

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

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## Summary

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- **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

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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

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## Introduction

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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

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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

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This video shows how the pad is used to perform the task.

## Experimental design

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## Experimental design

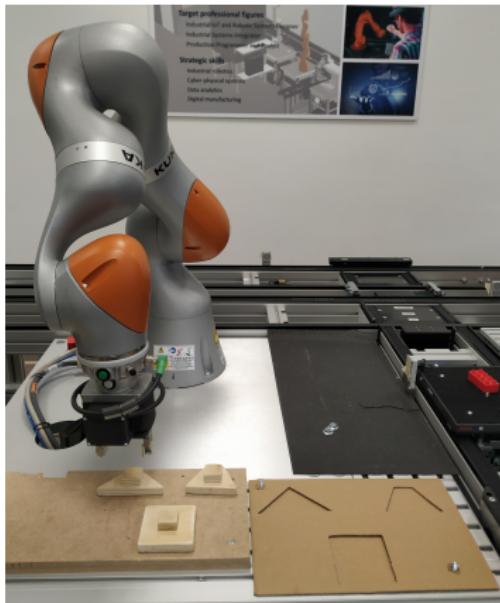
Before the experiment, was asked to the users to take confidence with both the modalities. Every user perform this phase without seeing other users do the same.

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.

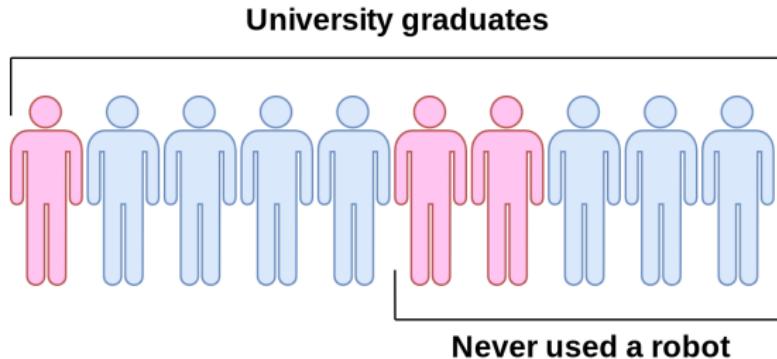


# Experimental design

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



## Experimental design



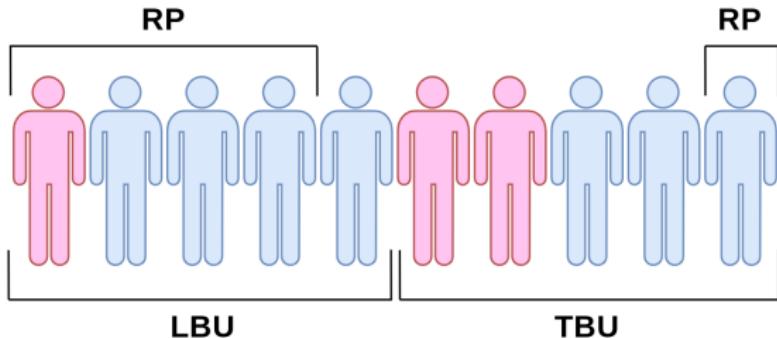
To obtain better and diversified results among the participants, half of them started with teleoperation teaching, while the other with kinesthetic teaching.

## **Results discussion**

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## Results discussion

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



For reasons of time, only two of the research questions (the most important ones) are demonstrated through data. For a more complete and in-depth explanation, refer to the thesis.

## Results discussion

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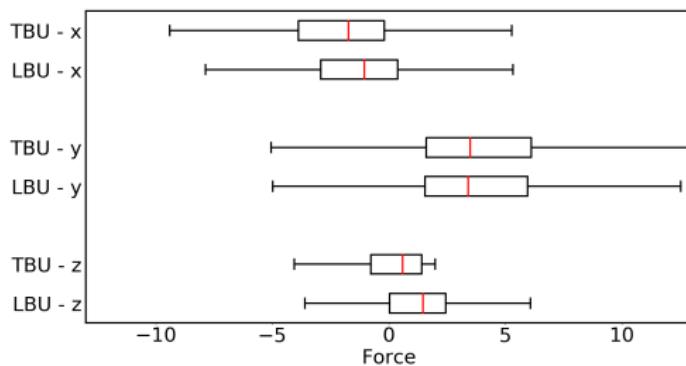
**There is a correlation between physical characteristics of the users and kinesthetic teaching?**

- 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

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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  $N$  and the time in *seconds*.



## Results discussion

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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

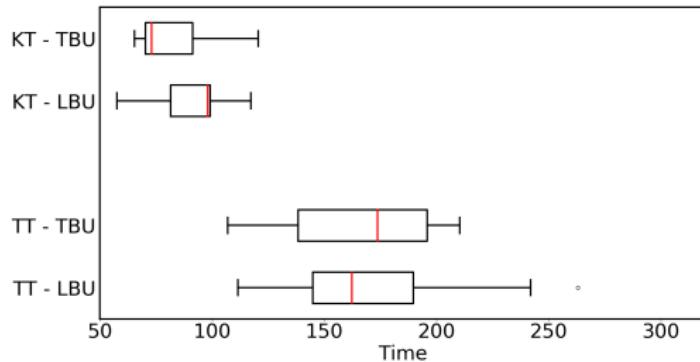
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**Users who have familiarity with the pad are better with teleoperation teaching?**

- 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

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The concept of time and distance to complete the task is also related with the concept of ratio and precision of waypoints.

Therefore, the mental efforts in teleoperation teaching are: 5,6 for **LBU** and 6 for **TBU**.

## Conclusions

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Thank you for your interest and attention.