

Towards a New Generation of User Support System in Maintenance Operation (IARMO)

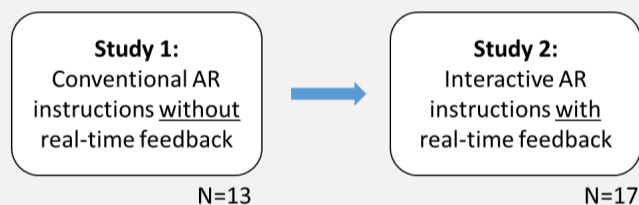
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1 Introduction

The global railway industry faces an **increasing shortage of skilled workers**, while railway equipment is becoming more and more elaborate. To tackle these challenges, finding more effective and faster methods of training and guiding technicians in their work is crucial. **Augmented reality (AR)** shows promise in guiding technicians during complex maintenance operations, but **current applications are limited** as they only provide static information. Palmarini et al. [1] stressed the importance of future AR systems being adaptable to specific situations and users' current needs. In our previous work [2], we have proposed a **new generation of adaptive AR guidance** that analyses eye, hand, and head tracking data on AR glasses in real time to provide dynamic feedback and alert technicians to potential errors. This study investigates the perceived benefits and user acceptance of such an adaptive AR system during real maintenance operations.

2 Methods

Two studies were conducted to compare conventional AR step-by-step instructions against adaptive AR instructions with real-time feedback for missed process- or safety-critical steps



3 Apparatus



Fig 1: A technician performing a functional checkup of the train coupling while being guided with (a) augmented reality instructions. In the second study, the operator received (b-c) real-time feedback if a safety- or process-critical step was missed (e.g., switching off electrical fuses before working on electrical components).

4 Results and discussion

All participants felt increased safety when real-time feedback was provided and did mostly not feel patronized by the system. Most participants said they would not be annoyed by erroneous warnings, as they prefer being warned too often than too little for safety-critical tasks. In addition, we found that user acceptance increased significantly when real-time feedback was provided.

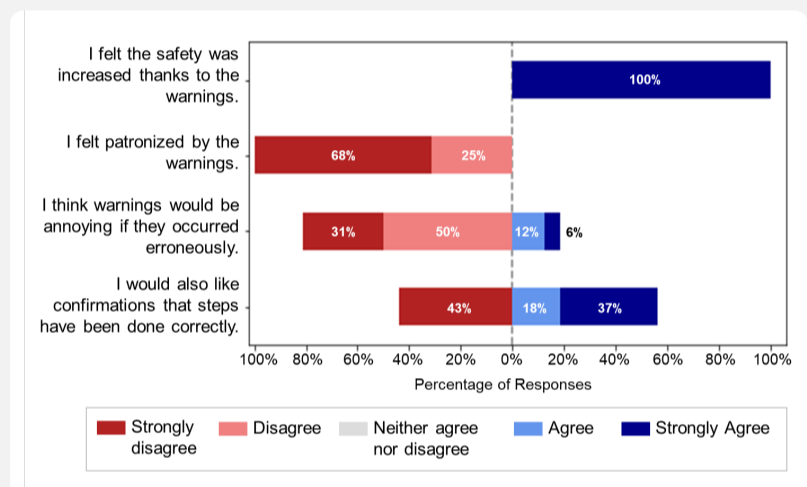


Fig 2: Results of the second study on how participants perceived AR instructions with real-time feedback. Colored bars represent the percentage of participants that chose this answer.

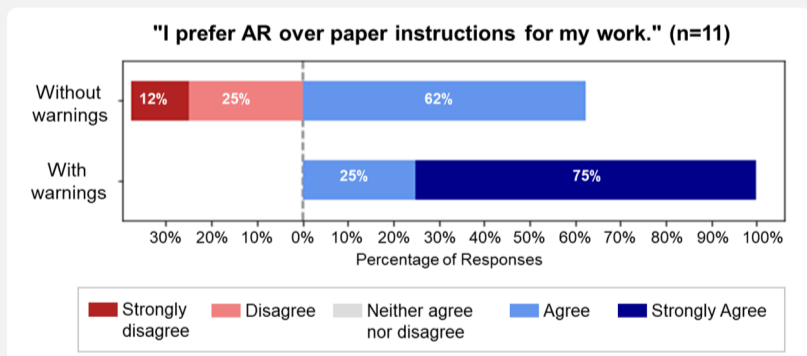


Fig 3: Comparing user acceptance of conventional AR instructions (Study 1) against adaptive AR instructions with real-time feedback (Study 2). Colored bars represent the percentage of participants that chose this answer.

5 Conclusion and expected impact

- Despite the benefits of AR instructions (reduced errors & completion time), technological availability and acceptance are still low
- Our results show that **technology acceptance can be significantly increased when real-time feedback is provided** as technicians see a clear added value compared to paper instructions
- For successful deployment of the technology, it is therefore beneficial for organizations to **go beyond AR glasses as a display** and also provide advanced functionality like real-time feedback

References

1. R. Palmarini, J. A. Erkoyuncu, R. Roy, and H. Torabmostaedi. A systematic review of augmented reality applications in maintenance. *Robotics and Computer-Integrated Manufacturing*, 49:215 – 228, 2018.
2. J. Wolf, Q. Lohmeyer, C. Holz, , M. Meboldt. Gaze comes in handy: Predicting and preventing erroneous hand actions in ar-supported manual tasks. In 2021 IEEE International Symposium on Mixed and Augmented Reality (ISMAR), pp. 166-175. IEEE.