Playing Games with Baxter

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Abstract

The goal of this project is to allow Baxter to play a game of Tic-Tac-Toe with a user. Other attempts at having Baxter play Tic-Tac-Toe have been done, but they all require significant modifications to the game. Our technical approach will use Ein to recognize the piece locations, which will allow us to build the board state. Then we will have a Tic-Tac-Toe playing algorithm that will tell Baxter where to move the pieces. Our goal is to allow Baxter to play Tic-Tac-Toe with users while minimizing changes to the pieces.

Introduction

The ability to actually physically play a game with a robot in real life is not only fun, it can also be useful for outreach. Tic-Tac-Toe is a natural choice because it is a game that people of nearly all ages can play. Playing a game with a robot is a great way to introduce people (especially kids) to interacting with robots, which will be especially useful if robots are going to be integrated into everyday life.

A previous implementation of a Tic-Tac-Toe playing Baxter has been done by another group (https://www.youtube.com/watch?v=ZcUig11wnzg). However their project uses specialized pieces and a specialized board. Our goal is to allow the robot to play Tic-Tac-Toe in a less constrained environment.

We will have the robot scan the board to check for the current locations of all the pieces on the board. Then, we will use the locations of the pieces to determine an actual board. This is done by taking two calibration points and then transforming the real life points into coordinates on a non-rotated unit length board. From there, we determine which center location the piece is closest to. Finally, an algorithm will determine Baxter's next move.

We will know that the project is successful if we are able to successfully play a game of Tic-Tac-Toe with Baxter. We would like to record a video of someone playing a game with Baxter as a final goal.

Related Work

The AI required for the moves behind Tic-Tac-Toe has been solved so the difficulty for this project will lie in its implementation. Robots today can play more complicated games such as chess using specialized grippers to move pieces and by using magnetic sensors to detect the pieces. This simplifies the perception and movement logic greatly for these robots. It is far difficult to use Baxter's camera to detect tic-tac-toe pieces. Versions of tic-tac-toe playing Baxters exist but they use a modified board and modified Pieces.
(https://www.youtube.com/watch?v=ZcUig11wnzg).

Technical Approach

The core of the program is a subscriber and a publisher to ROS. The publisher sends one-time text commands (such as "goHome") to the Baxter, and then waits for Baxter to execute the command to continue the program. Meanwhile, the subscriber listens for the locations and type of the pieces in the scene.

When the program is run, the publisher starts by commanding Baxter to scan the board. Then it tells Ein to find all of the objects in the scene, based on the scan of the board. Once Ein is done with this process, we wait for the subscriber to hear the new locations of the pieces.

With the locations of the pieces, we need to determine the actual state of the board. To do this we use two calibration points, which are the bottom left and the bottom right edges of the board. We translate every piece location so that the bottom left calibration point is at (0,0). Then, we rotate the the points by the angle between the calibration points, and finally we scale each point by the length of the board. Now, all of the points are between (0, 0) and (1, 1) and are no longer rotated. Then, its a simple matter of finding out which position the point is closest to, where the bottom left piece would be centered at (⅙, ⅙) and the top right piece is centered at (⅚, ⅚).

Once it knows where all the pieces are, it decides on what move to make by randomly choosing its move among legal moves. Once it decides on a move, it reverses the transformation process to determine the real world coordinates where the piece

should go, and points to that location. Then, it waits for the user to make a move, and the process starts over from the scan of the board until the game is finished.

Evaluation

Our goal for the final was to have Baxter be able to play a game of Tic-Tac-Toe. While we were unable to get the Baxter to pick up the pieces due to time constraints, we were able to recognize the state of the board through the Baxter's cameras.

Also, there was nothing unique about the pieces that we chose except that the camera is able to distinguish them. In theory, a process could be made that allows users to scan in arbitrary pieces and play on an arbitrary board, as long as the pieces are easily distinguishable through Ein's object detection software.

Here is a video of Baxter playing two moves of Tic-Tac-Toe with a user: https://drive.google.com/file/d/15QMBA8y8mXlCHN7FRjHQbeimt3CxPnpp/view?usp=sharing

Conclusion

In conclusion, our goal was to allow Baxter to play a game of Tic-Tac-Toe with a user. There have been other attempts at this goal, but they all use customized pieces. Our technical approach used a publisher and subscriber to communicate with Ein to determine piece locations, and then transformation math to determine board state from these positions.

There are several ways that this project could be improved as part of future work. First, we would like to have Baxter actually pick up pieces and place them on the board instead of pointing. Second, we would like Baxter's facial expression to show it thinking while the Baxter is playing the game. Third, we would like to include a more sophisticated AI for Tic-Tac-Toe. These improvements would make playing against Baxter more enjoyable and realistic.

We would also like to write a program that actually allows users to scan in custom pieces, point out reference points, and play on a custom board. The difficulty in this would be finding a way to make this process consistent. This would also make the gripping problem more difficult, as it would require users to train the robot to grab the pieces themselves. However, if successful this would allow any Baxter to play a game of Tic-Tac-Toe on any board.