# Exploring User Interactions in Robot Teleoperation

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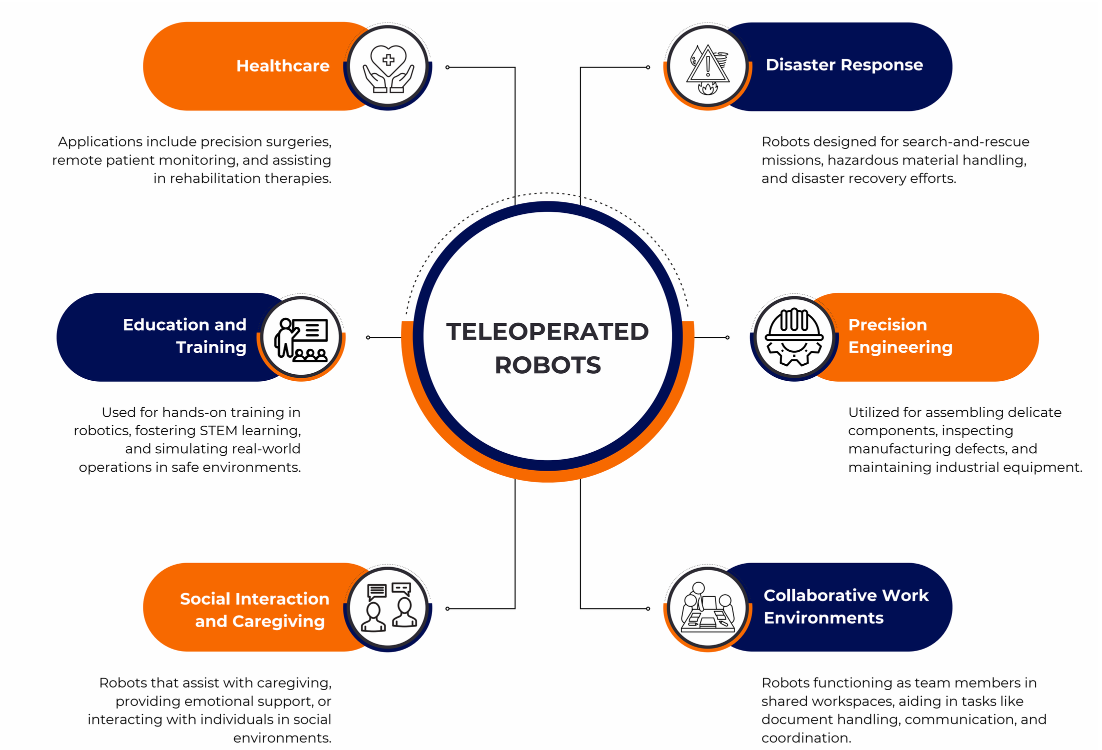
This research investigates user-robot interactions in teleoperated systems, applying insights from video game psychology to optimize relational dynamics and enhance task performance in diverse work environments

