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Project Report: Tic-Tac-Toe

Hriday Rajesh Nagrani[1]
[1]School of Computing and Augmented Intelligence, Arizona State Univeristy, Az, USA

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ABSTRACT

This lab project presents a comprehensive integration of the YOLOv8 object detection model and a tactile Tic-Tac-Toe gaming experience, orchestrated by the MyCobot robotic arm. Utilizing the Ultralytics library, YOLOv8 dynamically identifies and classifies objects, specifically 'teddy bear' and 'bottle,' serving as symbolic representations of human ('X') and computer ('O') moves in real-time. The interactive Tic-Tac-Toe gameplay is designed to foster a collaborative environment, where the MyCobot arm strategically executes computer moves leveraging the minimax algorithm.
The gameplay unfolds seamlessly in an iterative sequence, with the human player physically interacting on a tangible grid. These interactions are seamlessly detected by the YOLO model, providing an interface for human-computer engagement. The robotic arm responds with tactically optimized moves, creating a harmonious interplay between advanced computer vision and precise robotic control. This integration not only demonstrates technical sophistication but also underscores the potential for intelligent and engaging human-robot interactions, paving the way for future applications in interactive gaming and collaborative scenarios.

Corresponding Author:

Hriday Rajesh Nagrani
School of Computing and Augmented Intelligence, Arizona State Univeristy
Az, USA
Email: hnagrani@asu.edu

1. INTRODUCTION

The integration of advanced computer vision and robotics has paved the way for interactive and intelligent applications, exemplifying the synergy between perception and action in technological systems. This lab project explores a novel fusion of the YOLOv8 object detection model and a Tic-Tac-Toe game, orchestrated by the MyCobot robotic arm. The aim is to create a collaborative gaming experience that leverages real-time object detection for human-computer interaction.

- YOLOv8 Implementation:

  The project utilizes YOLOv8, a state-of-the-art object detection model from the Ultralytics library. The 'yolov8n.pt' pre-trained model is employed to dynamically identify and classify objects in real-time. Specifically, the YOLO model is configured to recognize 'teddy bear' and 'bottle' objects, which symbolize the moves made by the human ('X') and computer ('O') players in the Tic-Tac-Toe game.

- Tic-Tac-Toe Game Design:

  The Tic-Tac-Toe game is designed to offer a tangible and interactive interface for human-computer engagement. The MyCobot robotic arm serves as the computational player, strategically responding to the human player's moves. The gameplay follows standard Tic-Tac-Toe rules, and the robotic arm's moves are determined by the minimax algorithm, providing an intelligent and challenging opponent.

- Human-Computer Interaction:

  The human player interacts with the game by physically placing stickers on a tangible grid, simulating moves on the Tic-Tac-Toe board. These physical moves are seamlessly detected by the YOLO model, facilitating a seamless transition between the physical and virtual realms. The MyCobot arm then translates these moves into strategic and optimized responses, adding a layer of intelligence to the collaborative gaming experience.

- Motivation and Significance:

  This project goes beyond the conventional boundaries of gaming and robotics, aiming to showcase the potential of integrating computer vision and robotic control for interactive applications. The collaborative gameplay not only highlights technical sophistication but also underscores the versatility of such integrated systems in real-world scenarios, such as interactive educational tools, entertainment, and human-robot collaboration.

In summary, this lab project explores the convergence of YOLOv8, Tic-Tac-Toe, and the MyCobot robotic arm to create a novel and interactive gaming experience. The integration showcases the potential for intelligent human-computer interactions and sets the stage for future developments in the realm of computer vision and robotics.

The serial number of the cobot for this experiment was : ERMC2800120230201192

2. PROBLEM STATEMENT

This lab project focuses on the fusion of the YOLOv8 object detection model and the MyCobot robotic arm within the framework of a Tic-Tac-Toe game. The central challenge addressed is the seamless collaboration between cutting-edge computer vision capabilities and precise robotic control to enhance human-computer interactions. By configuring the YOLOv8 model to dynamically identify and classify objects, such as 'teddy bear' and 'bottle,' symbolizing human ('X') and computer ('O') moves respectively, the project establishes a dynamic and responsive gaming environment.

The Tic-Tac-Toe game, designed to transcend traditional gameplay, serves as an interactive interface where the human player physically engages by placing stickers on a tangible grid. This physical input is seamlessly translated into the digital domain through the YOLO model, facilitating a fluid transition between the physical and virtual realms. The MyCobot robotic arm, acting as the computational player, strategically responds to the human player's moves using the minimax algorithm, not only showcasing the integration's technical complexity but also offering an intelligent and adaptive gaming experience. This innovative collaboration between computer vision and robotics opens avenues for applications beyond gaming, suggesting possibilities for interactive educational tools, entertainment systems, and collaborative human-robot scenarios.

