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

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Summary

- **Motivations**: within the Industry 4.0, collaborative robot 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 modality for teaching assembly tasks. Therefore, with an user experiment, the work wants to highlight the differences between the two modalities for teaching assembly tasks.

Summary

Some research questions can be done:

- Which mode is preferred for ease of use?
- The two proposed approaches are said to be intuitive, but how much when they are used for assembly tasks in industry?
- There is a correlation between physical characteristics of the users and kinesthetic teaching?
- Users who have familiarity with the pad are better with teleoperation teaching?

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Introduction

Introduction

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

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

The use of a collaborative robot such as KUKA LBR IIWA and kinesthetic teaching doesn't allow us to fully use the collaborative features.

Introduction

For these reasons and inspired by other works, a new modality for teaching assembly tasks was implemented.

Teleoperation teaching provides a way to control robot using a **PS4 pad** that allows us to have more control options.

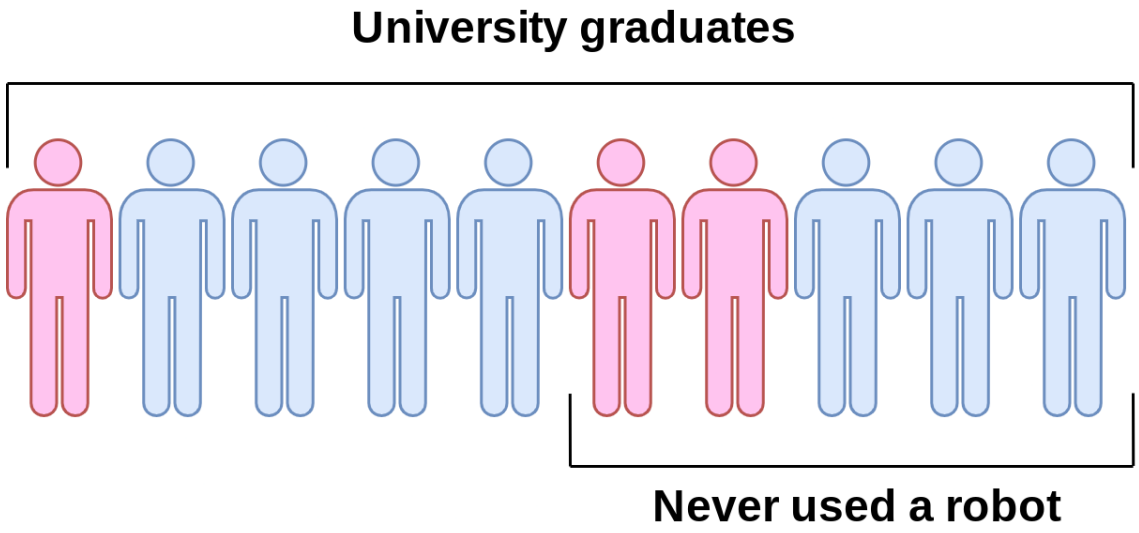
It allows to have a safe remote control of the robot through the use of buttons and analogs. It also have a force feedback features based on the vibration of the pad.

Introduction

This video shows how teleoperation teaching is used to perform the task.

Experimental design

Experimental design



To obtain better and diversified results among the participants, half of them started with teleoperation teaching, while the other with kinesthetic teaching.

