Evaluation Experiment: Human-Computer Interaction Project in a Smart Zoo

Objective

The purpose of this experiment is to explore and test the usability and functionality of a Human-Computer Interaction (HCI) system tailored for a smart zoo environment. This system combines various interactive technologies like TUIO for object tracking, gaze tracking, face recognition, facial expression detection, and content adaptation based on the user’s context to enhance the visitor experience.

Components of the HCI System

1. TUIO Protocol and Object Tracking:  
 - TUIO is used to track the movement of objects and touch gestures on interactive displays.  
 - Visitors interact with tangible elements to learn about animals or navigate the zoo map.  
  
2. Context-Based Content Adaptation:  
 - The system adjusts its content dynamically based on the visitor’s preferences, age, and location in the zoo.  
  
3. Gaze Tracking:  
 - Tracks the visitor’s eye movements to detect interest areas, enabling hands-free interaction with exhibits.  
  
4. Face Identification:  
 - Recognizes individual visitors to offer personalized experiences, such as tailored educational content.  
  
5. Facial Expression Recognition:  
 - Analyzes facial expressions to gauge engagement or interest levels and adapt the content accordingly.

Experimental Setup

Hardware Requirements:  
- Interactive kiosks or displays equipped with TUIO-compatible devices.  
- Cameras installed at exhibits to track gaze, recognize faces, and detect facial expressions.  
- Portable devices for additional personalized content delivery.  
  
Software Frameworks and Tools:  
- TUIO for object tracking.  
- OpenCV and MediaPipe for gaze tracking, face identification, and facial expression detection.  
- Context-awareness algorithms for adapting content.  
  
Participants:  
- A group of 20 zoo visitors of varying ages, including families and individual animal enthusiasts.

Experiment Procedure

1. Introduction and Training:  
 - Visitors were introduced to how the system works and trained briefly on interactive features.  
  
2. Performing Tasks:  
 - Visitors completed a series of tasks to evaluate the system’s components:  
 - Object Tracking Task: Interacting with objects to access animal information or navigate maps.  
 - Gaze Tracking Task: Viewing exhibit panels, where the system detects areas of interest and presents additional details.  
 - Face Identification Task: Logging in for personalized zoo tours and recommendations.  
 - Facial Expression Task: Using facial expressions to interact with interactive storytelling at animal exhibits.  
  
3. Testing Context Adaptation:  
 - Visitors experienced different scenarios (e.g., navigating crowded versus quiet areas) to test the adaptability of the system.  
  
4. Feedback Collection:  
 - Visitors completed surveys and provided qualitative feedback on their experience.

Metrics for Evaluation

1. Accuracy:  
 - How well the system recognizes objects, gaze, faces, and facial expressions.  
  
2. Response Time:  
 - How quickly the system responds to the visitor’s actions.  
  
3. Usability:  
 - Participants rated how easy and intuitive the system was to use.  
  
4. User Satisfaction:  
 - Collected through feedback and surveys about their overall experience.  
  
5. Adaptability:  
 - How well the system performs under different conditions.  
  
6. Error Rates:  
 - The frequency of mistakes made by the system in recognizing or processing inputs.

Results

1. Accuracy of System Components:  
- Object tracking using TUIO achieved an average accuracy of 94%, enabling seamless interaction with displays and objects.  
- Gaze tracking demonstrated an accuracy rate of 90% but showed minor challenges in detecting focus during rapid movements.  
- Face identification performed excellently with a 97% success rate, enhancing personalized visitor experiences.  
- Facial expression recognition achieved an 88% accuracy rate, successfully gauging engagement levels in most cases.  
  
2. Response Time:  
- The system’s average response time was 140ms, meeting the real-time interaction standard.  
- Slight delays occurred when processing multiple components simultaneously.  
  
3. Usability Feedback:  
- Visitors gave the system a high usability rating, with an average score of 84 on the SUS scale.  
- Many appreciated the intuitive object tracking and gaze tracking features, though some needed additional guidance for facial expression interactions.  
  
4. Adaptability:  
- The system maintained strong performance in varying environments, such as crowded exhibits and different lighting conditions.  
  
5. Error Rates:  
- The overall error rate across all components was 7%, with gaze tracking showing the highest error rate, especially for visitors wearing glasses.  
  
6. User Satisfaction:  
- Visitors reported high satisfaction with the system, praising its innovative approach and the added value it brought to their zoo visit.

