The Terminator

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Background

- Cultural **multiplayer** board games involving two or more human players, such as tic-tac-toe.
- Can be played anywhere at any time as long as flat surface is readily available.
- Playing against one's self can result in inevitable tie and/or biased results.
- **A Strong Need** to have the ability to play board games without another human opponent

Problem Definition & Objectives

- **Target Users:** Board Game Players
- **Problem Definition:** To design, build and integrate the elements of an autonomous robotic system that plays Tic-Tac-Toe on a 3 by 3 grid
- **Primary Objectives**: Create a competitive board game when no other person is around

Design Requirements

Essential

- Perception of Environment (eg Board layout)
- Capability to evaluate moves based on state of board
- Robot should know the rules of tic tac toe
- Able to grip tic tac toe pieces (ranging 1 - 4 cm in width)
- Robotic arm must be able to reach every location in playing space (3 x 3 grid)
- Sensory information on the state of the robot and its environment

Proposed Vision Related

- Camera stand of height 25 - 35 cm above board
- Max camera stand weight of 1 kg for portability
- Manufacturable at Howard University

Energy, Power, and Environment

The power needed to execute robot motion must be easily supplied by 9V batteries

Size and Weight

The robotic arm should weigh no more than 1 kg while the camera stand and the board should weigh no more than 2 kg

Gameplay (Control)

- Execution of play turn in less than 30 seconds
- Accuracy and repeatability of at most 2 cm
- Ensure a stable motion with minimal or no vibrations/oscillations