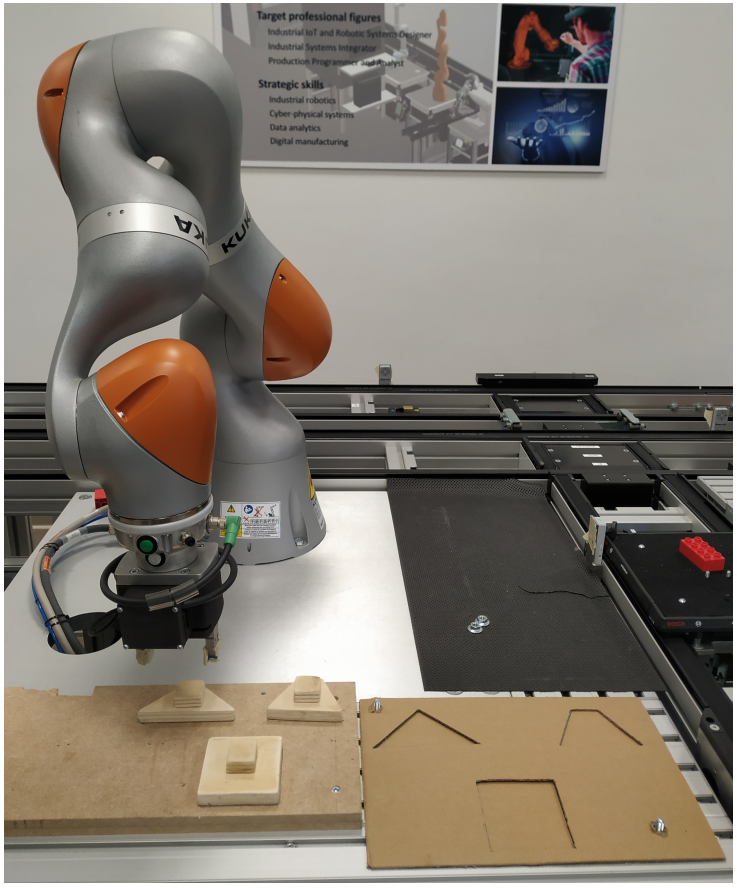
Experimental design

Before the experiment, was asked to the users to take confidence with both the modalities. Every user perform this phase without seeing other users do the same.

The experiment consists in two tasks in ascending order of difficulty repeated for three times. These tasks were repeated in kinesthetic and teleoperation and the users were rated with the data collected.

Experimental design

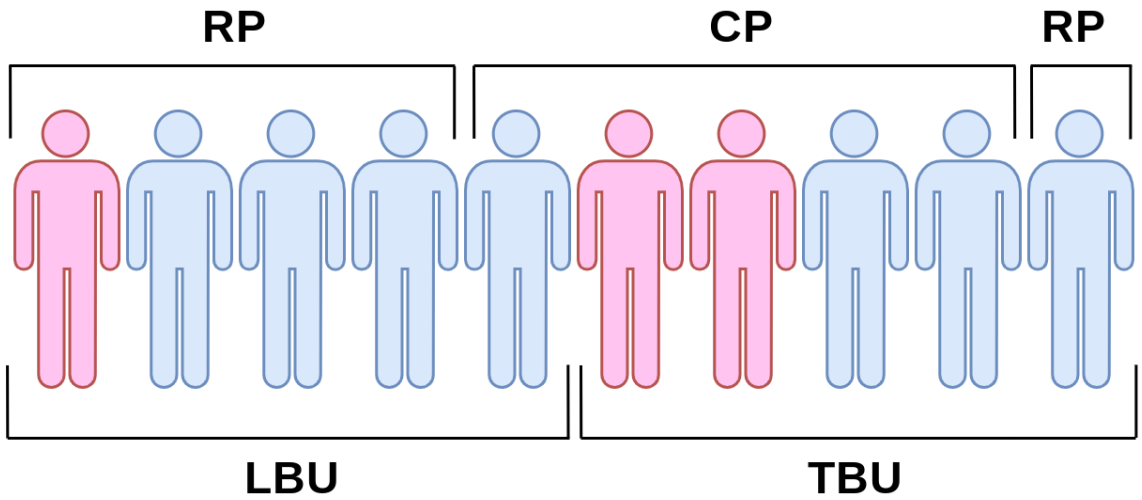
In this figure the setup overview: the KUKA LBR IIWA and the shapes used for the task.



Results discussion

Results discussion

For the analysis the users were divided into groups and their characteristics were analyzed.



For reasons of time, in this presentation only two of the research questions are demonstrated through data. For a more complete and in-depth explanation, refer to the thesis.

