Towards an optimal teaching method for industrial assembly tasks using collaborative robots: teleoperation vs kinesthetic

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Summary

- **Motivations**: within the Industry 4.0, collaborative robots with advanced features, more flexibility and safety are increasingly exploited in production plants. Cobot requires new reprogramming techniques, such as kinesthetic and teleoperation.

- **Goals**: this work proposes a new teleoperation scheme for teaching assembly tasks. Therefore, with an user experiment, the work wants to highlight the differences between the two modalities and to find the optimal method for teaching assembly tasks.

Summary

We formulate some preliminary questions:

- Which mode is preferred for easy of use?
- The two proposed approaches are said to be intuitive, but how much when they are applicable for industrial assembly task programming?
- Are the physical characteristics of the users impacting on kinesthetic teaching?
- Are users who are familiar with the pad better in teleoperation than the other users?

Table of contents

Introduction

Introduction

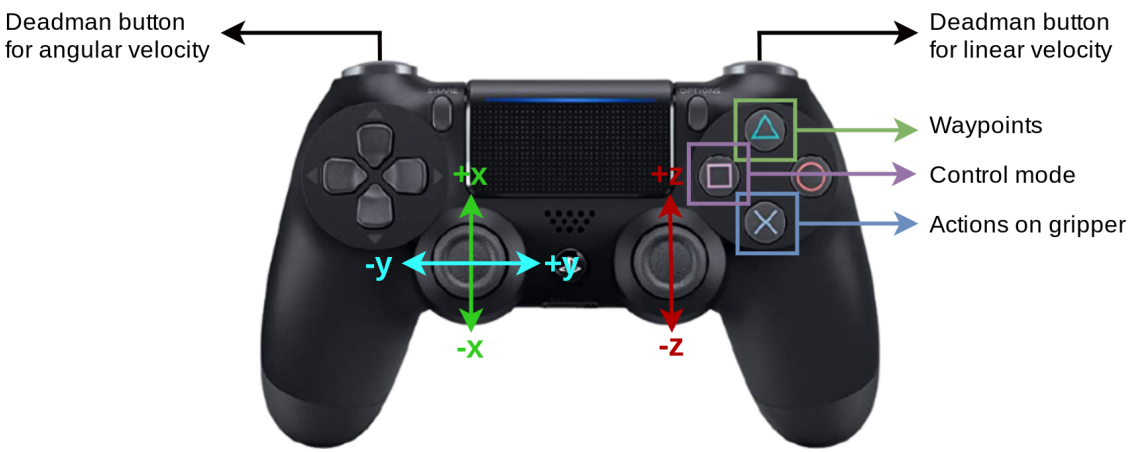
In automotive industry welding and painting tasks are already highly automated, while assembly tasks in industry are mainly performed manually today.

For those tasks that are performed by robot, the default modality for teaching assembly tasks is kinesthetic teaching.

The use of a collaborative robot and kinesthetic teaching doesn't allow us to fully use the collaborative features.

Introduction

For these reasons and inspired by other works, a new teleoperation modality for teaching assembly tasks was implemented using the Kuka LBR IIWA and a **PS4 pad**.

