

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

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Introduction

Within the industry 4.0, robots are increasingly exploited in production plants.

With the ambition to introduce robots into assembly lines the need to reconfigure the workspace requires faster modalities for robot reprogramming.

Actually, in automotive industry, welding and painting tasks are already highly automated.

Instead assembly tasks are mainly performed manually today and they are absolutely repetitive and they can be constantly changed.

These tasks are mainly:

- pick and place
- peg into hole

To facilitate reprogramming of robots, the new paradigm which is used more frequently is *PbD*: Programming by Demonstration.

Pbd is often used with collaborative robots that are installed in industrial environments.

It's a technique for teaching a robot new behaviors by demonstrating the task through a sequence of commands.

From *PbD* paradigm a comparison between two modalities was made to find the optimal method for teaching industrial assembly tasks.

The two modalities compared were:

- **kinesthetic teaching**: the robot is gravity compensated and the user physically guides the robot within his workspace
- **teleoperation teaching**: the user controls the robot with a **Ps4** pad

Before starting the work 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 teleoperation teaching?

Experiment

Experimental design

The experimental design describes the entire flow which is done by every participants of the experiment.

During the experiment some data were collected from ROS topic with sample rate of $10Hz$. Those data are related to cartesian pose, cartesian wrench, joint position and joint velocity.

The experiment has been divided into three stages for convenience:

1. pre experiment
2. experiment
3. post experiment

Pre experiment phase

At this stage users were asked to take confidence with both the modalities.

If the user complete this phase an ascending unique id is assigned to him.

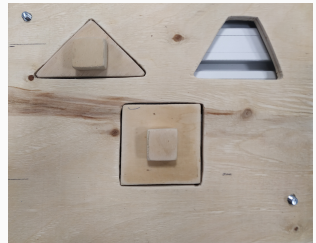
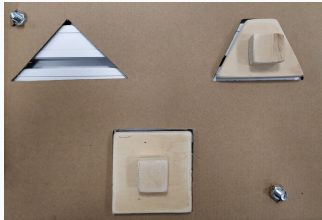
Every user perform the pre-experiment and experiment phase without seeing other users do the same.

Experimental phase

The experiment was repeated both for kinesthetic and teleoperation.

It consists in two tasks in ascending order of difficulty repeated for three times. For simplicity the repetitions were called “trial”.

The figure on the left is a pick and place with a simple interlocking, while the figure on the right is a difficult interlocking.



Experimental phase

After every trial a *vote* to the work done is given to the user.

After the *first* trail of every task the replay phase based on the waypoints and actions on gripper is shown to the users. IN this way the user understands where he can improve

The starting position of the robot is always the same for all the users to unify the times.

Every trial of the users were considered valid, even if a mistake were made by the user.

Post experiment phase

At the end of the experiment an evaluation questionnaire was filled by the users.

It's divided in three parts:

1. personal informations as physical characteristics and confidence with pad
2. some questions about mental and physical effort
3. general questions about the experiment

Participants

The total number of participants is ten: seven male and three female. All of them are university graduates or students. Their ages are between 24 and 27 years old.

Half of them never use a robot as KUKA LBR IIWA.

To obtain better and diversified results among the participants, the modality in which each user starts with the experiment is diversified. Half of them started with teleoperation, the other with kinesthetic.

Results discussions

Comments about trials

Division in groups

Conclusion

Thank you so much for your
interest and attention.