3. METHODOLOGY

1. YOLOv8 Configuration for Object Detection

   - Model Selection and Customization:

     The YOLOv8 model was selected due to its real-time capabilities and accuracy. The 'yolov8n.pt' pre-trained model was fine-tuned to recognize specific classes relevant to the Tic-Tac-Toe game – 'teddy bear' and 'bottle.' Class definitions and weights were adjusted to optimize the model for accurate identification.

   - Ultralytics Library Integration:

     The Ultralytics library was integrated into the Python environment to harness the full potential of YOLOv8. This library facilitated easy model configuration, training, and real-time inference, streamlining the integration process.

- Training Data Generation:
  To enhance YOLOv8's accuracy, a custom dataset was created. Synthetic and real images of 'teddy bear' and 'bottle' objects were captured from various angles, lighting conditions, and distances. The dataset was annotated with bounding box coordinates to train the model for precise object localization.

2. Tic-Tac-Toe Game Design and MyCobot Control:
   - Human-Computer Interaction Setup:
     The Tic-Tac-Toe game was designed to involve physical interaction from the human player. A physical grid was constructed, and the player interacted by placing stickers on designated grid cells. This physical input was pivotal for bridging the digital and tangible gaming realms.
   - MyCobot Robotic Arm Integration:
     The MyCobot robotic arm was integrated into the system using the PyMyCobot library. Python scripts were developed to establish communication with the robotic arm and control its movements. Precise joint angles and gripper actions were programmed for optimal gameplay responses.
   - Minimax Algorithm Implementation:
     The computer player's moves were determined by the minimax algorithm. This algorithm explored potential moves within the Tic-Tac-Toe game tree, assigning a score to each move based on its outcome. The MyCobot arm's movements were synchronized with the algorithm's decisions, ensuring strategic and intelligent gameplay.
3. YOLO Integration with Tic-Tac-Toe:
   - Object Detection in Tic-Tac-Toe Grid:
     The YOLOv8 model was applied to the live video feed from a webcam, focusing on the region corresponding to the Tic-Tac-Toe grid. The detected objects were classified in real-time, and their coordinates were extracted to determine the human player's moves.
   - Coordination with MyCobot Arm Movements:
     Detected moves were seamlessly integrated into the Tic-Tac-Toe gameplay. The grid positions identified by YOLOv8 were translated into commands for the MyCobot arm, ensuring precise and synchronized movements in response to the human player's actions.
4. Iterative Gameplay Loop:
   - Human Player Moves:
     The gameplay loop initiated with the human player placing stickers on the physical grid. YOLOv8 detected these moves, updating the digital representation of the Tic-Tac-Toe board in real-time.
   - Computer Player Moves:
     The computer player, driven by the MyCobot arm, executed moves determined by the minimax algorithm. The robotic arm's precise movements were orchestrated to place stickers strategically on the physical grid, simulating intelligent gameplay.
   - Real-time Feedback and Display:
     Throughout the iterative gameplay loop, real-time feedback was crucial for an engaging experience. The YOLO model's detections, the updated Tic-Tac-Toe board, and the MyCobot arm's movements were displayed, providing a comprehensive and immersive gaming environment.
5. End of Game Conditions:
   The gameplay continuously monitored for win conditions, ties, or the need for further moves. Once a game-ending condition was met, appropriate messages were displayed, and the players were informed of the game's outcome.

This detailed methodology ensured a seamless and intelligent integration of YOLOv8, the MyCobot robotic arm, and the Tic-Tac-Toe game, creating an interactive and immersive gaming experience that transcends conventional boundaries.

4. RESULTS AND DISCUSSIONS

4.1. YOLOv8 Object Detection Performance

- Detection Accuracy:

  The YOLOv8 model demonstrated high accuracy in real-time object detection. The fine-tuned model effectively identified 'teddy bear' and 'bottle' objects, crucial for distinguishing human ('X') and computer ('O') moves in the Tic-Tac-Toe game.

- Robustness to Environmental Variability:

  The model exhibited robust performance across various environmental conditions, handling changes in lighting, object orientations, and distances effectively. This robustness is critical for providing a consistent and reliable gaming experience.

4.2. Tic-Tac-Toe Gameplay Integration

- Human-Computer Interaction:

  The physical interaction aspect of the Tic-Tac-Toe game, where the human player placed stickers on a tangible grid, seamlessly integrated with the digital realm. YOLOv8 accurately detected the physical moves, ensuring a fluid transition between the physical and virtual components of the game.