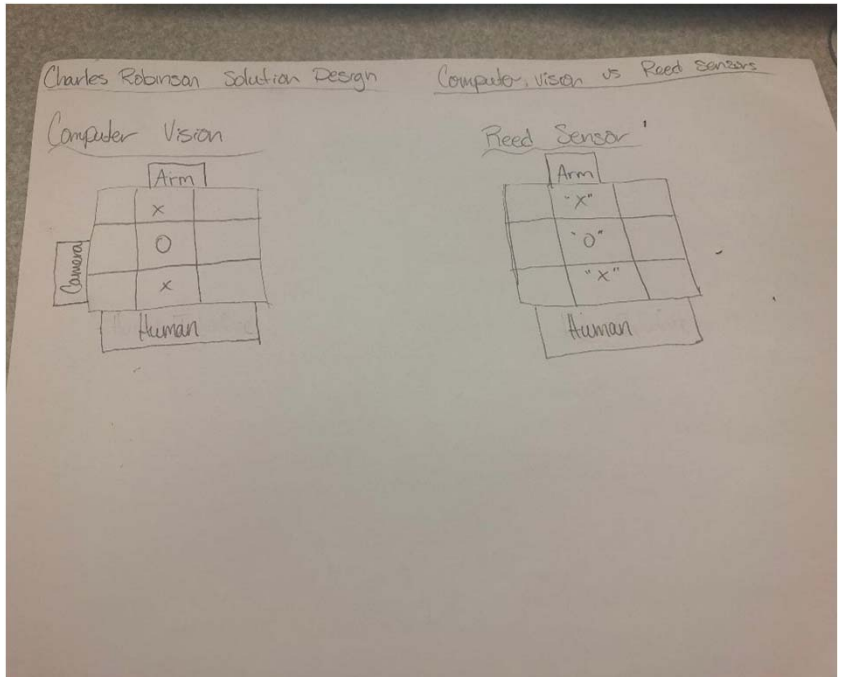
Standards & Regulations

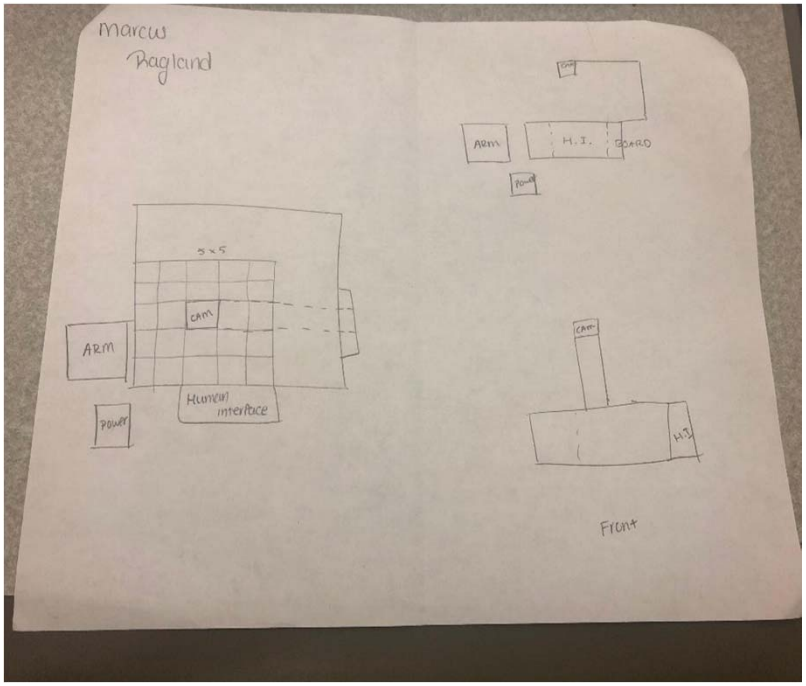
- The robotic arm must comply with the following requirements:
  - OSHA 29 CFR 1910.333, Selection and Use of Work Practices
  - OSHA 29 CFR 1910.147, The Control of Hazardous Energy (Lockout/Tagout).

Constraints

- Alert method: (audio/visual and vibration) should be culture-responsive for global acceptance
- Robot should cost less than $50 to manufacture

Top 2 Designs Selected





Pros and Cons of Top 2 Designs

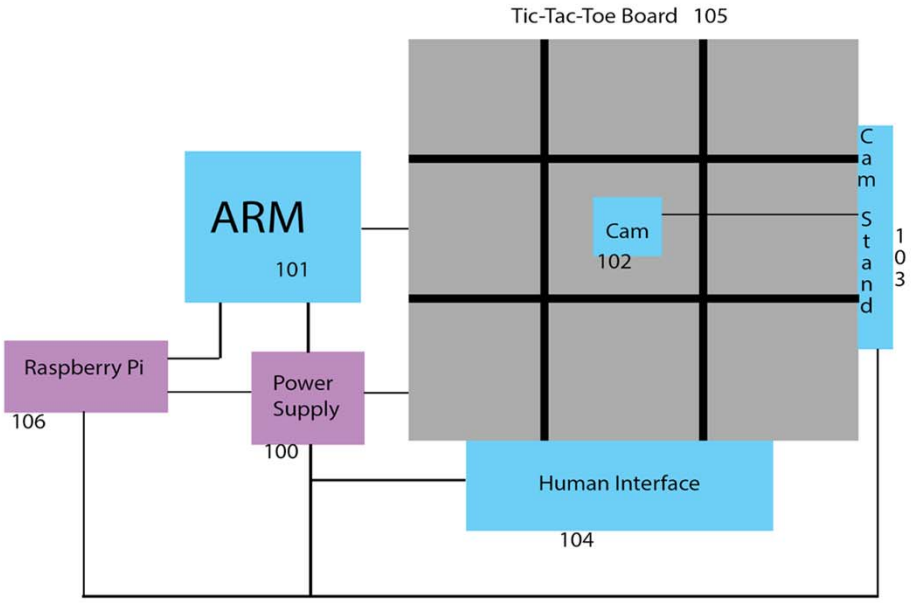
Pros	Cons
Easy detection if spaced is used through sensors	Can't determine if marked with "x" or "o"
Simple method of moving pieces	Requires more power for lifting pieces and powering sensors
Simpler communication to code when cell is filled/empty	Grip may drop pieces prematurely
	Outside objects may confuse sensors if on board