## Advancing Human-Robot Collaboration

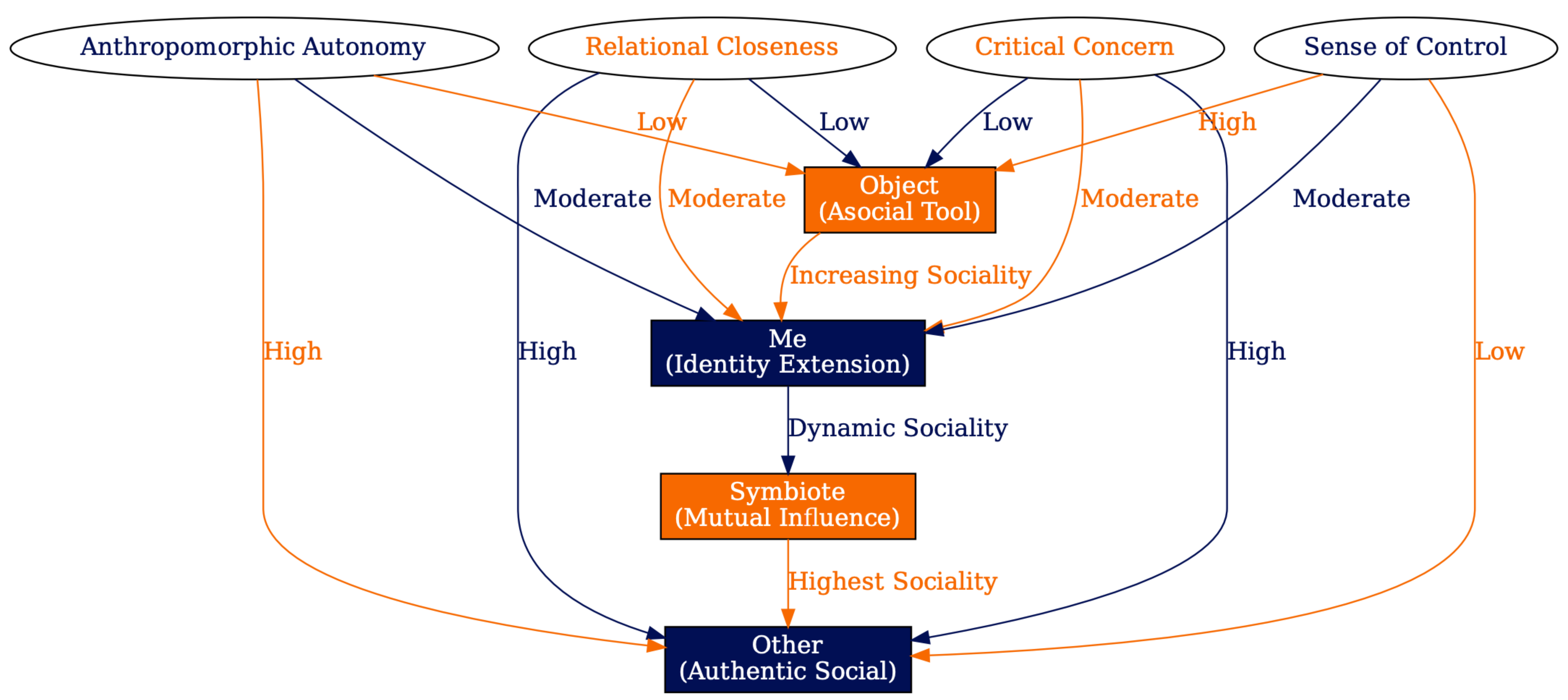
Teleoperated robots are changing the way humans interact with technology, allowing us to perform tasks in high-risk or hard-to-reach environments. These systems are used in fields such as healthcare, disaster response, and precision engineering, where human expertise and robotic capabilities combine to overcome challenges.

Our research focuses on understanding how people perceive and engage with these robots during teleoperation. By analyzing how users experience trust, control, and adaptability in these systems, we aim to improve how teleoperated robots are designed and used across industries. This foundational work paves the way for a deeper exploration of how relationships between humans and robots shape system effectiveness, which we will explore further in the theoretical framework.




## Theoretical Framework

Our research draws on established frameworks from video game psychology—**Player-Avatar Interaction Scale (cPAX)** and **Player-Avatar Relations (PAR)**—to understand user-robot relationships in teleoperated systems. These frameworks provide a robust lens for analyzing interactions between users and robots, emphasizing sociality and psychological dynamics.




The visual UML diagram illustrates these relationships, mapping cPAX dimensions onto the PAR typology to provide a comprehensive framework for analyzing user-robot interaction dynamics. This theoretical foundation informs the design and evaluation of teleoperated systems, ensuring alignment with diverse user needs and tasks.

**Player-Avatar Interaction Scale (cPAX)**
The cPAX framework identifies four key dimensions that quantify the depth and quality of user-robot interactions:

- **Relational Closeness**: Measures the emotional bond and interdependence between the user and the robot.
- **Anthropomorphic Autonomy**: Assesses the degree to which the robot is perceived as having independent, human-like agency.
- **Critical Concern**: Captures the user's attention to the robot's consistency, coherence, and operational reliability.
- **Sense of Control**: Reflects the user's confidence and ability to govern the robot's actions effectively.

