Implementation and validation of DWI System with Assembly Assistance

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Situation

The manufacturing industry is increasingly adopting digital tools to improve efficiency. Digital Work Instructions (DWIs) can reduce training time, minimize errors, and provide real-time guidance [1]. At Bewel, a sheltered workshop, the goal is to support people with a distance to the labor market in performing meaningful work.

However, existing systems either lack physical assistance or are too complex to configure without technical expertise. As a result, workers remain dependent on close supervision.

This thesis aims to develop an intuitive DWI system with physical assembly assistance that is easy to configure by non-technical staff.

Method

Figure 1 shows the architecture of the developed system. A JavaFX Core App coordinates all components and enables supervisors to create step-by-step digital work instructions:

- **Hand Tracking** streams real-time hand positions via **WebSocket** to the Core App;
- **Picking Bins** communicate over **MQTT**, receiving LED activation commands and sending hand detection feedback;
- **The Core App** controls **LED strips** and a vibrating **smartwatch via Websockets** to guide users with **light and vibration cues.**

Two user studies were conducted:

- In a pre-study, participants ranked five variants of the system to identify the most effective one:
  - **Static Light**: A fixed LED lights up the target location;
  - **Live Light**: The LED shows an arrow like pattern to guide the user to the target location;
  - **Haptic**: A smartwatch vibrates to guide the user;
  - **Flow Light**: LEDs create a directional flow toward the target;
  - **Gradient**: LEDs transition in color from red to green.
- In a final AB test, the best-performing configuration was compared to the existing system using step timing and a UEQ+ usability survey.

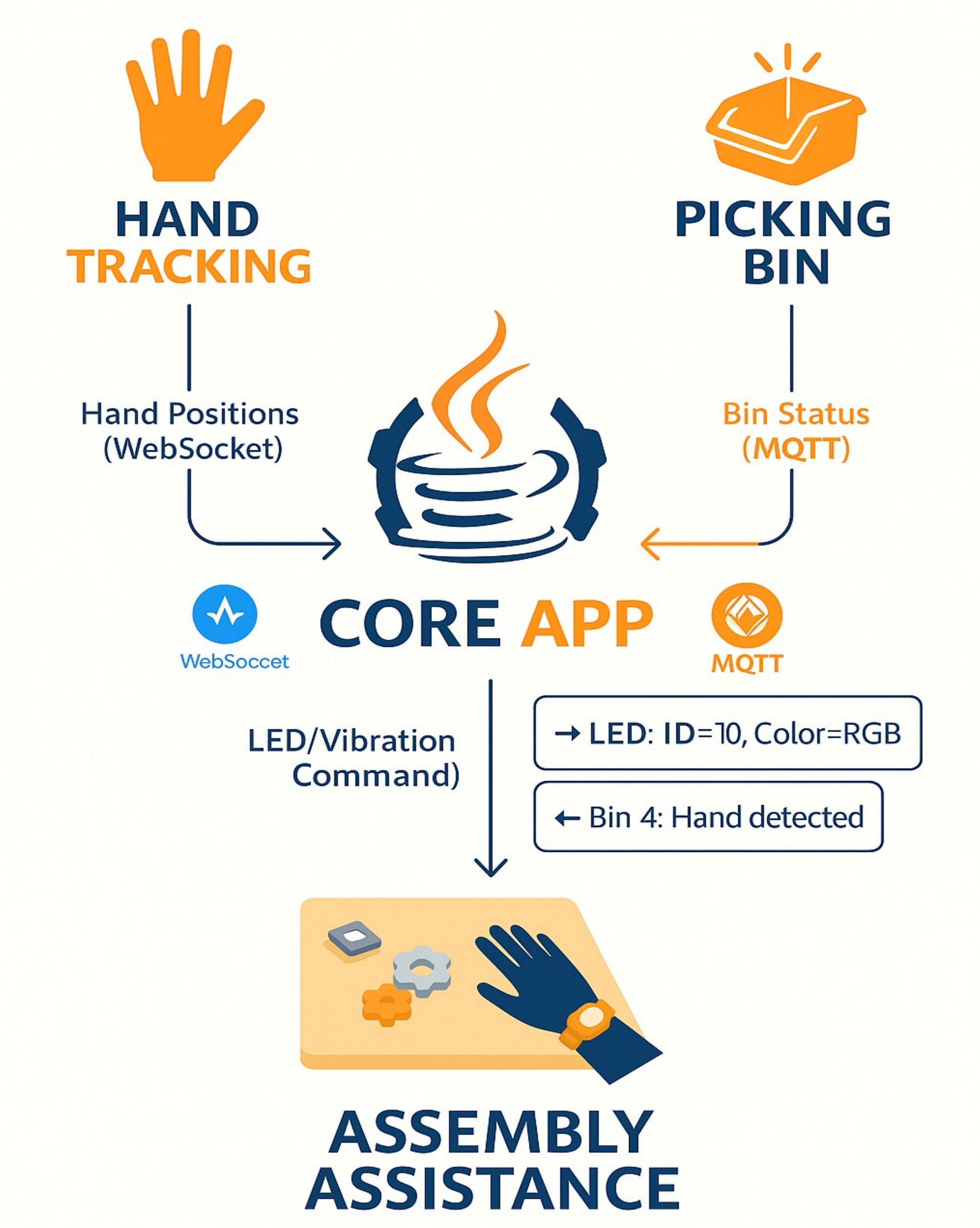

Figure 1: System Architecture

Results and conclusion

Results:

In the **pre-study**, participants ranked five assembly assistance variants. **Static Light** and **Graident** scored highest (Figure 2) and where selected in combination with Haptic and Live for the AB test.

