FORCE-CONTROLLED DRILLING USING INDUSTRIAL ROBOT ASSEMBLY OPERATIONS

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Drilling is one of the most costly and labor-intensive operations in high-precision assembly with accuracy requirements often exceeding what could be accomplished by contemporary industrial robots. Thus far, robotic development has been focused on high precision (repeatability) in repetitive operations. For example, a standard industrial robot for 60 kg payload could a repetitive accuracy of ±0.05 mm. If, however, the same robot is given a new coordinate that it has never visited before, the accuracy is in general around ±3 mm, which is 60 times the size of the repetitive accuracy. Today it is possible to buy the same robot with an option pack that includes calibration for high accuracy. This will improve accuracy to become within ±0.5 mm, which is still 10 times the repetitive accuracy. In addition, this accuracy is only guaranteed under the condition that no unmodeled external forces act on the robot, i.e., only during motion in free space. For contact tasks such as polishing, drilling, and riveting, the effects of the limited mechanical stiffness of the robot must be taken into account in order to maintain the positioning accuracy, which is not feasible unless a detailed model of the particular robot specimen is available.

In this contribution, we present a method for drilling using an industrial robot with high-bandwidth force feedback, which is used for building up pressure to clamp-up an end-effector to the work-piece surface prior to drilling. The focus is to eliminate the sliding movement (skating) of the end-effector during the clamp-up of the end-effector to the work-piece surface, an undesired effect that is due to the comparatively low mechanical stiffness of typical serial industrial robots. This compliance makes the robot deflect due to the cutting forces, resulting in poor hole quality. Recently, functionality for high-bandwidth force control has found its way into industrial robot control systems. This could potentially open up the possibility for robotic drilling systems with improved performance, using only standard systems without costly extra hardware and calibration techniques. Rather than automating with expensive fixtures and precise machinery, our approach is to make use of standard low-cost robot equipment in combination with sensor feedback. As shown by our experimental results, the resulting sliding suppression control results in greatly improved hole positioning and quality. The conceptual idea behind the force control is believed to be useful also in many other applications requiring external sensor feedback control of industrial robots.