Tic-Tac-Toe Playing Robot

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ABSTRACT

This report outlines the development and integration of a comprehensive system utilizing OpenCV2 and MyCobot280M5 for an autonomous Tic Tac Toe playing robot. The system leverages computer vision techniques for color detection and the MyCobot280M5 robotic arm for object manipulation. The system starts by detecting Aruco markers to determine the dimensions of the Tic Tac Toe board and divides it into playable positions. The gameplay alternates between a human player (represented by blue color cubes) and the robot (represented by green color cubes), with the robot employing computer vision to determine its moves.

1. INTRODUCTION

The amalgamation of computer vision methodologies and robotics has led to the emergence of sophisticated systems capable of perceiving, analyzing, and responding to their surroundings. This project aims to synergize OpenCV2-based color detection with the MyCobot280M5 robotic arm to construct an autonomous Tic Tac Toe player. In addition to the integration of color detection and robotics, a dedicated Tic Tac Toe game engine forms the core logic of the system.

Traditionally played on a 3x3 grid, Tic Tac Toe is a simple yet strategically rich game where two players take turns marking spaces with their respective symbols, typically X and O, aiming to form a row, column, or diagonal of their symbols. This project not only incorporates the physical manipulation of color-coded cubes but also integrates a virtual representation of the game using a Tic Tac Toe game engine.

2. METHODOLOGY

The system's methodology encompasses the fusion of computer vision techniques to detect and interpret color-coded cubes on a physical board and a sophisticated game engine to manage the virtual representation of the Tic Tac Toe game. The MyCobot280M5's precise movements and the game engine's decision-making logic are harmonized to create a seamless and interactive gaming experience. By leveraging OpenCV2 for color detection, robotics for physical manipulation, and the game engine for computational decision-making, this project showcases the convergence of various technologies to accomplish an automated and immersive gaming system.

Step 1: Initial Frame and Board Detection
The system initialization involves activating the camera to capture the initial frame of the playing area. Using image processing techniques in OpenCV2, Aurco markers on the platform are identified. These markers act as reference points to delineate the dimensions of the Tic Tac Toe board. The marker’s positions and relative distances provide the necessary information to divide the board into nine playable positions.

Step 2: Human's First Turn
The game starts with the human player's participation, denoted by placing a blue-colored cube on the designated playing position on the board, representing the human's move (X). The system registers this move as the starting point for the game.

Step 3: Color Assignments
To distinguish between the human player's moves and the MyCobot280M5's moves, blue color cubes signify the human's moves (X), while green color cubes are designated for the robot's moves (O).

Step 4: Loading Area for MyCobot
A specific loading area is allocated adjacent to the playing board for the MyCobot280M5 to access and retrieve green-colored cubes. This designated zone ensures the robot's easy access to the cubes required for its moves.

Step 5: Computer Vision for Robot's Move
Following the human's move, the camera initiates, capturing the current state of the board. Using image processing techniques and algorithms within OpenCV2, the system analyzes the position of the blue-colored cube on the board. It computes the best possible move for the MyCobot280M5 by evaluating the current state of the game and employing strategic decision-making logic.

Step 6: Robot's Move Execution
Upon determining the optimal move, the MyCobot280M5 is directed to move to the loading area. Utilizing the robotic arm's precision and control, it picks up a green cube and accurately places it on the board, marking its move (O).
Tic Tac Toe Game Engine Integration:
The system's architecture encompasses a robust Tic Tac Toe game engine implemented in the software layer. This game engine functions as the decision-making core, dictating the strategies for the robot's moves and validating the game's progression and conclusion. It manages the game state, computes optimal moves based on the current board configuration, and determines winning conditions or a draw, ensuring adherence to the game's rules.
By combining the physical interaction facilitated by the MyCobot280M5 and the computational capabilities of the game engine, the system orchestrates an interactive experience between the physical world and the virtual representation of the game. This integration bridges the gap between the tangible manipulation of color-coded cubes and the logic-driven decision-making required for a successful and engaging Tic Tac Toe gameplay.

Step 7: Iterative Process
After each move, the camera activates, capturing the updated state of the board. The system analyzes the image feed, identifies the positions of Xs and Os based on color detection, and updates the board accordingly. This iterative process ensures the consistent progression of the game, alternating between human and robot moves.

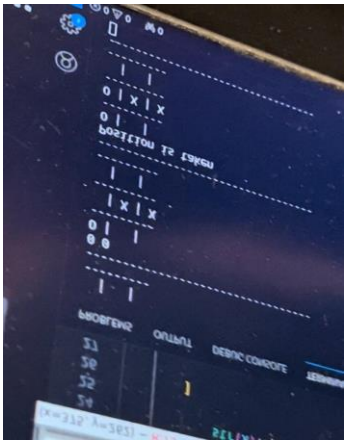
Step 8: Game Continuation
The game proceeds in this manner, with the camera consistently monitoring and updating the board based on color detection. This cycle continues until the game reaches its conclusion, either by a player or robot achieving a winning combination or the board being filled, resulting in a draw.

3. RESULTS

The system demonstrated consistent and accurate performance throughout multiple gameplays. The color detection algorithms reliably identified blue and green color cubes, enabling the robot to comprehend the human player's moves and make strategic decisions for its own. The MyCobot280M5 executed precise movements, successfully picking and placing the cubes onto the board as intended. Additionally, the system efficiently adapted to changes in cube positions and consistently marked the board with Xs and Os based on color recognition, enabling a seamless gaming experience also the Tic Tac Toe game engine collectively contributed to the system's efficiency and reliability.
Accurate Color Detection: The color detection algorithms showcased robustness in accurately identifying blue and green color cubes used as markers for human (X) and robot (O) moves, respectively. The system reliably distinguished between these colors despite varying lighting conditions, ensuring the precise interpretation of the players' moves.
Precise Robotic Manipulation: The MyCobot280M5 demonstrated exceptional precision and agility in handling the physical manipulation of color-coded cubes. It efficiently picked up the green cubes from the loading area and accurately placed them on the designated positions of the Tic Tac Toe board, maintaining the integrity of the game setup.
Strategic Decision-Making: The integration of the Tic Tac Toe game engine played a pivotal role in driving the robot's decision-making process. By analyzing the current state of the board captured through the camera feed, the game engine determined optimal moves for the robot. These moves were strategically calculated to maximize the chances of winning or preventing the opponent from winning.

Consistent Game Progression: Throughout the gameplay sessions, the system consistently alternated between the human and robot turns, updating the board state based on color detection. The iterative process of capturing, analyzing, and updating the board led to a seamless and uninterrupted gaming experience.
Adaptive Gameplay: The system showcased adaptability in accommodating various gameplay scenarios. It dynamically adjusted to changes in the board configuration, responding adeptly to human moves, and adapting its strategies to make informed decisions for the robot's moves.
Game Conclusion Handling: As per the rules of Tic Tac Toe, the system accurately identified winning combinations or a draw, concluding the game appropriately. The game engine validated the board state, identifying winning sequences of Xs or Os or declaring a draw when the board was filled without a winner.

Link to the video: [TicTacToe Playing Robot]



4. CONCLUSION

This project exemplifies the seamless integration of OpenCV2-based color detection and the MyCobot280M5 robotic arm to create an automated Tic Tac Toe player. The system dynamically responds to human moves and employs computer vision algorithms to determine optimal moves, providing an interactive gaming experience.