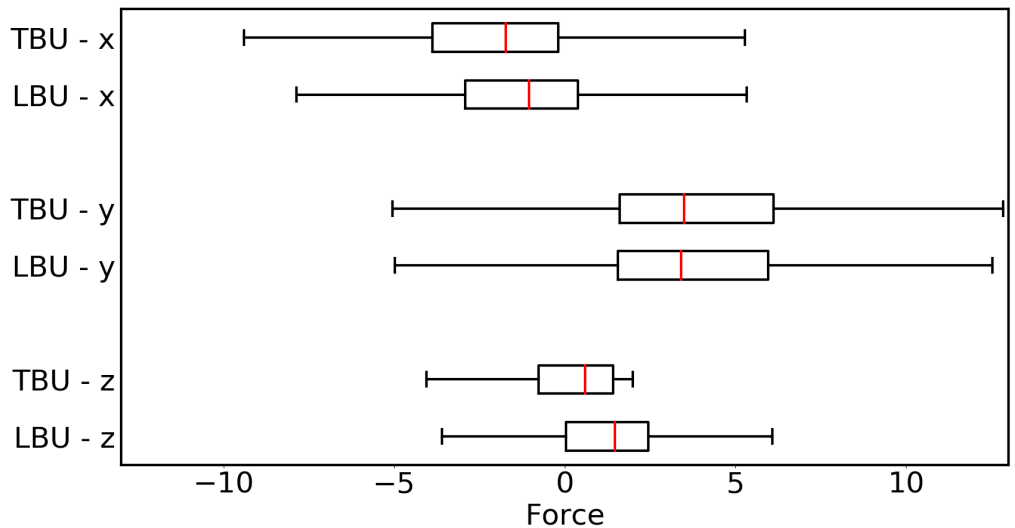
Results discussion

There is a correlation between physical characteristics of the users and 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 **TBU** group.

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

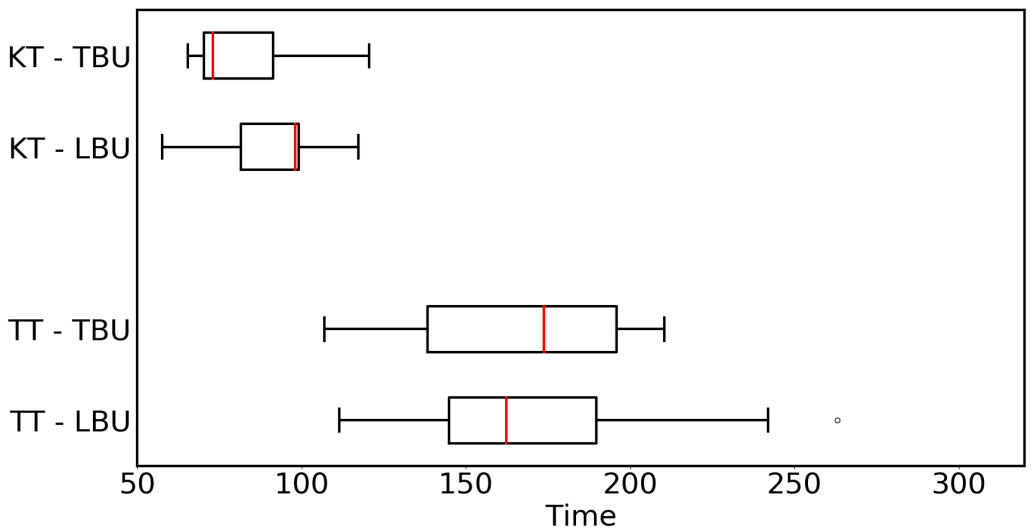
Results discussion

Users who have familiarity with the pad are better with teleoperation teaching?

- Time and distance to complete the tasks for both groups were analyzed.
- Therefore, the answers to the question regarding the *mental effort* required by 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 concept of time and distance to complete the task is also related with the concept of ratio and precision of waypoints.

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

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

Conclusions

Conclusions

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

Kinesthetic introduces inequality among users due to physical characteristics.

Furthermore, thanks to its simplicity kinesthetic teaching can be used 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 of exploiting more functionalities of the collaborative robot.

Thank you for your attention.