An Integrators perspective on AI-Enhanced Cyber-Physical Systems to support Flexible Configurable Manufacturing

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Abstract

"AI Enhanced Intelligence" in the context of control systems is a term associated with injecting Artificial Intelligence into shopfloor systems that incorporate PLC, Robotics or CNC control systems. Flexible Configurable Manufacturing systems require real-time decision-making capabilities on the shop floor to be effective. As Human-Robot collaboration is increasing becoming the norm, it is important that certain decisions are left to those who have in-depth process knowledge and can be supported by providing relevant information to make process changes. The data collected from the machines is already being used to optimise the process, but unpredicted events need immediate responses and standard programming architecture is not designed for flexible configuration and needs to be modified to embrace new knowledge streams from AI to respond to every eventuality.

Keywords 1

Collective Intelligence, Enhanced Intelligence, interoperability, manufacturing, Artificial Intelligence, AI, I4.0

1. Introduction

"AI Enhanced Intelligence" in the context of control systems is a term associated with injecting Artificial Intelligence into shopfloor systems that incorporate Programmable Logic controllers (PLCs), Robotics or Computer Numeric Control (CNC) systems. Flexible Configurable Manufacturing systems require real-time decision-making capabilities on the shop floor to be effective but currently, much of the processing of the data is carried out on remote servers and therefore introduce time delays which means that it is not possible to reconfigure production systems on the fly. As Human-Robot collaboration is increasing becoming the norm, it is important that certain decisions are left to those who have in-depth process knowledge and can be supported by providing relevant information to make process changes. Of course, this assumes that operators have had time to become skilled and can make such critical decisions, so a belt and braces approach is always preferable in case the wrong decisions are made. The data collected from the machines is already being used to optimise the process, but unpredicted events need immediate responses and standard programming architecture is not designed for flexible configuration and needs to be modified to embrace new knowledge streams from AI to respond to every eventuality.

2. Input signals for AI Enhanced CPS Systems

The development of technologies can often be traced back to the early pioneering developments of IT or Control Systems. Automating tasks has been the cornerstone of the manufacturing sector to reduce

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labour costs. The replacement of people with machines is nothing new; it has always been about repeatability, reliability, accuracy and speeding up tasks. Vision systems for example, have been around for a long time and AI has been used behind the scenes to provide the data required that mimics the observing operator but with much better accuracy and longer-term performance.

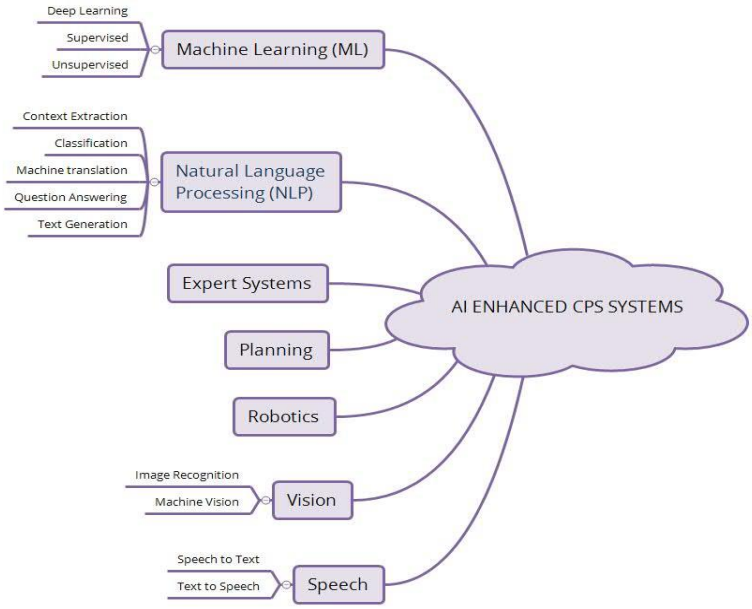

Figure 1: Knowledge Chain of Pulled Data from Shopfloor

A multitude of heterogeneous systems are typically deployed on the shopfloor all supporting the drive for greater productivity.

If all this data and technology could be filtered into one deployable solution it would clearly significantly increase production, improve efficiency, and reduce waste for all manufacturing companies. Figure 1 shows the data paths of incoming knowledge that could be filtered into an "Enhanced CPS System" (ECPS) and provide vital intelligence for decision making. The added feature of this knowledge is not just about the process and associated hardware, but additional data pertaining to the "surroundings" of the production line could also be collated.

This new knowledge is the start point to "Collective Intelligence" [1] that can be "injected" into control systems to eliminate errors typically caused by imperfections and anomalies in the production process. The more "connected" an enterprise becomes, the better the chances of achieving the reduction of costs and increasing profits.