- MyCobot Robotic Arm Precision:

  The MyCobot robotic arm showcased precision and accuracy in executing moves based on the minimax algorithm's decisions. The programmed joint angles and gripper actions allowed for strategic placement of stickers on the physical grid, enhancing the intelligent gameplay experience.

4.3. Synchronization of YOLO and MyCobot Movements

- Real-time Coordination:

  The synchronization between YOLOv8 detections and MyCobot arm movements was seamless, providing real-time coordination between the human and computer players. This ensured a natural and responsive gameplay experience.

4.4. Iterative Gameplay and Strategic Moves

- Minimax Algorithm:

  The implementation of the minimax algorithm for computer player moves resulted in strategic and intelligent gameplay. The MyCobot arm's responses were not only precise but also reflected a thoughtful decision-making process, adding a challenging dimension to the Tic-Tac-Toe game.

- Engaging User Experience:

  The iterative gameplay loop, consisting of human and computer player moves, created an engaging and immersive user experience. Real-time feedback on the Tic-Tac-Toe board, YOLOv8 detections, and MyCobot arm movements contributed to the overall enjoyment of the game.

4.5. Discussion

The successful integration of YOLOv8, the MyCobot robotic arm, and the Tic-Tac-Toe game demonstrates the potential for collaborative and intelligent human-computer interactions. The project's strength lies in the seamless coordination between computer vision and robotics, allowing for a dynamic and responsive gaming experience.

The combination of robust YOLOv8 object detection and precise MyCobot arm movements creates opportunities for applications beyond gaming, such as interactive educational tools and collaborative scenarios. The iterative gameplay loop, driven by strategic moves from both players, showcases the versatility and sophistication of the integrated system.

4.6. Video Demonstration

A video demonstration of the integrated YOLOv8, MyCobot, and Tic-Tac-Toe system is available here (Tic-Tac-Toe). The video provides a visual walkthrough of the gameplay, highlighting the real-time object detection, intelligent robotic arm movements, and the overall interactive experience.

This demonstration serves to showcase the practical implementation of the project, offering insights into its performance and potential applications. Viewers can observe the seamless collaboration between computer vision and robotics in a tangible and engaging gaming environment.

5. CONCLUSION

In conclusion, this lab project successfully integrated the YOLOv8 object detection model, the MyCobot robotic arm, and the Tic-Tac-Toe game to create a novel and interactive system. The collaboration between advanced computer vision and precise robotic control resulted in a seamless and intelligent gaming experience. The key outcomes and contributions of the project can be summarized as follows:

1. High-Performance Object Detection:

   The YOLOv8 model exhibited high accuracy and robustness in real-time object detection, effectively recognizing 'teddy bear' and 'bottle' objects that represented human and computer moves in the Tic-Tac-Toe game.

2. Precise Robotic Arm Movements:

   The MyCobot robotic arm showcased precision and accuracy in executing moves based on the minimax algorithm's decisions. This precision enhanced the overall strategic and intelligent gameplay.

3. Seamless Synchronization:

   The synchronization between YOLOv8 detections and MyCobot arm movements was seamless, providing a real-time and coordinated interaction between the human and computer players. This contributed to the natural flow and responsiveness of the gameplay.

4. Engaging User Experience:

   The iterative gameplay loop, combined with real-time feedback on the Tic-Tac-Toe board and dynamic MyCobot arm responses, created an engaging and immersive user experience. The project demonstrated the potential for intelligent and collaborative human-computer interactions.

5. Video Demonstration:

   A comprehensive video demonstration provided a visual walkthrough of the integrated system, showcasing the practical implementation of the project. The video serves as a valuable resource for understanding the project's performance and potential applications.

The successful integration of YOLOv8, the MyCobot robotic arm, and the Tic-Tac-Toe game not only highlights the technical capabilities of the integrated system but also suggests broader applications in interactive educational tools, entertainment systems, and collaborative human-robot scenarios. This project serves as a foundation for future developments at the intersection of computer vision and robotics, offering a glimpse into the possibilities of intelligent and interactive systems.

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BIOGRAPHIES OF AUTHORS

Hriday Rajesh Nagrani is a master's student of Robotics and Autonomous Systems, specializing in Artificial Intelligence (AI) at Arizona State University, set to graduate in May 2025.He brings expertise in computer vision, AI, and machine learning. During his undergraduate studies, Hriday's work in emotional stress detection through Micro-facial Expressions and Chest X-ray segmentation earned recognition. He is also a published author, with three impactful publications in deep learning and computer vision.Hriday is a dynamic and highly motivated student with a passion for AI, robotics, and machine learning. His diverse skills, strong academic background, and practical experience make him a promising candidate in the field. He can be contacted at email: hnagrani@asu.edu