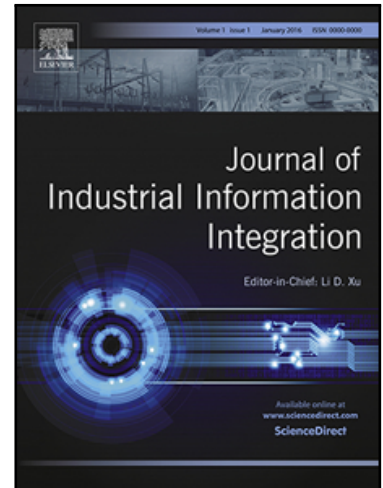


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# Real-Time Force Monitoring of Smart Grippers for Internet of Things (IoT) Applications

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**Abstract** — Manufacturing environments are globalized; enterprises are highly pressured to increase their competitiveness to deal with dynamic and turbulent markets, and developing intelligent manufacturing system has been identified as an effective way to increase competitiveness of enterprise. The level of intelligence of a manufacturing system depends on the number and types of ‘smart things’ in the system. Therefore, an irreversible trend in evolving manufacturing system is to make as many ‘smart’ manufacturing resources as possible to leverage system adaptability and resilience for uncertainties and changes. This requires equipping machines and tools with sensors and instruments, so that sensors can collect status data in a real-time mode, and the collected data can be shared and processed to support high-level system decision-making. Motivated by our observation that very few of cost-effective solutions are available to measure a gripping force of a robotic gripper; we analyze the requirements of dynamic measurements of gripping forces, and we introduce a conceptual design of sensors and instrumentations for grippers. Strain gauges are used as sensors to meet the requirements of accuracy and sampling rate with a minimal cost, and the design of instrumentation includes data acquisition and processing, layout design and embedded electronic circuit design. Finally, we conduct the validation experiments where the proposed sensing system is implemented in a robotic gripper, and the measured force on gripper is validated. The proposed sensing system can be readily extended to measure dynamic forces of other functional modules with a motion.

**Keywords** — Internet of Things (IoT), sustainable manufacturing, robot modules, grippers, sensors and instrumentation, strain gauges, calibration, programmable logic controller (PLC).

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