An Application of HRI in Low-Cost Digital Manufacturing

Lavindra de Silva   Gregory Hawkridge   German Terrazas   Marco Perez Hernandez

Alan Thorne   Duncan McFarlane   Yedige Tlegenov

Institute for Manufacturing (IfM), University of Cambridge, UK

lpd25@cam.ac.uk

Figure 1: An instance of our SOA (left). Our robot monitoring (middle) and low-cost part tracking demonstrator (right).

ABSTRACT

Digital Manufacturing (DM) broadly refers to applying digital information to enhance manufacturing processes, supply chains, products and services. In past work we proposed a low-cost DM architecture, supporting flexible integration of legacy robots. Here we discuss a demo of our architecture using an HRI scenario.

KEYWORDS

low-cost, digital manufacturing, services, legacy integration, SME

1 MOTIVATION

Our ultimate goal is the adoption of low-cost digital solutions by manufacturing SMEs, who need to keep development and legacy integration costs low and for solutions to be simple to deploy. To address these joint needs, we proposed in [1] the use of off-the-shelf and/or open source technologies, and a Service Oriented Architecture (SOA). A SOA is a framework for the composition of complex systems from autonomous, interoperable services, facilitating digitalisation and flexible integration of legacy machines and robots by "bolting on" low-cost technologies. A service represents device-specific functionality, exposed via a well-defined interface. A service is realised by a connectivity technology (CT), such as OPC-UA (OPC Unified Architecture) and DDS (Data Distribution Service) [2], which enables interoperable data and message exchange between heterogeneous technologies. A SOA requires certain core functionalities within a CT, such as *addressing*, *discovery*, *service metadata exchange*, and *messaging*.

Two key features of our SOA for low-cost DM are *wrapping* legacy and newly added technologies as needed, and *bridging* CTs, as recommended by [2]. Wrapping may involve installing a CT on a robot, or on a Raspberry Pi attached to one, enabling the robot's discovery and incremental inclusion in the SOA. A bridge is a software module – possibly coupled with hardware – that performs protocol (data and message) translation between CTs. CTs may be bridged to connect parts of an SME's existing factory, e.g., if a robot only natively supports OPC-UA and a separate PLC network is already using DDS for data distribution. Figure 1 (left) depicts an instance of our architecture, comprising CTs (blue); low level industrial messaging protocols (green); and database technologies (orange), each wrapped in one oneM2M [2] CT. The instance can be reached incrementally, e.g. by (1) wrapping CouchDB in oneM2M, (2) wrapping the field device in a DDS service, (3) bridging DDS and OPC-UA, etc.

We will demonstrate aspects of our SOA: how a robot/machine and phone/tablet can each be wrapped in a CT, and automatically discover and use each other's services over Wifi. The tablet has an open source AR library, which we have configured to augment the robots/cells in a factory with status/condition information that humans can see quickly and intuitively from a safe distance. For portability, we will swap the robot cell with our low-cost cell that uses QR codes to identify parts and track their locations on shelves. The cell uses a Raspberry Pi, a camera, and open source vision libraries; it supports instant scanning and storing of parts held in a tote by a human/robot, and sends stock levels to the tablet (Figure 1 middle and right).

REFERENCES

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