Human-like Assembly Robots in Factories

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Industrial robots were born in the USA in early 1960s and grew up in Japan in 1970s. In 1980s they began to spread all over the world into many processes such as welding (arc and spot), painting and material handling. At present more than one million robots are working mainly at automobile manufacturing. However, even now, many assembly processes depend on human workers, because current industrial robots are controlled only in position and it is difficult to achieve assembly process by position control. Force control is needed for assembly robots.

Force control had been intensively researched during 1980s. In 1990s some robot companies tried to apply force control to industrial robots, but force control didn't become popular mainly because force sensors were expensive. After middle of 2000s the situation has been changed. Force sensors have been getting inexpensive and vision sensors have greatly advanced. By combining force sensor and vision sensor, applicability of assembly robot becomes wider and stronger. Therefore robot companies started to try force control again and also to develop practical vision sensor. In addition, human-like industrial robots have emerged. These robots have dual arms with 7 degrees of freedom (DOFs) respectively like human and are almost same size as human, so that the robots can easily substitute for human workers with minimum changes of peripheral equipment in assembly lines or cells.

Recently, dexterous manipulation (so-called manipulation skill or skill-based control) based on force control has been increasingly researched and developed. Dexterous manipulation aims at accomplishing assembly task by controlling target force and virtual compliance like human. But it is not sufficient for practical use. To compensate such insufficiency, following technical issues need to be solved.

- Recognition: how to precisely recognize success or failure of assembly task
- Teaching (tuning): how to easily tune parameters of force control

Features or patterns in sensor responses are effective to recognize success or failure. We will present an example of practical way of recognition. It is strongly required that everyone can easily tune parameters in short time without special technical knowledge. We will also present an example of practical tuning method.

Solving these issues, human-like assembly robots will be realized soon. Finally, we will introduce future challenges and future directions of industrial robots.

Keywords:
Industrial robot: Broadly, a manufacturing machine that substitutes for human workers. Strictly, it is defined by ISO8373:1994 as an automatically controlled, re-programmable, multipurpose manipulator with three or more axes. Generally end-effecters are mounted on the tips of the manipulators to do various tasks. The end-effecters such as welding devices, spray guns and grippers are selected according to each application.

Position control: To control positions of target systems. In robotics, position control aims at keeping positions and/or orientations of the end-effecter at the desired values or keeping each joint at desired angle.

Force control: To control force that is given to work pieces through the end-effecter by the manipulator's motion and sometimes includes controlling virtual compliance at the end-effecter by sensor feedback.

Manipulation skill: Control approach that enables reliable task execution like human, although positions and dimensions of work pieces are inaccurate as compared to positioning accuracy of the manipulators. Generally the manipulation skill consists of several primitive skills.