Generating skillful robotic manipulation motion by human demonstration

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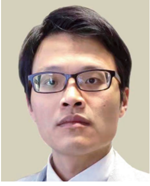


Abstract

There is a wide range of skillful motions in human manipulation tasks. It is challenging to robotize these motions using conventional motion planning and imitation methods. Under this background, we developed a method to overcome the difficulties by distinguishing between motion planning and the reuse of human teaching trajectories. In the method, we track the motion trajectories of an object using visual recognition and extract the key pose or key pose sequences by differentiating the taught trajectories. Then, the trajectories for planning and imitation are separated and will be used for motion planning and imitation respectively to generate skillful motions. Experiments and analysis showed the efficacy of the method.

Background & Results

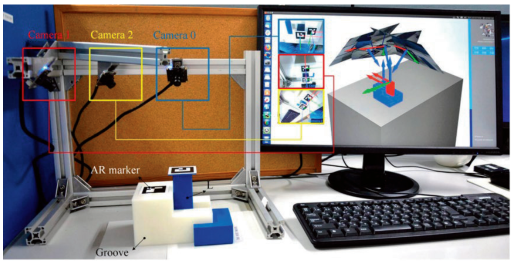
Recently, several examples of the introduction of robots in Small and Medium-sized Enterprises (SMEs) have been presented. Robots have taken the place of humans to perform production tasks, leading to an efficient and low-cost production environment. However, the introduction of robots requires coordination by experts, which is not suitable for engineers of SMEs who do not have expertise and know-how in robotics. It has hindered the broad deployment of robots.

Under this background, robotizing human production tasks through intuitive human instruction, a.k.a. intuitive teaching, is highly demanded. Intuitive teaching has the potential to increase productivity by facilitating the introduction of industrial robots and has long been the focus of robotic integration. Currently, a promising method to achieve intuitive implementation is teaching with AI. While there is progress in the development of AI techniques for extracting human behavior with deep learning, mimicking behavioral primitives, and probabilistically generating collision-free behavior with motion planning, applying them to complex behavior with skill is very difficult. From the viewpoint of motion planning, complex actions with skillfulness are a narrow path problem in motion planning. It isn't easy to solve them in a general way using conventional methods.

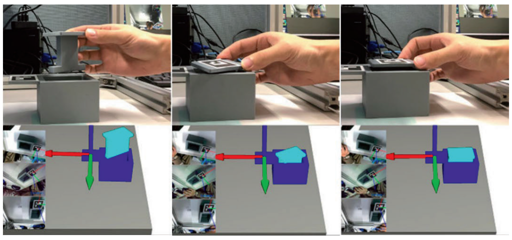
This study extracts key poses or key pose sequences of skillful actions by using the derivative of human teaching trajectories recognized by the vision and separate trajectories for planning and imitation. Then, by applying motion planning and reuse of the human teaching trajectory to each separated trajectory, we implemented intuitive teaching of tasks such as replacing a door or connecting a rotary connector. We also used reinforcement learning to extend the planned trajectory to similar parts (those that change size or have multiple of the same geometric features). For more detailed information, please refer to related papers 1 and 2.

Significance of the research and Future perspective

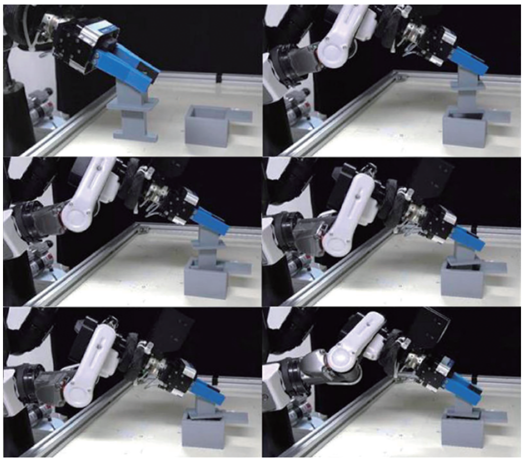
The direct teaching method of cooperative robots is best suited for linear motions but is difficult to extend to delicate and complex ones. Our implementation can solve the problem of delicate and complex motions. It can be combined with direct teaching to simplify robotic system integration. Our method is expected to promote the RaaS industry, where robots and humans will be employed equally.



Demonstration Interface



An Example of Human Demonstration and Object Trajectory Tracking



Motion Generated Using Considering Key Poses of the Demonstrated Trajectories

Patent	
Treatise	Wang, Yan; Harada, Kensuke; Wan, Weiwei. Motion planning of skillful motions in assembly process through human demonstration. Advanced Robotics. 2020; 34(16): 1079-1093. doi: 10.1080/01691864.2020.1782260. Wang, Yan; Beltran-Hernandez, Cristian C; Wan, Weiwei; Harada, Kensuke. Hybrid Trajectory and Force Learning of Complex Assembly Tasks: A Combined Learning Framework. IEEE Access. 2021; 9: 60175-60186. doi: 10.1109/ACCESS.2021.3073711.
URL	https://www.youtube.com/watch?v=xHLChh4Y2I0 https://www.youtube.com/watch?v=B75rBqCLYRQ
Keyword	robot motion planning, imitation, reinforcement learning