Holonic Assembly System
(Prof. T. Arai and Lecturer Y. Maeda (Yokohama National Univ.))

In recent years, manufacturing systems must have high flexibility (fault-tolerance, versatility, agility, etc.) to cope with dynamic changes of their environment. We have proposed a flexible assembly system with the concept of holon, as a decentralized autonomous manufacturing system.

Holons are autonomous and cooperative components of the system. They form a "holarchy" (hierarchical control architecture) to execute assembly tasks. The holarchy of the system consists of management holons and execution holons (Fig. 1). If a management holon is ordered to assemble a product, this assembly task is decomposed into subtasks for lower management holons. A management holon (operation holon) secures appropriate execution holons, which correspond to real manufacturing devices, using the contract net protocol. Then the operation holon makes the execution holons execute a simple job, such as assembling parts. We implemented a real holonic assembly cell shown in Fig. 2. The decentralized nature of the system enables us to realize "Plug & Produce," a system function that supports easy addition/removal of manufacturing devices. We are developing some techniques for Plug & Produce, such as a distributed resource allocation method for installation of new robots (Fig. 3), and an automated calibration for mutual positional relationship between an existing robot and a newly added one (Fig. 4).

Keywords: Holon, Holarchy, Assembly, Manufacturing Systems, Plug & Produce

References

1) Masao SUGI, Yusuke MAEDA, Yasumichi AIYAMA Tomokazu HARADA and Tamio ARAI: "A Holonic Architecture for Easy Reconfiguration of Robotic Assembly Systems," IEEE Trans. on Robotics and Automation, Vol. 19, No. 3, pp. 457~564, 2003.
2) T. Arai, Y. Maeda, H. Kikuchi, M. Sugi: "Automated Calibration of Robot Coordinates for Reconfigurable Assembly Systems, Annals of the CIRP, Vol. 51, No. 1, pp. 5~8, 2002.
3) Yusuke MAEDA, Haruka KIKUCHI, Hidemitsu IZAWA, Hiroki OGAWA, Masao SUGI and Tamio ARAI: "An Easily Reconfigurable Robotic Assembly System," Proc. of 2003 IEEE Int. Conf. on Robotics and Automation, pp. 2586~2591, 2003.
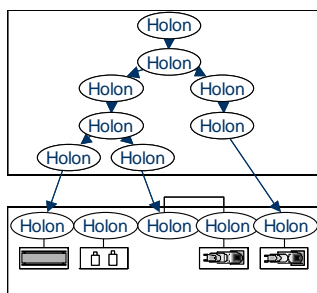
Fig. 1   Holarchy for Holonic Assembly Cell
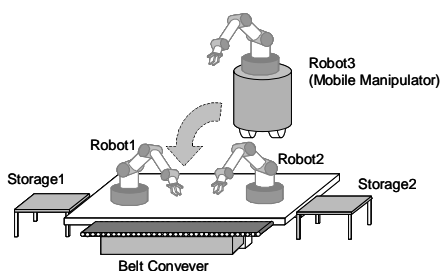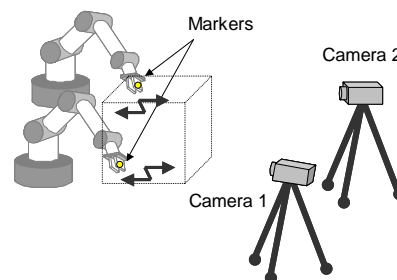

Fig. 2   Holonic Assembly Cell

Fig. 3   Plug-in of a New Device

Fig. 4   Automated Calibration for Plug & Produce