The Third hand, Cobots Assisted Precise Assembly

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Abstract. Collaborative robots (Cobots) are indispensable tools in the factories of the future. Due to their safety centered design, Cobots are allowed to work side by side with humans. Which makes their use as an assistive third hand appealing for tedious assembly tasks. Consequently, a robot can be hand-guided to lift and hold parts in place, while giving the human coworker an opportunity to apply the fixtures (perform the assembly task). Such functionality reduces the risk to workers and properties (falling components), provides precision, allows lifting heavier parts, and increases productivity by keeping less workers occupied in manual tasks on the factory floor.

Keywords: Collaborative robots · smart assembly · hand-guiding.

1 Methodology

One of the least automated tasks on the factory floor are assembly works. This fact is more evident in high-tech production facilities, as in aerospace industry. For example, during aircraft and satellite assembly, where in the last scenario the product is specifically customized to client's requirements. In such situation, assembly tasks are mainly done by human workforce, making them prone to delays and human errors. In this study, we investigate the integration of collaborative robots [1] as assistants to human coworkers for performing precise assembly tasks. We test our solution on a satellite dummy, where it is required to assemble sensitive equipment in the roof of the dummy. Traditionally, such task requires at least two workers (depending on the instrument's wight). Thus our idea of using a collaborative robot as a third hand, allowing one worker to do the task and reducing the risk of fallen parts. Due to their safety centered design, collaborative robots can work side by side with humans safely. Consequently, in our solution the coworker utilizes hand-guiding for performing the assembly works. Two operation modes are made available, the hand-guiding at the joints level, which is suitable for performing rapid and long displacements of the robot. On the other hand, the worker can switch to our precise hand-guiding application [3] for performing the precise motion. To guarantee precision, in our application the robot is hand guided at its end-effector (EEF) level, where the motion of the robot is divided into three different groups:

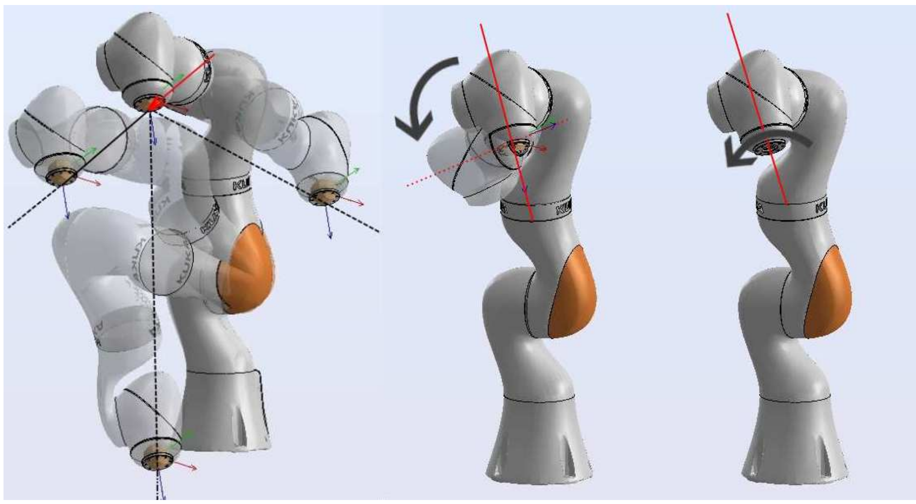

Fig. 1. First motion group (Left). Second motion group (Middle). Third motion group (Right).

1. First motion group, Fig. 1 at left: in this case the operator can move the EEF on a line along the axes of the robot base frame, while the orientation of the EEF is kept unchanged during the motion.
2. Second motion group, Fig. 1 in the middle: in this case the operator can orient the EEF in space by applying a moment, the position of the EEF is kept fixed.
3. Third motion group, Fig. 1 at right: in this case the user can rotate the EEF of the robot round its axis, the position of the EEF is kept fixed, and the orientation of the EEF's axis is also kept fixed.

Our solution offers various advantages over the traditional way of positioning robot's EEF using the teach-pendant, which suffers various drawbacks:

1. Unlike the hand-guiding, when using the teach-pendant the user does not have a feel of the force applied between the instrument and its surrounding in case of a contact. Accidents could happen and the user might over press the sensitive instrument against the surrounding without noticing.
2. When using the teach-pendant to position the EEF in Cartesian space, the user has to keep a track of the orientation of the robot base, this could become confusing even for the experienced worker (especially if the robot is mounted on a mobile platform).

3. For adjusting EEF's orientation, most teach-pendants use Euler rotation angles convention. This way for describing the orientation is not intuitive for humans.
4. The override control to change the velocity of the robot while performing the positioning operation is not convenient.

2 Demonstration

Figure 2 shows a demonstration of the third hand application. The collaborative manipulator Kuka iiwa was used in the demonstrator, while the required software was developed using the Kuka Sunrise Toolbox (KST) [2]. In Fig. 2 (a) the instrument is picked up using the gripper. Afterwards in Fig. 2 (b), the hand guiding at the joints level is used for rapid displacement of the instrument, and for rough adjustment of its position Fig. 2 (c). Using a button on the flange of the robot, the user switches into the precise hand guiding application Fig. 2 (d). The integrated LED lights switch from red to blue signaling that the precise hand guiding at EEF level is initiated. Consequently, the worker moves the object steadily towards its installation site at the top of the satellite dummy Fig. 2 (e). Our proposed solution gives the worker the ability to adjust precisely the placement of the instrument in its place Fig. 2 (f), allowing him to apply the fixture (bolts).

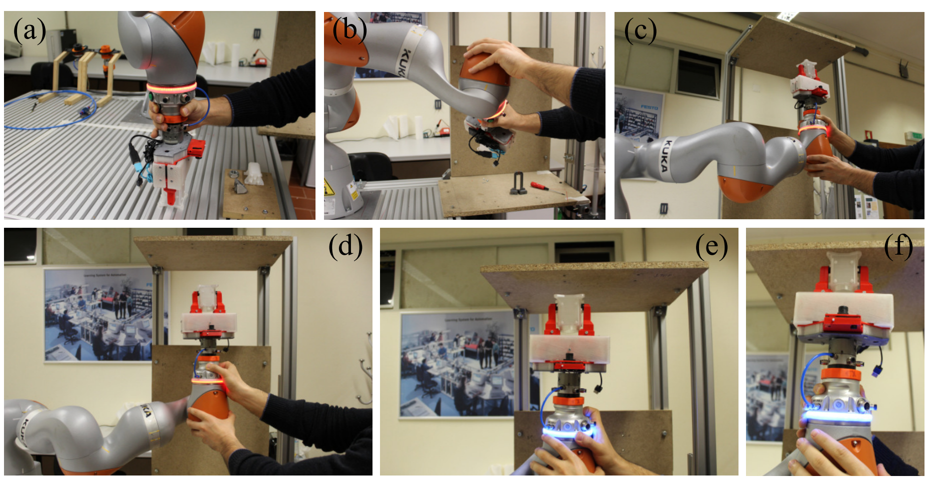

Fig. 2. Demonstrator of the third hand application. (a-c) Rapid motion using hand-guiding at joints level. (d) Switching to precise hand-guiding application. (e-f) Precise adjustment of the position of the instrument.

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