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An Eye Tracker Study on Cognitive Ergonomics in Human-Robot Collaboration

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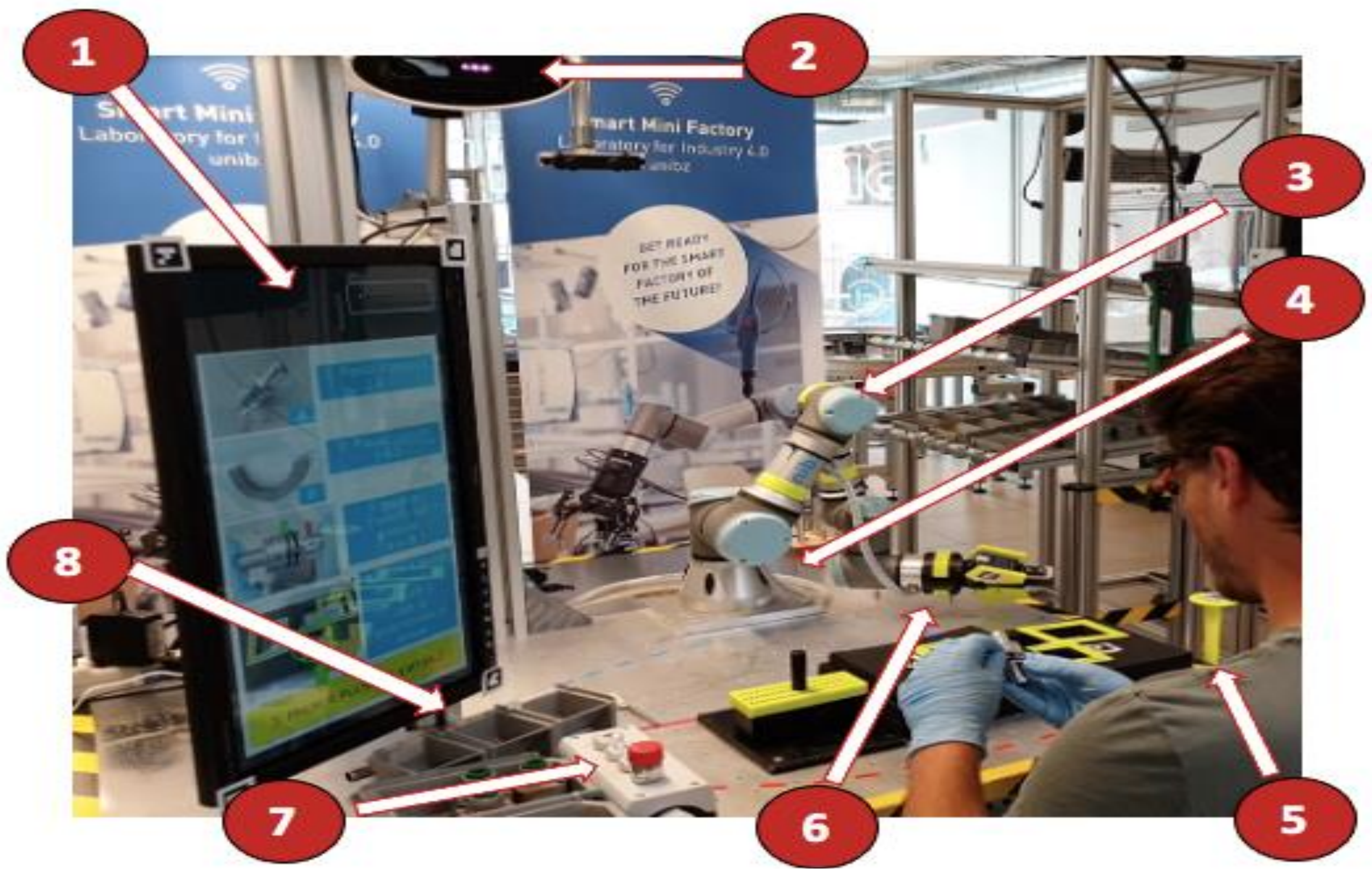
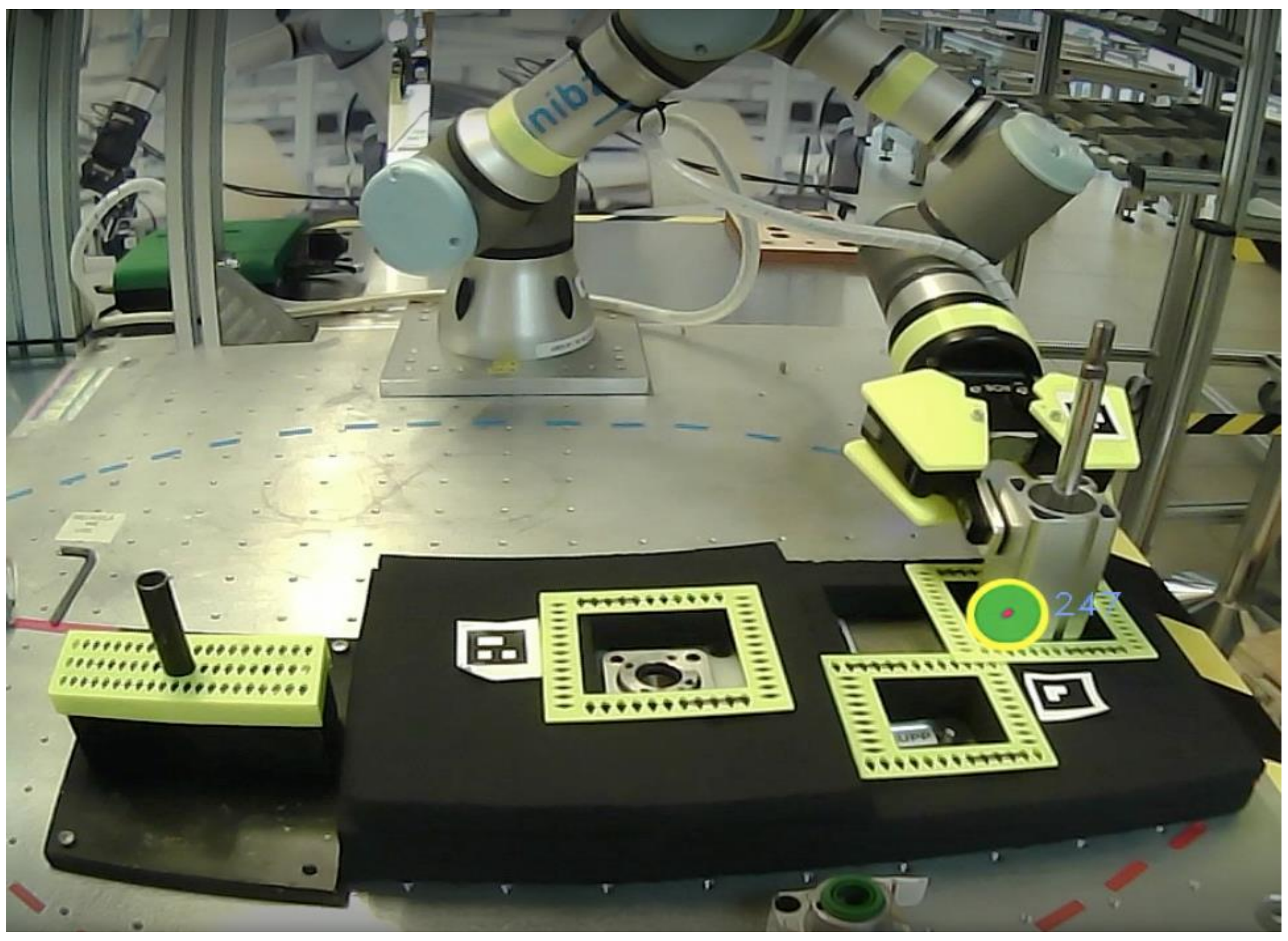
THE STUDY