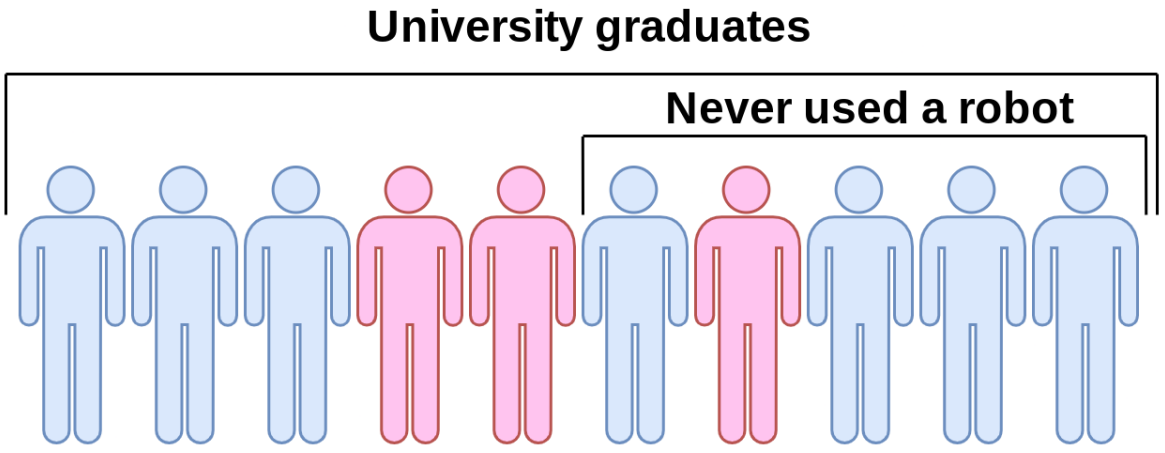


Introduction

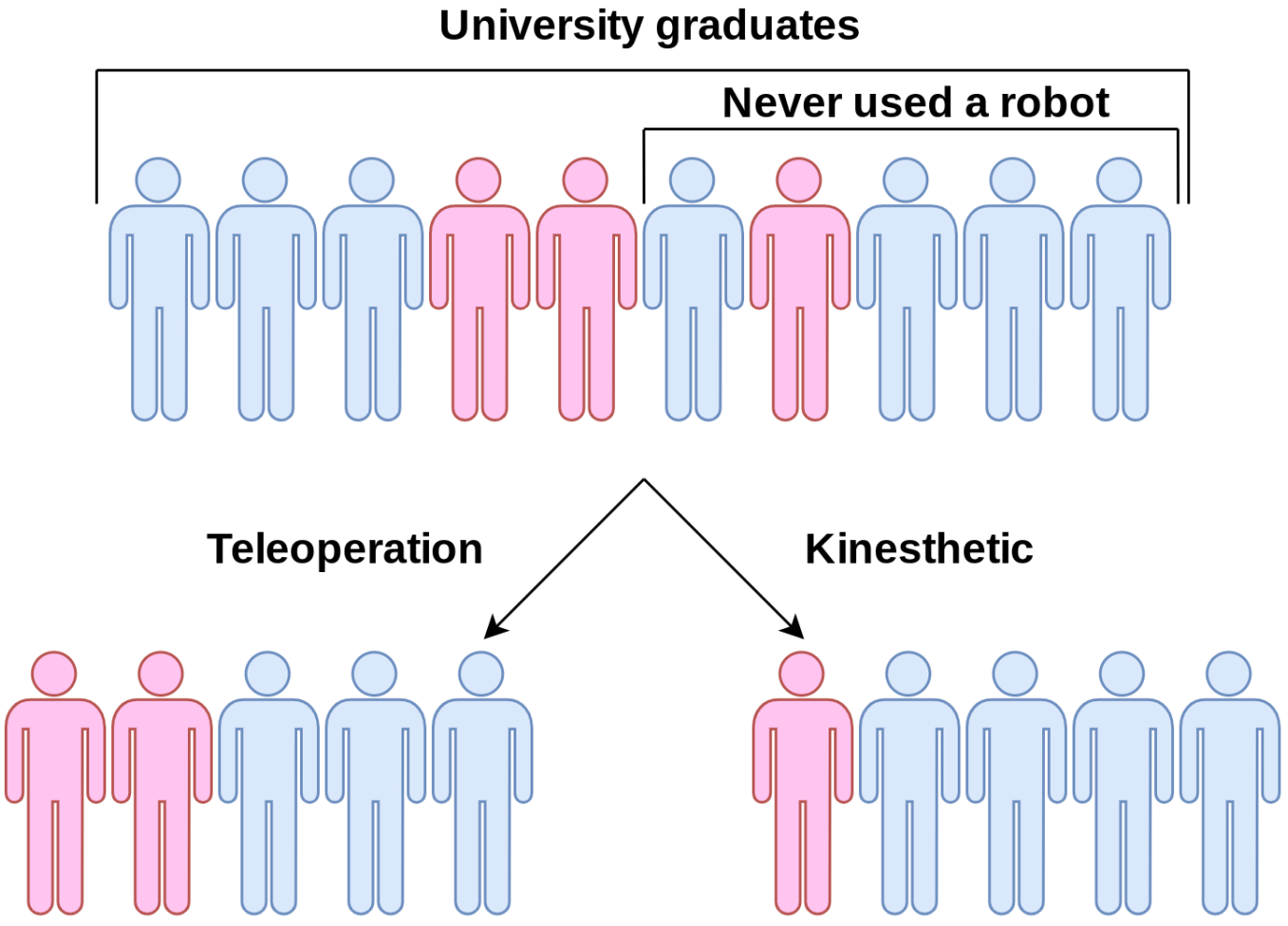
Playback speed: 1x (normal)