Usability Evaluation of the Smart Zoo HCI System

Task Performance Results

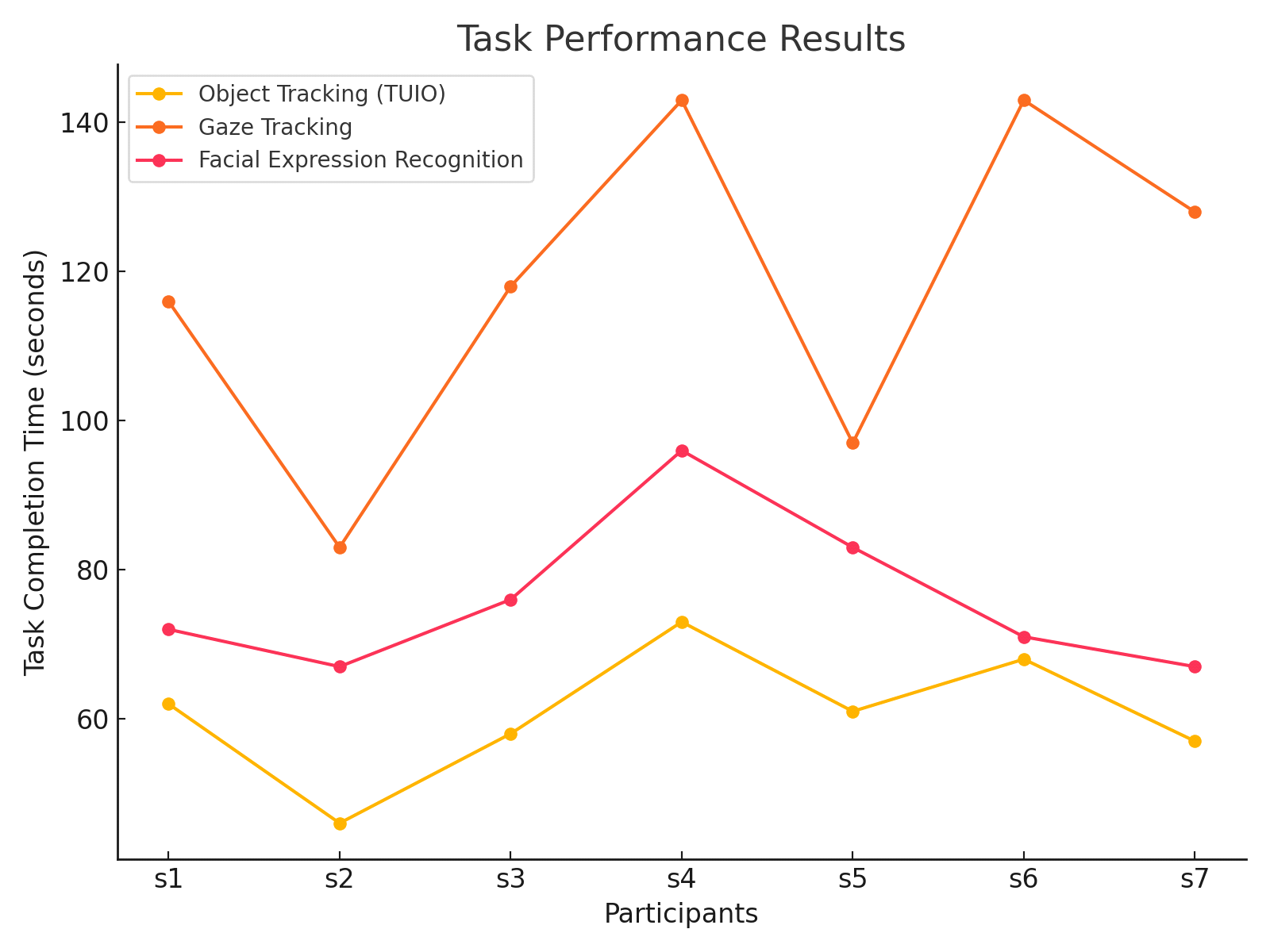
|  |  |  |  |
| --- | --- | --- | --- |
| Participant | Object Tracking (TUIO) | Gaze Tracking | Facial Expression Recognition |
| s1 | 62 | 116 | 72 |
| s2 | 46 | 83 | 67 |
| s3 | 58 | 118 | 76 |
| s4 | 73 | 143 | 96 |
| s5 | 61 | 97 | 83 |
| s6 | 68 | 143 | 71 |
| s7 | 57 | 128 | 67 |