Aim and motivation

- The implementation of **collaborative robots (Cobots)** in industrial settings combines their accuracy and tirelessness with human's flexibility and dexterity [1]. In this scenario, the operator can physically interact with the robotic co-agent in a cage-less workspace in order to perform **simultaneous actions towards a shared goal**.
- New forms of interaction between the operator and the cobot entails risks, which require **human-factors and ergonomics experts** to address factors like **cognitive overload** [2] and **stress** [3] that may negatively impact worker's **safety** as well as task **performance.**
- The present work **aims** to assess the impact of workstation features on the workers, ultimately promoting **safe** and **reliable human-robot collaboration**.



(1) Graphic User Interface
(2) AI based 3D perception device and vision system
(3) Collaborative Robot
(4) Working table with assembly jigs
(5) Virtual Button
(6) Collaborative Gripper
(7) Button array and emergency stop
(8) Boxes for assembly parts



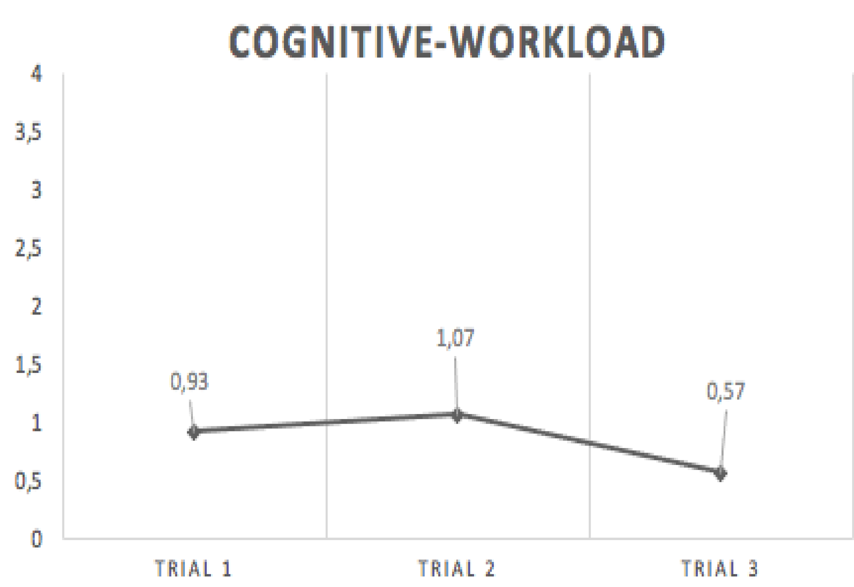
Fixation sample captured by the eye-tracker device during the assembly task

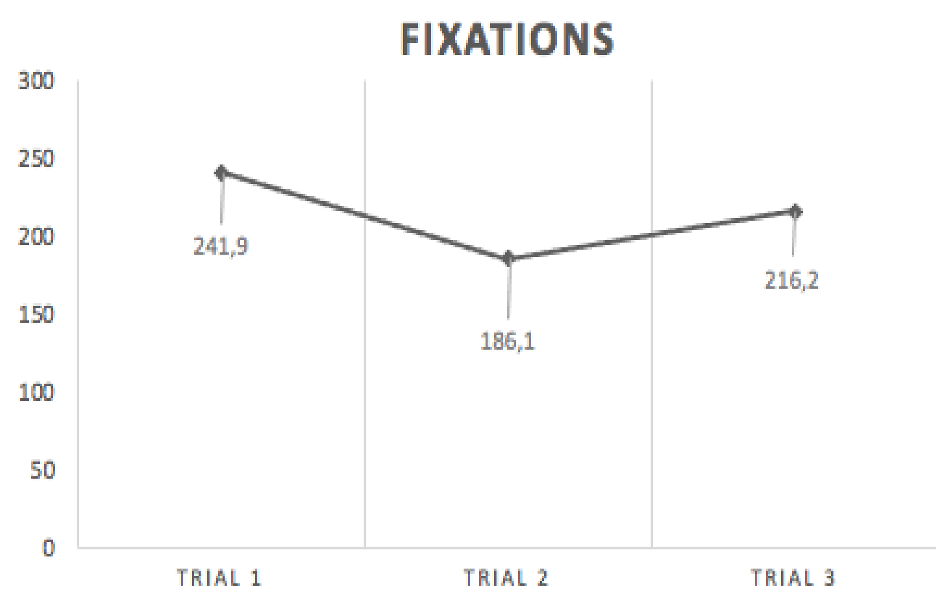
Data collection

- 14 volunteers - Completing simplified assembly task of an industrial pneumatic cylinder. Hypothesis: the situation will **improve by shifting from the first to the last**.
- Firstly, participants completed a **training session,** without the cobot, in order to reduce possible errors. Then, they were tested in three **different** and **sequential trials** (different robot features, elements of the workstation, conditions of human interaction with the robot, and information content). Survey Administration at the end of each scenario – assessing cognitive workload [4] and perceived stress [5].
- Cognitive workload was further investigated through **"Core",** an eye-tracker device by Pupil Labs. Recordings allowed to assess cognitive workload by measuring **fixations' number**, **duration** and **location**.

RESULTS

- **Participants improved their cognitive experience** of collaborative assembly with the enhancement of workstation features and interaction conditions.
  - Stress decreased along the three different trials;
  - Cognitive Workload increased from trial 1 to trial 2 and reduced considerably from trial 2 to trial 3.





Participants significantly **reduced the number of fixations from trial 1 to trial 2.**

- Results demonstrate a **significant reduction in fixations' number** toward the **action** from the first scenario to the other ones;
- Subjects gaze **significantly more** at the **arm** and the **gripper in the last scenario** compared with the previous ones.

CONCLUSIONS

- Quantitative data (gathered from NASA-TLX) and qualitative data (obtained from the eye-tracker device) seem in line, reporting a higher cognitive workload in the second scenario with a lower number of fixations.
- The arrangement of the selected features in the third trial increased cognitive ergonomics as operators reported lower levels of stress and cognitive-workload.
- The implementation of human-like movements contributed to a sense of predictability and familiarity as less cognitive resources are used in the last scenario.

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