Experimental design

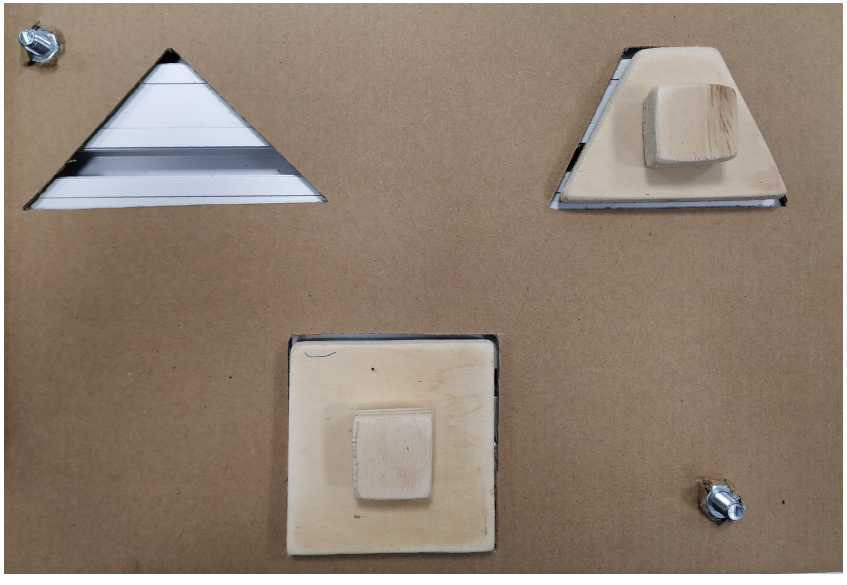
Participants

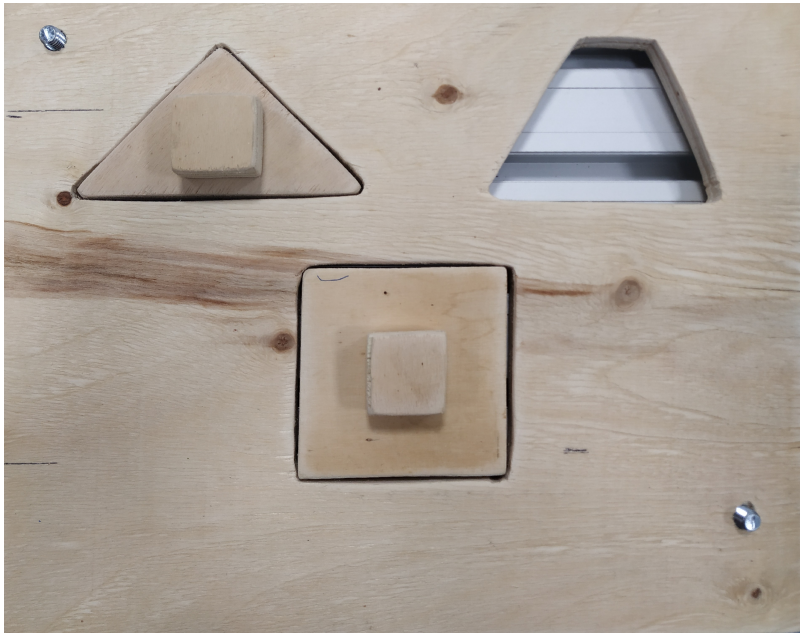


Participants

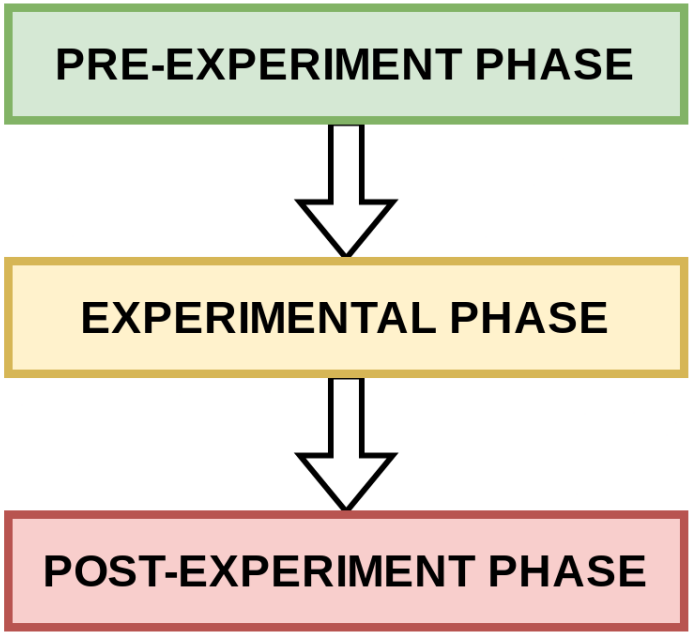


