Support for critical collaboration tasks through gaze guidance and visual augmentation

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Motivation

Critical tasks like **search-and-rescue** and **hazardous environment operations** require seamless **human-robot collaboration** to enhance **decision-making** and **efficiency**. Existing systems often suffer from **high cognitive workloads** and **limited adaptability**. Our work addresses these issues through a modular **system** that integrates **gaze detection**, **visual augmentation**, and **input mapping** to **reduce user workload** and **improve task performance**. By seamlessly connecting automation with human intuition, this approach ensures **scalability** and **effectiveness** across diverse, **high-stakes scenarios**.

Method

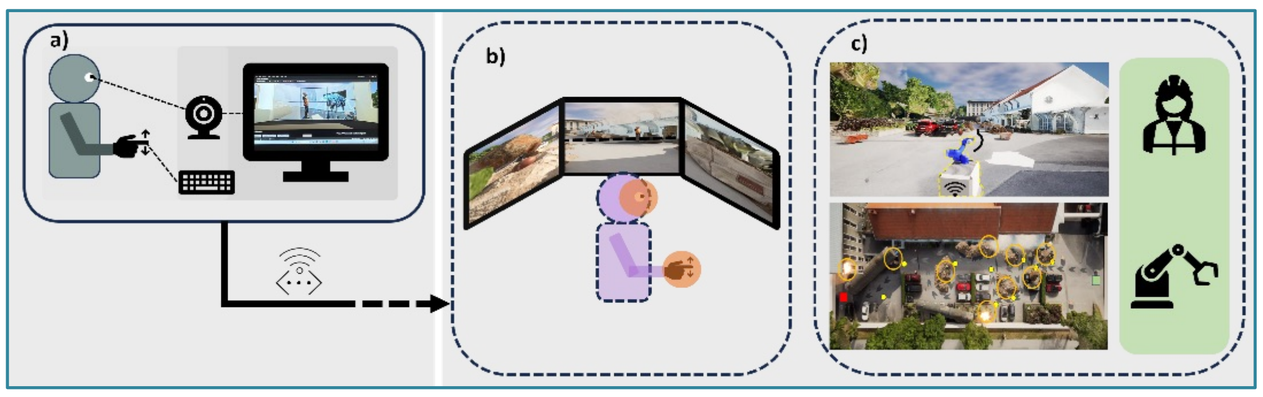

Fig 1: System Architecture

1. System Architecture

Modular design with the following components:

- **Gaze Detection:** Tracks user head gaze direction
- **Input Mapping:** Maps gaze to commands using dual-confirmation
- **Robot Command Generation:** Translates inputs into real-time commands
- **Visual Feedback:** Displays real-time robot camera views
- **Augmentation Module:** Highlights areas of interest (AOIs)

2. Validation

Tested in a search-and-rescue scenario comparing:

- **System-Assisted (SA):** Augmented AOIs for user guidance.
- **Human-Assisted (HA):** Manual navigation with keyboard inputs.

3. Key Takeaways

- Faster and efficient visual search due to guided focus in high stake scenarios
- Gaze stability and reduced exploratory behaviour in SA
- Higher precision in attention guidance in SA
- Reduced Cognitive Load for users
- Extrafoveal attention capture around key AOIs
- Combining human intuition with automation ensures improved decision making and system usability

Results: System Validation and User Study

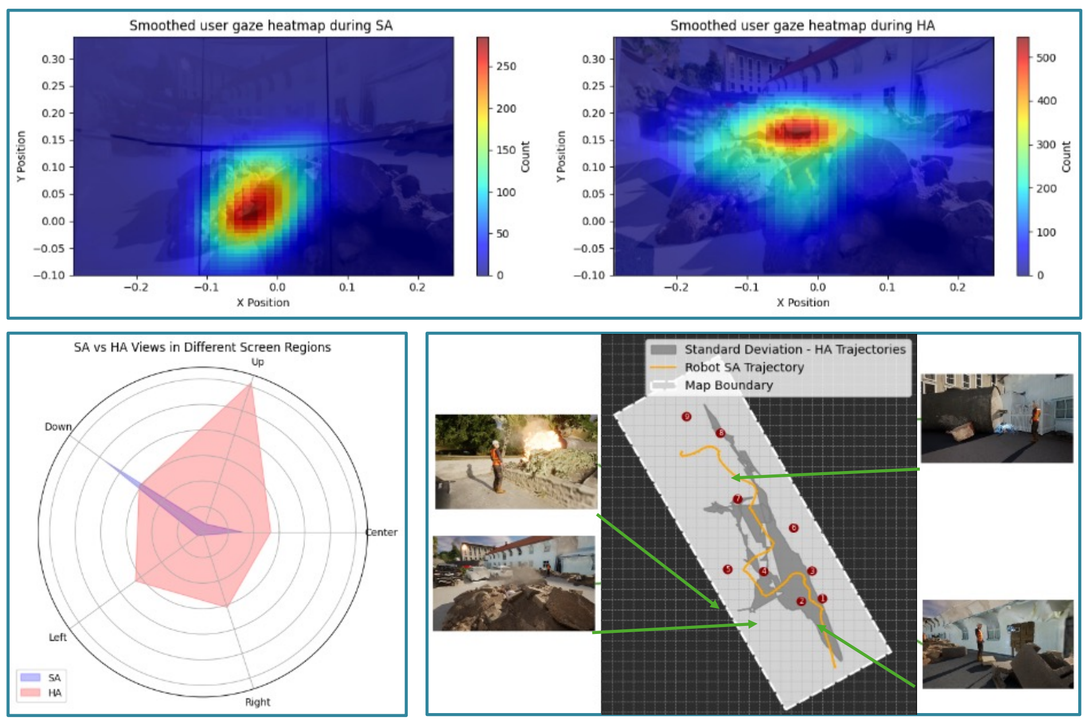

Fig 2: Difference in user behavior for SA and HA scenarios.

Measure	Value
Latency	10ms
Data Transmission Rate	60Hz

Table 1: Core components achieved low latency and high data transmission rates, ensuring smooth operation in dynamic environments.

Measure	System-Assisted (SA)	Human-Assisted (HA)
Task Completion Time	274.41s	678.88s
Cognitive Load (NASA TLX)	33.4	53.85
System Usability Scale	80.13	58.61

Table 2: Comparing the System-Assisted (SA) and Human-Assisted (HA) approaches demonstrates that SA significantly enhances human performance by reducing cognitive load and improving task efficiency.

References

[1] Jena, A. and Topp, E.A., 2023, March. Chaos to Control: Human Assisted Scene Inspection. In *Companion of the 2023 ACM/IEEE International Conference on Human-Robot Interaction* (pp. 491-494).
[2] Jena, A. and Topp, E.A., 2024, February. Towards Understanding the Role of Humans in Collaborative Tasks. In 7th International Workshop on Virtual, Augmented, and Mixed-Reality for Human-Robot Interactions.

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