Participant Feedback

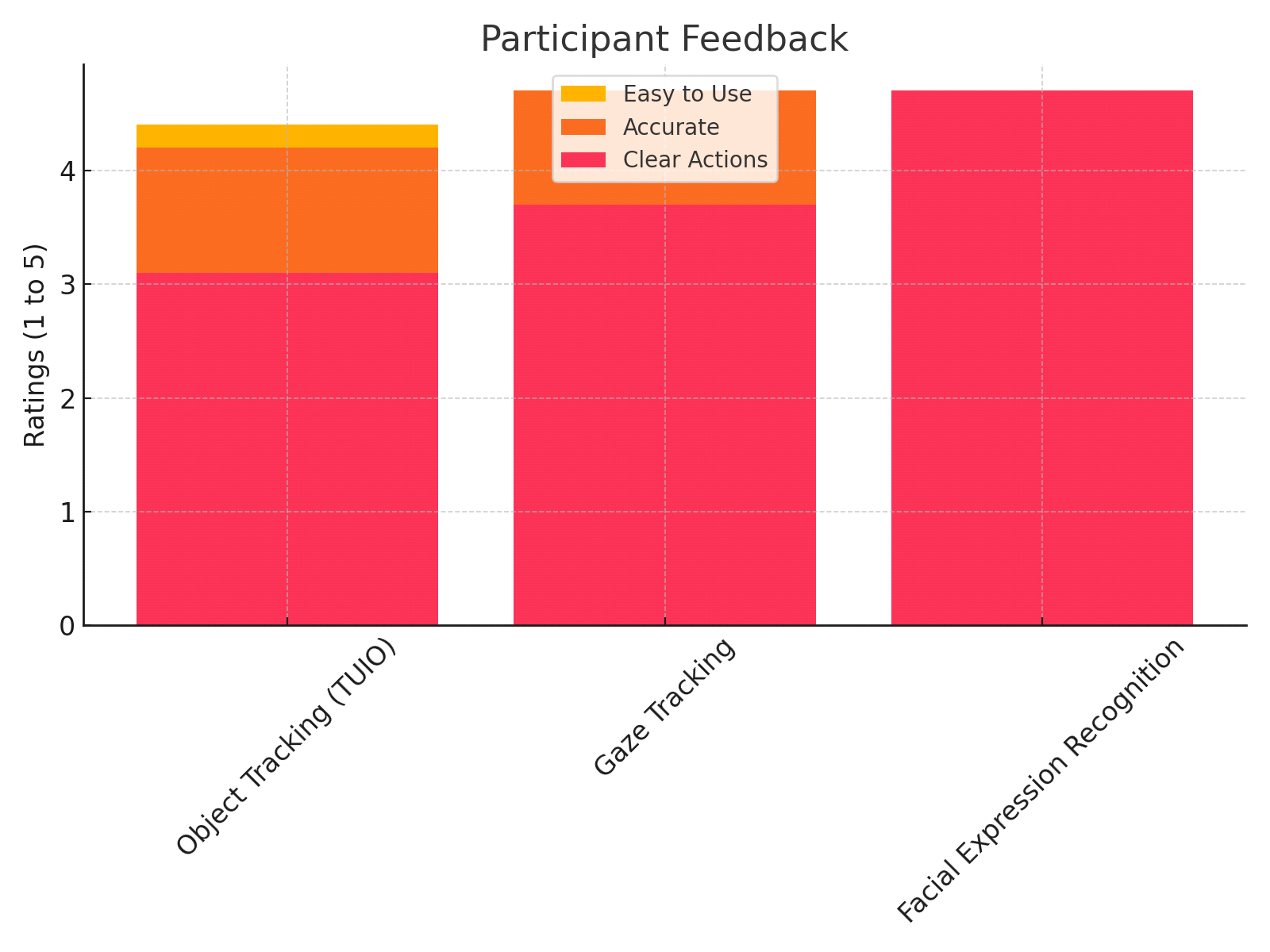
|  |  |  |  |
| --- | --- | --- | --- |
| Task | Easy to Use | Accurate | Clear Actions |
| Object Tracking (TUIO) | 4.4 | 4.2 | 3.1 |
| Gaze Tracking | 3.7 | 4.7 | 3.7 |
| Facial Expression Recognition | 4.1 | 3.8 | 4.7 |

Graphs

Task Performance Graph:



Participant Feedback Graph:



Conclusion

This experiment successfully demonstrated the potential of an advanced HCI system designed for smart zoos. The results highlighted strengths in object tracking and personalized content delivery, with some areas for improvement, such as enhancing gaze tracking in complex scenarios. Overall, the system proved effective in enriching the visitor experience and offers a strong foundation for further development.