Tasks

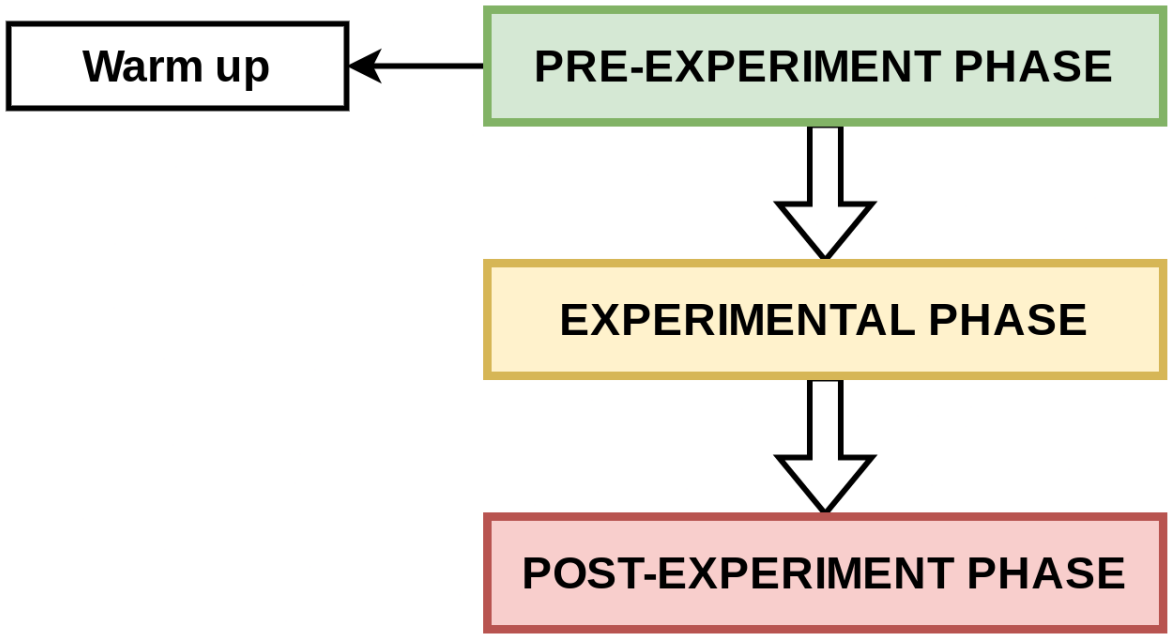




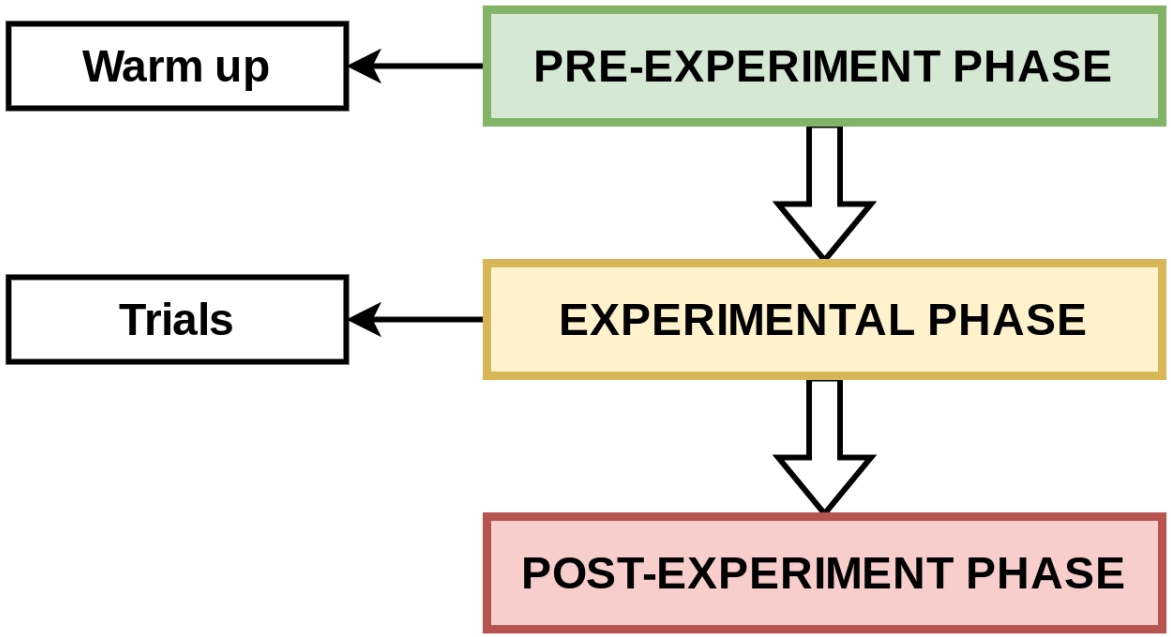
Experimental flow



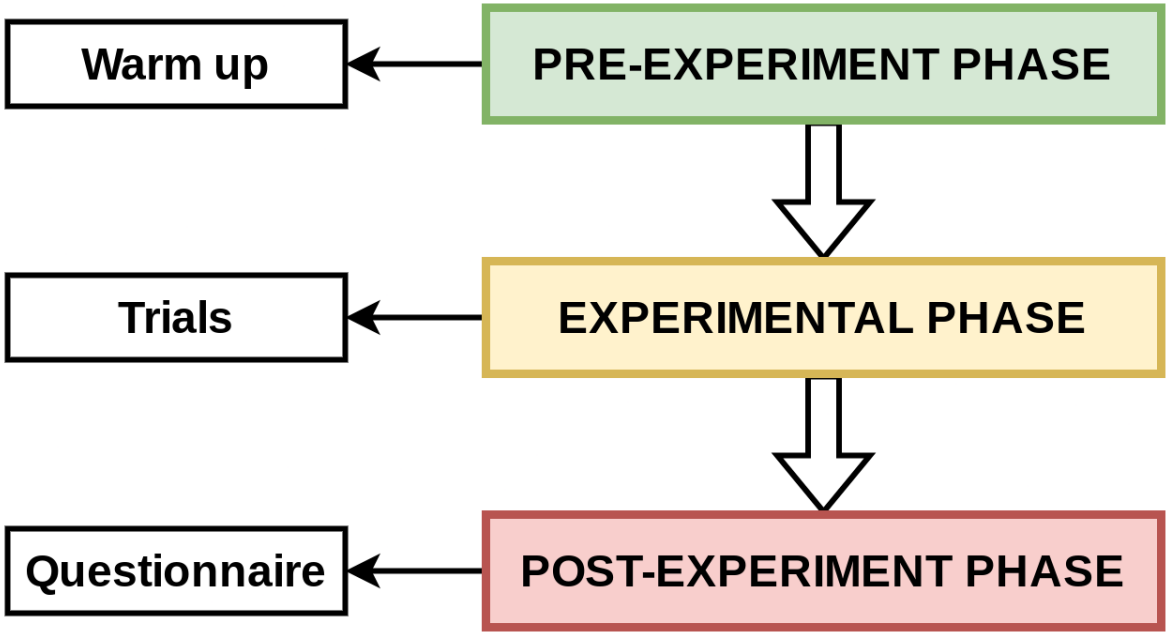