Pros	Cons
Simple method of moving pieces	Grip may drop pieces prematurely
Enables greater control over individual pieces	Requires more power to lift pieces
Basic algorithm readily available on open software for easy implementation	Difficulties processing images

Decision Matrix For Top Design

	Weight	Design 1	Score	Agg. Score	Design 2	Score	Agg. Score
Functionality	5	Uses sensors & grip method	3	15	Uses Computer vision & grip method	3	15
Power	4	More components to be powered	4	16	Fewer components to be powered	5	20
Weight	3	<3kg	4	12	<3kg	4	12
Convenience	2	At home edit	3	6	At home edit	3	6
Connectivity	1	Wired	5	5	Wired	5	5
Total				54			58

Top Solution Design



Computer Generated Terminator Arm

Top Solution Design Details

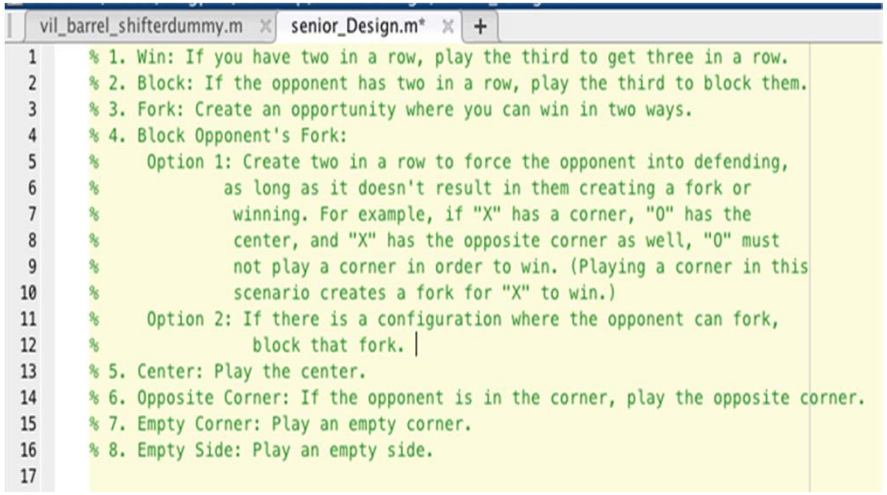
- Power supply **100** provides power to the initial system in order to power the robot arm **101**, camera **102**, driver-vehicle interface **104**, and raspberry pi **106**
- Raspberry pi **106** offers the algorithm to the system for playing tic tac toe
- User interacts with the driver-vehicle interface **104** to decide who goes first, the human or robot arm **101**
- Algorithm allows the player to play against the robot arm in a competitive game of tic tac toe
- robot arm **101** uses a grip method to physically pick-up and drop its pieces to the desired position in the game
- Reed sensors are used under the board to help identify which spaces are open and which are used.
- Camera **102** sees where the piece has been placed and signifies the owner of that space on the board **105**
- When three of the same pieces have been recognized in a horizontal, diagonal, or vertical fashion, the camera **102** recognizes this, and the system denounces the winner. If players have filled the board with no recognition of three-in-a-row, the system calls a tie.

Brain of the Robot

The programing of the Robot is separated into two (2) main parts

- The physical controls for moving the robot
- The Tic-Tac-Toe engine which tells the robot how & where to play the pieces

Newell and Simon's Tic-Tac-Toe Algorithm



This Algorithm tells the robot where to play next depending on the current board state. It guarantees that the robot will never lose in a game of Tic-Tac-Toe with the only possible outcomes a win or a draw, at worst.

Conclusion

- Building Robot to play board games without human opponent
- Robot will be able to move around and maneuver game pieces
- Robot will be able to identify and react to different game situations
- Robot will adhere to design requirements, cultural and environmental constraints