**Player-Avatar Relations (PAR)**
The PAR typology categorizes user-robot relationships along a sociality spectrum, ranging from asocial to highly social interactions:

- **Object**: The robot is perceived as a tool for achieving specific tasks with minimal emotional engagement.
- **Me**: The robot acts as an extension of the user's identity and agency, fostering a moderate level of connection.
- **Symbiote**: Represents a mutual influence where both the user and robot adapt to each other's roles dynamically.
- **Other**: The robot is recognized as an independent social entity with its own motivations and behaviors.

## Methodology

**Experimental Setup**
This study employs a **3D-printed robotic arm** operated via a custom-built teleoperation system designed to evaluate user-robot interaction dynamics. The system integrates hardware and software components to provide a seamless interface for controlling the robotic arm.

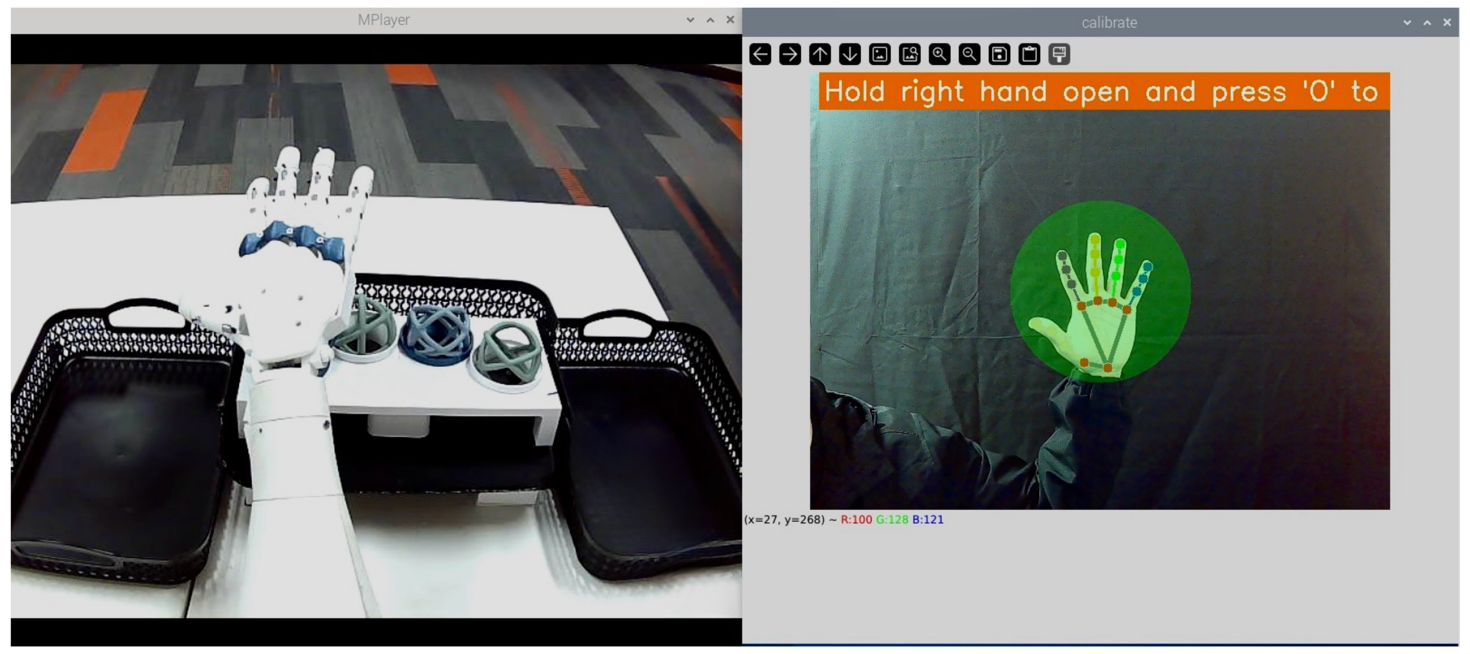
**Robotic Arm**: A 3D-printed robotic arm equipped with servos for precise movement and controlled remotely.