Experimental flow



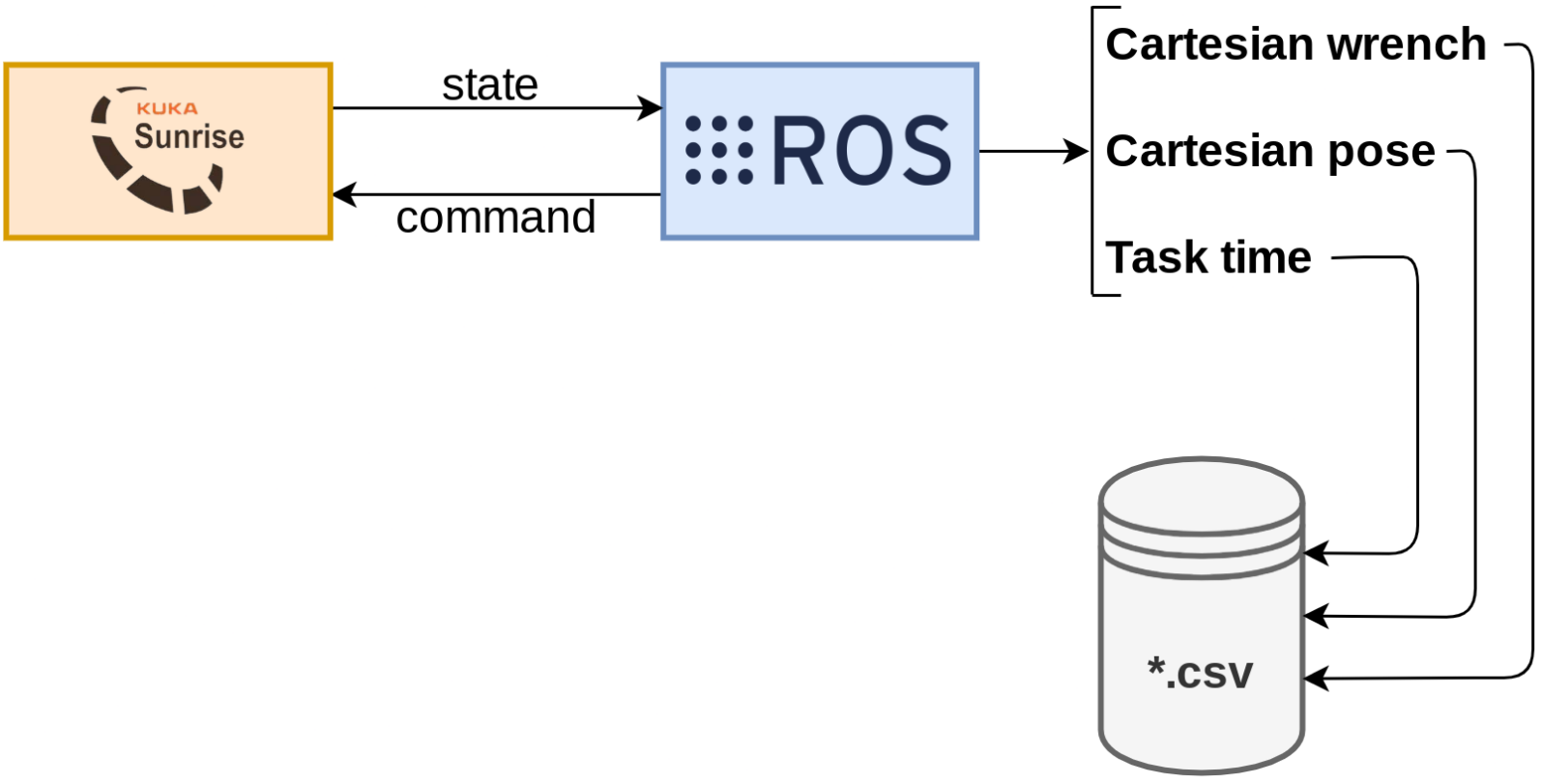
Experimental flow



Experimental flow



Data collection



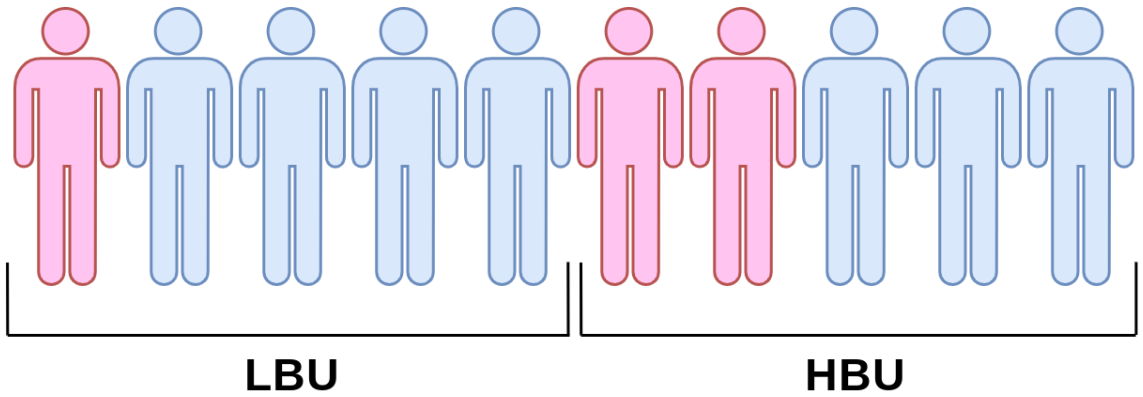
Replay phase

Playback speed: 1x (normal)

Results discussion

Results discussion

For the analysis the users were divided into groups using *BMI*.



