BSSS Journal of Computer: ISSN (Print) - 0975-7228, E-ISSN - 2582-4880, Vol. XVI, Issue-I (2025), pp: 33-36
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DOI Link: https://doi.org/10.51767/jc1605

Human-Robot Interaction: Design and Implementation of Hand-Based Interfaces for Robotic Arm Control

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ABSTRACT

The field of human-robot interaction (HRI) encompasses diverse disciplines, including robotics, human-computer interaction, ergonomics, and social sciences. Despite significant advancements, most robotic technologies are centered around efficiency and repetitive task automation. However, traditional robot control methods require significant technical expertise, presenting a barrier to broader adoption. This paper explores the development of a hand-based interface designed to control two robotic arms. It outlines the challenges of designing intuitive human-robot interfaces and highlights their potential to revolutionize industrial applications by enhancing usability, reducing training time, and enabling more natural interactions between humans and robots.

Keywords: Human-Robot Interaction (HRI), Robotic Arm Control, Hand-Based Interface, Intuitive User Interfaces, Industrial Robotics, Natural Interaction, Usability in Robotics, Human-Centered Design, Robot Control Systems, Ergonomics in Robotics.

I. INTRODUCTION

Robots are increasingly integrated into industrial, medical, and domestic environments, where their utility depends on effective control systems. Traditional control methods, which often involve programming or specialized controllers, are complex and require extensive training. To broaden robot usage, more intuitive human-robot interfaces (HRIs) are necessary. Hand-based gesture control systems offer a promising solution by allowing users to manipulate robots naturally.

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II. BACKGROUND AND RELATED WORKS

Numerous studies have investigated various forms of HRI:

- **Human-Computer Interaction (HCI):** Research has focused on gesture recognition technologies and their integration into control systems.
- **Robotics and Automation:** Traditional programming methods dominate, but advancements in machine learning enable more adaptive interfaces.
- **Ergonomics and Usability:** The ease of use and user comfort are critical for long-term adoption.

III. METHODOLOGY

The research aims to develop a hand-gesture-based interface for controlling dual robotic arms. The following steps were taken:

- **Hardware Design:** The robotic system includes two mechanical arms capable of multi-axis movement.
- **Software Development:** A gesture recognition system using machine vision techniques and motion sensors (such as Leap Motion or depth cameras) was implemented.
- **Control Mapping:** Gestures were mapped to specific robotic arm movements, ensuring smooth, responsive operation.

IV. CHALLENGES

Developing a robust, intuitive hand-based interface involves overcoming multiple technical and usability hurdles:

1. **Gesture Recognition Accuracy:** Differentiating between subtle hand movements and unintended gestures requires advanced machine learning models.
2. **Latency Issues:** Real-time responsiveness is critical to prevent lag in robot movement.

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3. **User Fatigue:** Extended use of hand gestures may cause fatigue, necessitating ergonomic design considerations.

V. APPLICATIONS AND CONCLUSION

Hand-based interfaces have a wide range of potential applications:

- **Industrial Automation:** Enhanced flexibility in assembly lines and manufacturing.
- **Healthcare:** Precision control of surgical robots.
- **Assistive Technologies:** Improved accessibility for users with disabilities.

The integration of intuitive hand-based interfaces in robotic systems represents a significant step toward more user-friendly human-robot interaction. Future work will focus on improving gesture recognition, reducing fatigue, and expanding the system's versatility for broader applications.

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