3. Challenges of incorporating AI into Control systems

In Julian Birkinshaw's paper "The future of firms in an AI world" [2] the increasing role of AI in all aspects of human interaction within social and business environments is going to radically change. Every process, every model and every system following on from the Industry 4.0 revolution, will need a complete overhaul. Systems thinking will need to make way for AI enhanced systems that will cross many barriers and sectors. So, it is clear that big changes are coming but it is less clear how the traditional interfaces with Robots, Programable logic controllers (PLCs Robots and Control Systems as in Figure 2 work in an Enterprise Interoperability (EI) environment will interface with back office and top office systems. Clearly new methodologies will need to be developed.

Figure 2: Key elements of knowledge support for future EI manufacturing systems

Focusing on the shop floor level, vendors such as Siemens, Rockwell, Omron, Schneider Electric are rapidly deploying cloud-based solutions with Orchestration software to link shopfloor to IT systems to Enterprise Resource Planning (ERP) systems. Bosch Rexroth is developing "Open Core Engineering" [3] methodologies to allow systems integrators to choose the operating systems they wish to deploy software directly into their control systems hardware.

These systems need interoperable middleware to "open up" or "connect" these islands of data to provide significant opportunities to exploit the knowledge held within these systems. Further enhancements mean that AI knowledge gained from the production line could directly influence software steps that would otherwise be "hard coded" into a typical control systems program. So, while the technology developments are allowing the direct manipulation of programmed steps, the method by which these changes "on the fly" would be monitored or documented since AI systems are constantly learning new algorithms and no two systems can ever be the same. So, if we take a typical line process where a robot is picking and placing goods and then gets information to realise that the product presented has minor defects and could be reworked, it needs to learn this and store it for future decisions.

4. Human-Robot Collaboration with Auditing System

The real challenge is to ensure that any changes made to the operation of a program carry an audit trail because the likelihood of a system getting taught incorrect procedures needs to be reversible and more importantly understandable to the control engineers that may need to override the machine programs.

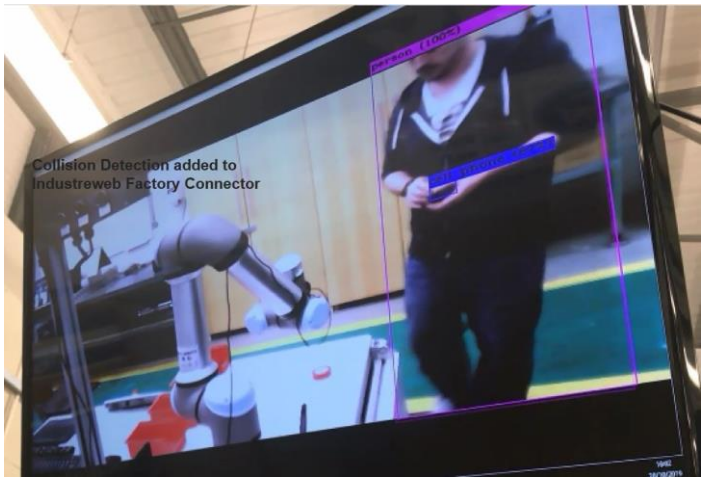

Figure 2: Presenting Data back down the Knowledge Chain

Maintenance staff need to understand how to re-commission a system if it has learned “bad habits” which is inevitable if the system is self-learning.

Industreweb 4.0 (IW) [4] is a middleware software system that can take multiple data sources that include AI learning systems that can learn to deal with human co-workers that need to interact safely with the automation. IW takes these enhanced AI streams and combines it with standard control systems software to not only keep the operator safe using a combination of vision systems and flexible program manipulation. A key feature to track changes or “understand” the rational of the responses adopted by the AI Control Systems is important to engineers who need to fix or repair processes that have failed or are exhibiting irregular behaviour. This requires the ability to understand the rationale behind control process decisions to correct or understand the reasons behind the failure. The rise of Explainable AI (XAI) systems [5] is welcomed in the world of control systems as it allows engineers to continue to interact, respond and maintain such systems keeping the decision making tasks firmly with the human.

5. Discussion and conclusions

AI Enhanced systems are likely to be making a big entrance to the shopfloor and take decision making to the heart of the process. They will allow the current existing decision making processes to focus on the business model and support the model by taking away the concerns of rescheduling production tasks as they can be handled between the human operator and the support robot / cobot.

6. References

[1] https://en.wikipedia.org/wiki/Collective_intelligence

[2] Birkinshaw J. What Is the Value of Firms in an AI World?. In: Canals J., Heukamp F. (eds) The Future of Management in an AI World. IESE Business Collection. 2020. Palgrave Macmillan, Cham

[3] https://www.boschrexroth.com/en/xc/products/engineering/opencoreengineering/what-is-open-core-engineering/index

[4] Industreweb Software developed by Control 2K Limited to act as the “Glue” to connect data systems www.industreweb.com

[5] https://en.wikipedia.org/wiki/Explainable_artificial_intelligence