Static + Live scored highest on **Novelty**, **Dependability**, and **Efficiency**.
Gradient + Haptic showed positive results.
DWI-only scored lowest, especially on **Perspicuity** and **Dependability**.
Static + Live offered the best user experience.

Conclusion:

A modular, low-cost DWI system was developed, combining pick-to-light verification, light-based, and haptic assembly assistance. **Pick-to-light** proved highly effective; **Static Light** provided the best assembly support. Haptic feedback works well as subtle confirmation. The system is flexible and suitable for broader applications.

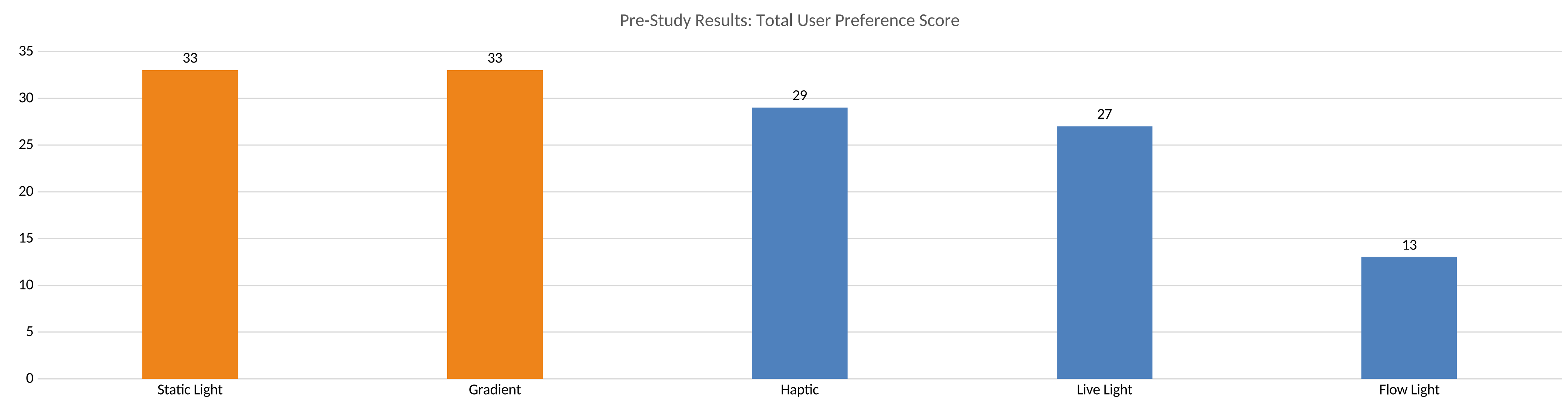

Figure 2: Pre-Study Results: Total User Preference Score

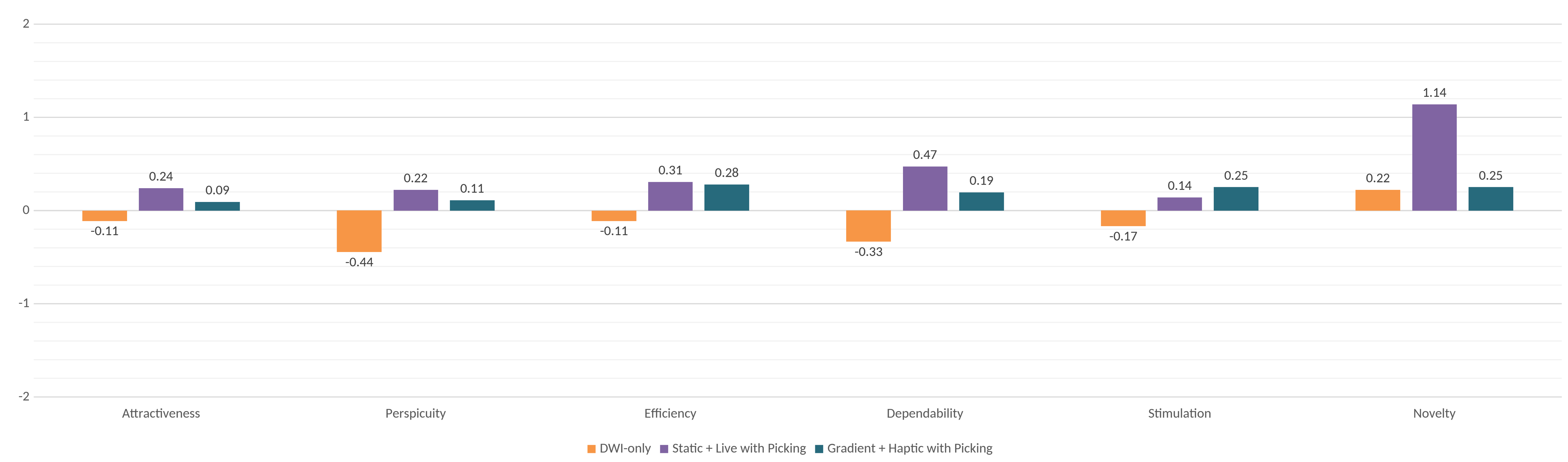

Figure 3: Mean UEQ Scores per Dimension for Each System

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Prof. dr. Davy Vanacken
Benny Claes (Technology & innovation engineer at Bewel)

References:
[1] D. Couckuyt, T. Imnadine, S. Dohogne, and T. Verkest, "Digital Work Instructions in Sheltered Workshops," European Conference on Innovation and Entrepreneurship, vol. 19, no. 1, pp. 979–983, Sep. 2024, doi: 10.34190/ECIE.19.1.2582.