18th International Conference
ENGINEERING MECHANICS 2012
Svratka, Czech Republic, May 14 – 17, 2012

pp. 66–67
Paper #221

FORCE-TORQUE CONTROL METHODS FOR INDUSTRIAL ROBOTS

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Abstract: *The paper deals with Force – Torque control methods for industrial robots. The key aspect of these methods is to control a contact between a tool and a workpiece when either the tool or the workpiece is mounted on the robot flange. Real-time control of contact forces and moments is necessary. It is suitable to use it on a variety of industrial operations such as grinding, deburring, other machining operations or automatic assembly. The experimental set-up is based on a KUKA robot with FTC sensor (SCHUNK FTC-050) mounted on the robot and an external PLC system used for main control and connecting other essential sensors and devices. Main practical results are concerned with a design of specific end effector for a specific workpiece and with determining the contact between a workpiece and the surface maintaining a constant force during robot motion.*

Keywords: ***Force-torque control, industrial robots, real-time control, PLC, robot motion***

1. Introduction

One of the greatest limitation and also one of the greatest space for further research represent a robot interaction with the worker. In many cases, it would be useful to alow this interaction and it can help with robots integration to new industry fields. Nowadays the worker and the robot are usually separated trough some type of safety system.

Other important space for further research is in a need to automate the applications that are nonstandard for robots. Need to control the contact forces and moments between the robot and its environment is essential for this type of operations to ensure a right task performance. One of the representatives of this field is finishing operations (Boque, 2009; Pires, et al., 2002) like grinding, polishing, deburring, etc.

The next demand is concerned with a new robot programming technique that is based on human robot interaction and cooperation. Needles, to say that safety is the biggest task for this approach, because the robot workspace is fully shared with the worker. This technique allows the tasks to be frequently and easily changed and robots can be programmed online by demonstration of non-expert.

To use a robotic cell for finishing operation or human robot interaction, there is need to ensure right force-torque feedback based on a force-torque sensor (Perry, 2002). Various control architectures can be applied (Bigras et al., 2007; Blomdell et al., 2005; Caccavale et al., 2005). The best way would be a force controller based on the complete model of the robot. Due to closed architecture of the robots that rarely allows a direct control of motor torque, this type of controller is difficult to implement on the actual range of industrial robots. Due to this fact, in this project we applied a cascade force controller even though we know that it does not take into account the whole model of the robot and only a tool position can be controlled.

2. Industrial demands

This project of force-torque control of industrial robots is motivated by real industrial demands. In collaboration with our industrial partner Blumenbecker Prag s.r.o. we received various components for testing and currently we are dealing mainly with components intended for finishing operations.

To answer the needs, the project have been initiated (we successfully asked for funding – Ministry of Industry and Trade of the Czech Republic) and we established a research platform based on academic-industry partnership.

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3. Control methodology

Data from the force-torque sensor (SCHUNK FTC-50) is sent to a PLC (Embedded PC Beckhoff) via serial connection RS232. Information about the contact force and torques are processed in the PLC and control deviation is processed here too. Control deviation is sending to the robot controller via DeviceNet interface. In the robot controller KUKA RSI (Robot Sensor Interface) is used to fulfill the condition of real-time data processing, it is a software package for communication with sensors and other devices in defined 12ms cycle.

4. Machinery stiffness

For more accurate regulators constants adjustments some experimental measurements of used machinery stiffness have been made. Measurements was made on belt grinding machine and universal grinding machine Protool. Force torque sensor mounted on the flange of the industrial robot and end effector with grasped object was used for push against the grinder. Amount of contact force was measured by force torque sensor and position (grinder deflection) was measured by the robot control system.

5. Results

Finally we present pilot results of the force-torque control based on the control structure described above. During motion along the surface the robot gaining and losing the contact and the process need to be further optimized and this will be the main part of our future work.

6. Conclusion

Pilot results were presented using the control architecture described in contribution where a desired contact force with object surface can be controlled allowing the robot follow object profiles.

All data processing and control algorithms is processed in the external PLC system (Embedded PC Beckhoff. Due to this, the control is independent on robot controller, it is important advantage of described control architecture. The only condition for KUKA robot controller is in need of RSI (Robot Sensor Interface) software package to be installed to fulfill the condition of real-time data processing.

Acknowledgement

This work has been supported and funded by the Ministry of Industry and Trade of the Czech Republic within the industrial research and development program TIP (2009); project number FR-T11/169: Adaptive Force-Torque Control of Robots for Industrial Applications.

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