Abbreviation	Extended form
LBU	**L**ow **B**MI **U**sers
HBU	**H**igh **B**MI **U**sers
RP	**R**egular **P**layers
CP	**C**asual **P**layers

Results discussion

For reasons of time, in this presentation only two questions are shown as they are interesting in terms of results achieved.

- Which mode is preferred for easy of use?
- The two proposed approaches are said to be intuitive, but how much when they are applicable for industrial assembly task programming?
- Are the physical characteristics of the users impacting on kinesthetic teaching?
- Are users who are familiar with the pad better in teleoperation than the other users?

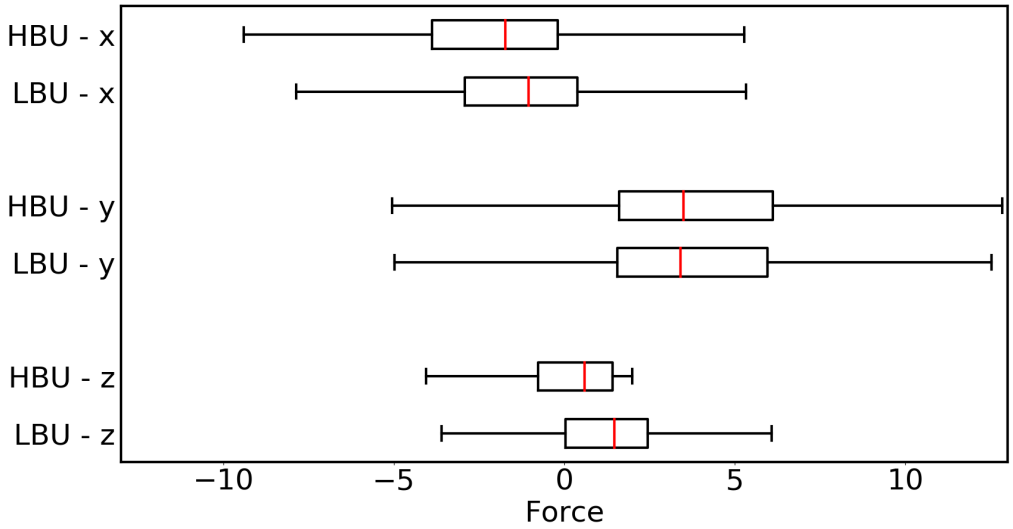
Results discussion

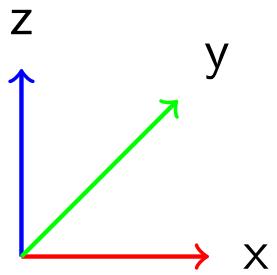
Are the physical characteristics of the users impacting on kinesthetic teaching?

- An analysis on the forces applied on the EE by the users of the two groups was made.
- Therefore, the questionnaire asked the *physical effort* required by users to perform the tasks.

Results discussion

This figure shows the difference of the forces applied by the groups while they were performing the tasks in kinesthetic teaching. The force is in N.





Results discussion

Therefore, the previous concept is supported by the answers in the questionnaire.

The averages of the physical effort of the users are: $5,4$ for **LBU** group and $3,8$ for **HBU** group.

Both personal opinions and scientific data show us that there is a correlation between kinesthetic teaching and physical characteristics.