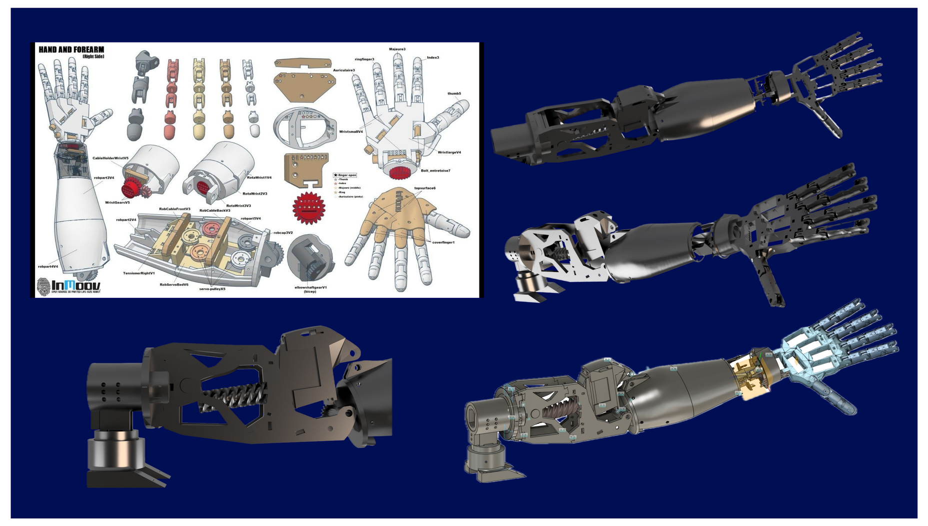
**Hardware Components**:

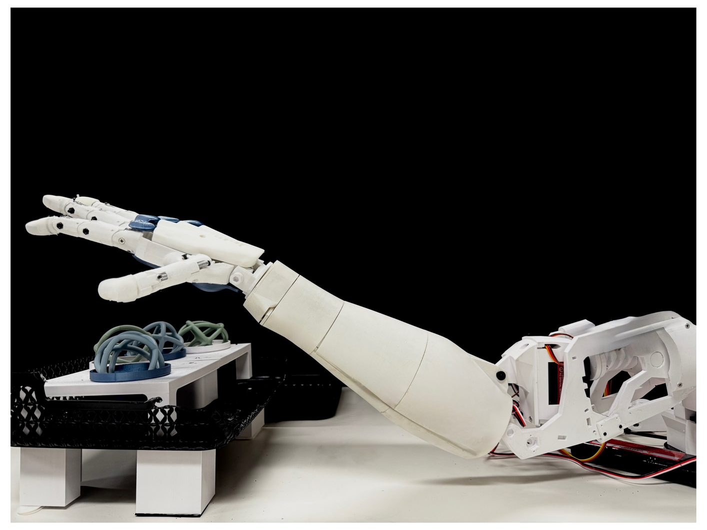
- **Raspberry Pi**: Acts as the central processing unit, managing communication between the robot and the user interface
- **Camera System**: Provides real-time hand-tracking capabilities and a live-streamed view of the arm during operation.

**Software Components**:

- A hand-tracking module for capturing and translating user gestures into robotic arm movements.
- Calibration software ensures accurate mapping of hand gestures to arm actions, enhancing user control.





**Control Interface**
The setup consists of two synchronized windows displayed to the user:
1. **Hand-Tracking Window**: Displays a live feed of hand calibrations, tracking gestures and providing feedback on control accuracy.
2. **Live-Streamed Robotic Arm View**: Shows the robotic arm in action, allowing users to observe and adjust their control inputs in real-time.

**Data Collection**
Participants interact with the system by performing task-specific operations using hand gestures. Metrics collected include:

- **Task Performance**: Completion time, accuracy, and error rate.
- **Interaction Metrics**: User calibration success, gesture responsiveness, and control fluidity.
- **User Feedback**: Survey responses mapped to cPAX dimensions and PAR typology.

## Next Steps

**Next Steps**
- **Revising the Framework**:
  - Refine the integration of **cPAX and PAR typologies** into the study of teleoperated robots.
  - Adjust the TARX scale based on emerging insights to better capture relational and functional aspects of teleoperation.
- **Data Collection and Analysis**:
  - Expand user trials to diverse contexts (e.g., precision tasks vs. collaborative scenarios).
  - Collect and analyze data on user satisfaction, task performance, and relational dynamics.
- **Design Recommendations**:
  - Develop customizable interfaces for task-specific needs.
  - Prototype features to enhance anthropomorphic autonomy and user trust.


## References

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