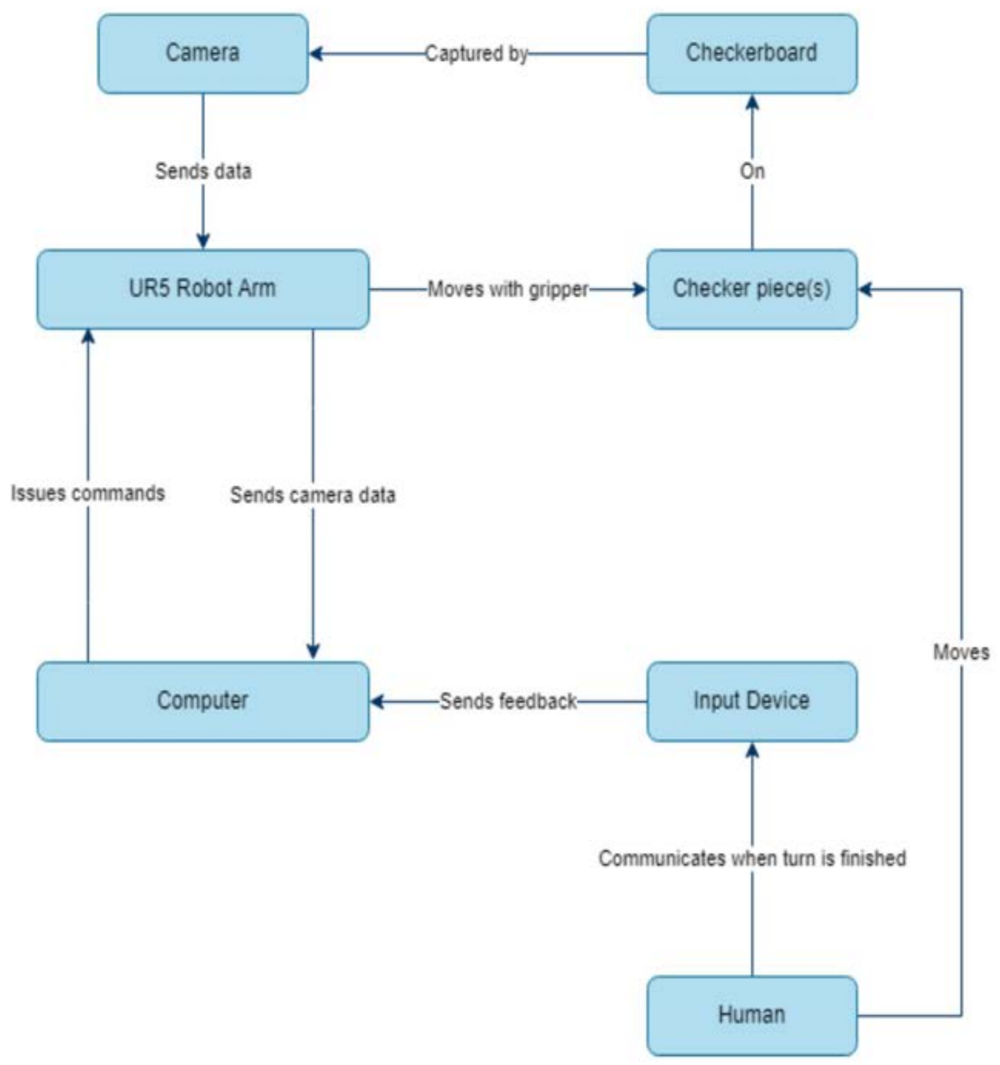

Figure 4. System Overview

- When the human player makes a move, the human must use the computer keyboard to communicate to the computer that they have completed their turn and it is now the UR5's turn to make a move.
- The computer will communicate with the robot arm and issue commands for it to make a particular move.

Experimental Results

- Computer vision allows the detection of the ArUco markers on the Checkers pieces and determines their position on the game board.
- The magnetic gripper accurately moves pieces from one cell to another through the program calculations and signals to the Arduino that controls the magnet.
- The UR5 Robot arm uses artificial intelligence to make optimal game decisions using the minimax algorithm.

Figure 6. Marker Detection

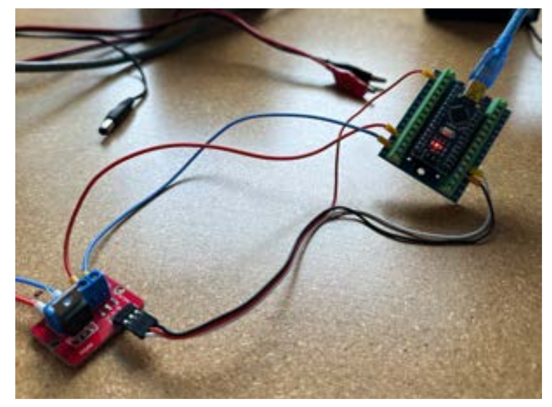

Figure 7. Arduino and MOSFET module setup

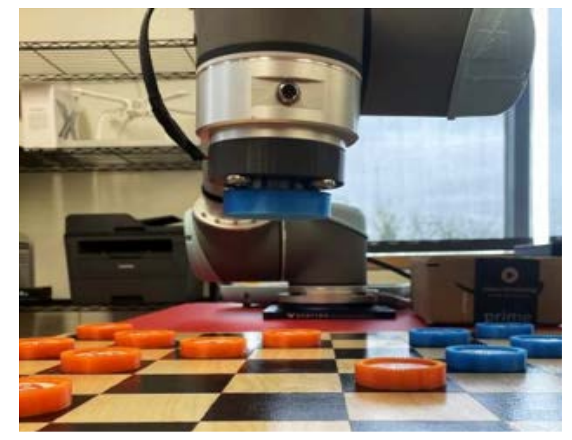

Figure 8. Functional Magnet Gripper

Conclusions

Insights:
- We were able to program the UR5 co-bot to be able to play a complete game of Checkers with a human player with all specifications and constraints met.

Lessons Learned:
- We started out with little knowledge of computer vision, artificial intelligence, electrical components, robotics, and over time, we were able to integrate these disciplinaries into the making of a fully functional interactive game.

Future Plans:
- Potential for UR5 to always win in a game of Checkers against a human player or another robot.
- UR5 can have capabilities to automatically reset the board and replace the Checkers pieces by itself with difficulty level settings.
- UR5 could have the option to play other regional variations of Checkers in the future.

Acknowledgments:
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References

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