

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

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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. But their use requires new reprogramming techniques, such as kinesthetic and teleoperation.
- **Goals:** this work propose a new teleoperation modality for teaching assembly tasks. Therefore, with an user experiment, it wants to highlight the differences between the two modalities for teaching assembly tasks.

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

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.

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

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

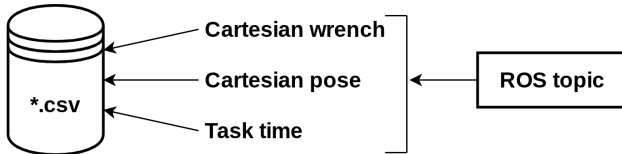
This video shows how the pad is used to perform the task.

Experimental design

Experimental design

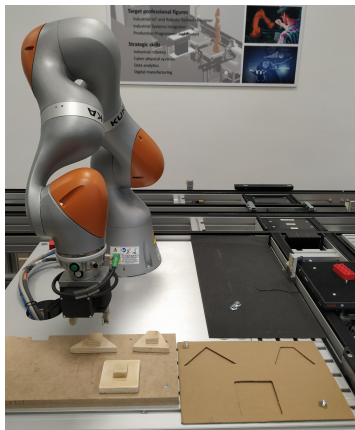
Before the experiment, we asked the users to take confidence with both the modalities. Every user performs this phase without seeing other users do the same.

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.

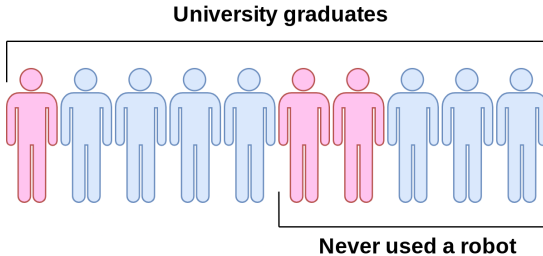


Experimental design

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



Experimental design

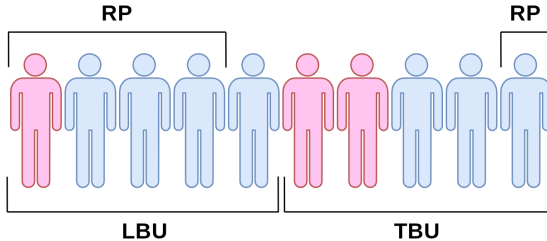


To obtain better and diversified results among the participants, half of them started with teleoperation teaching, the other with kinesthetic teaching.

Results discussion

Results discussion

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



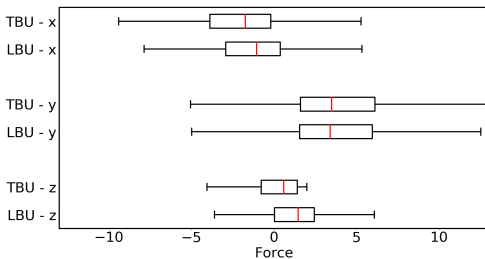
For reasons of time, only two of the research questions (the most important ones) are demonstrated through data. For a more complete and in-depth explanation of everything, refer to the thesis.

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

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

Results discussion

These figure shown the difference of force 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

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

The average physical effort of the users are: 5,4 for **LBU** group, and 3,8 for **TBU** group.

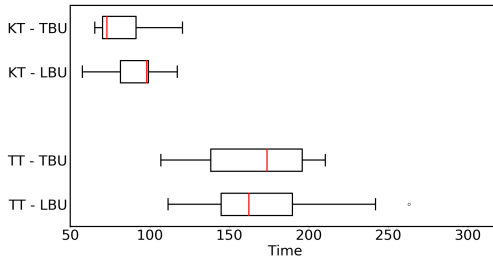
Both personal opinions and scientific data, show us how that there is a correlation between kinesthetic and physical characteristics.

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

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

Results discussion

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



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

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

Conclusions

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Thank you for your interest and attention.