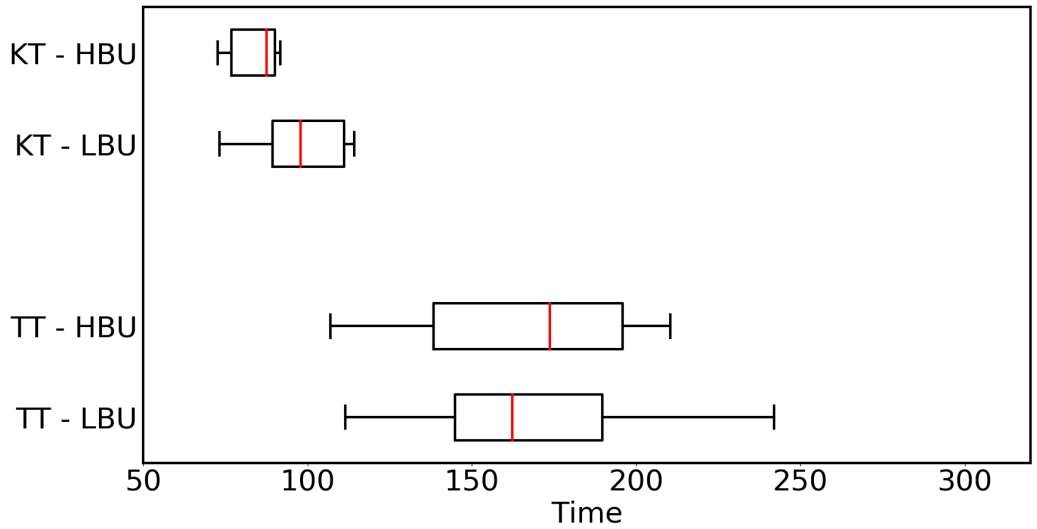
Results discussion

Are users who are familiar with the pad better in teleoperation than the other users?

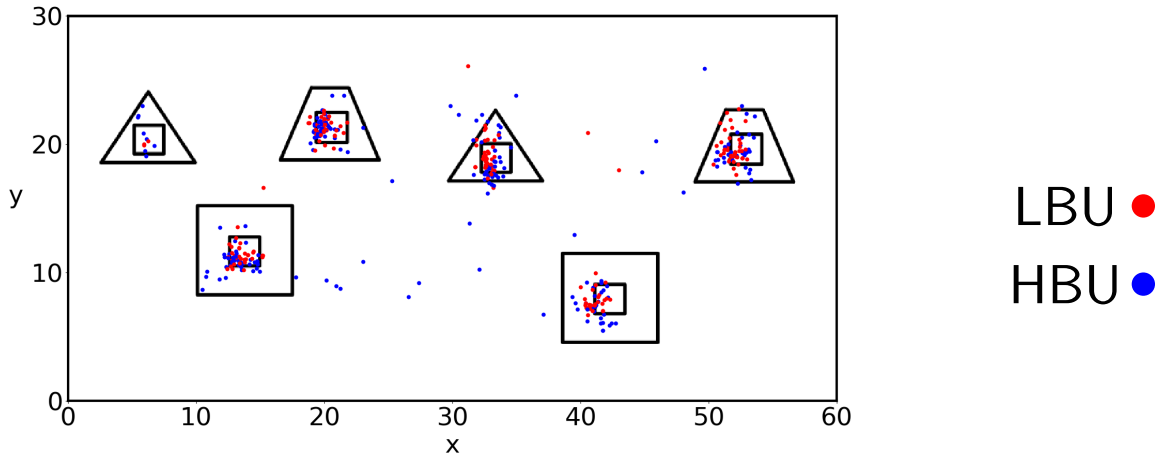
- Time and distance to complete the tasks for both groups were analyzed.
- Therefore, the answers to the question regarding the *mental effort* required by the users to perform the tasks were analyzed.

Results discussion

Only the times (in *seconds*) about task $t1$ are shown, for task $t2$ the values are similar.



Results discussion



The mental efforts in teleoperation teaching are: $5, 6$ for **LBU** and 6 for **HBU**. Also, the data show us how users confident with the pad are better in teleoperation.

Furthermore, from the previous figure it's possible to notice how teleoperation teaching is always slower than kinesthetic teaching.

Conclusions

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As mentioned, many aspects were considered and it isn't easy to find the best modality.

Kinesthetic highlights the physical differences between users.

Furthermore, thanks to its simplicity kinesthetic teaching can be used when an user wants to teach simple tasks.

Conclusions

To overcome the problem of different physical characteristics, teleoperation is used because unifies the differences.

Furthermore, the abilities of the users can be reused and trained for better performances.

We can for this reason say that teleoperation teaching can be used for difficult tasks that require precision as it offers the possibility to exploit more functionalities of the collaborative robot.

Thanks to ICE Laboratory for this opportunity.

Thank you for your attention.