International Journal of Advance Research in Science and Engineering
Volume No.06, Special Issue No.(04), December 2017
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354

CYBER-PHYSICAL SYSTEMS IN MANUFACTURING SYSTEMS

Anuj Doshi

Student, Mechanical Engineering, University of Mumbai (India)

ABSTRACT

The use of Cyber-Physical Systems (CBS) has been an issue that has accrued a lot of traction in the global industry in recent times. In it's basic state it is a mechanism that is controlled or monitored by computer-based algorithms, tightly integrated with the internet and its users. This paper advocates the use of such a system with its various other aspects and provides a detailed study of all the appurtenances that come along with the integration of such a system.This paper reviews current scope and also proposes various prospects in integrating machine learning in manufacturing systems, thus amalgamating the fields of computer science engineering and mechanical engineering.

Keywords: Manufacturing Control, Machine Learning, Internet of things, Performance evaluation, Computational Intelligence in concurrent engineering

I. INTRODUCTION

Every manufacturer has the potential to integrate computational advancements into their operations and become more competitive by gaining predictive insights into production. In such a competitive world the use of computational advancements provide a major head start to new innovations and processes. This is where the application of cyber-physical systems and machine learning takes place.

Machine learning's core technologies align well with the complex problems manufacturers face daily. From striving to keep supply chains operating efficiently to producing customised, built- toorder products on time, machine learning algorithms have the potential to bring greater predictive accuracy to every phase of production. Many of the algorithms being developed are iterative, designed to learn continually and seek optimised outcomes. These algorithms iterate in milliseconds, enabling manufacturers to seek optimised outcomes in minutes versus months.

Cyber-physical systems deeply intertwine the physical and software components, each operating on different spatial and temporal scales, exhibiting multiple and distinct behavioural modalities, and interacting with each other in a myriad of ways that change with context. Embedded computers and networks monitor control the physical processes, usually with feedback loops where physical processes affect computations and vice versa. The feedback provided thus further on guides the system. If the optimal range of outcome is well-defined than the process can be significantly controlled. Such a control system already exists in manufacturing system. The purpose of this paper is to acknowledge the presence and application of a even more advance system where is there is finer control by computational interference and networks of systems. The application of such a system is not only limited to a single mechanical machine such as the lathe or any other manufacturing machine but

IJARSE
ISSN (O) 2319 - 8354

involves an even broader vision to inculcate all of manufacturing components and processes involved in optimising production. The economic and societal potential of such systems is vastly greater than what has been realised, and major investments are being made worldwide to develop the technology. A report of such an investment with figures has been provided in the following image. [1].

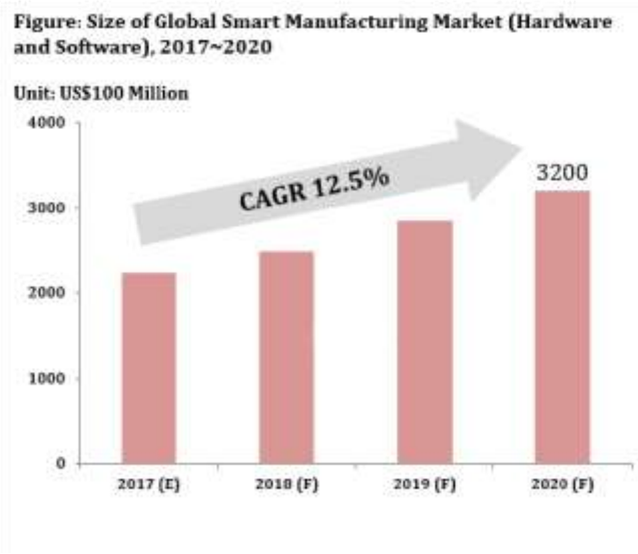

FIG. 1. THE GLOBAL MARKET SIZE FORECAST FOR SMART MANUFACTURING SOLUTIONS ACCORDING TO TREND FORCE PRESS RE-LEASE. - JULY 2017 [2]

Smart manufacturing is not simply about increasing the efficiency of the fabrication process. The concept also represents a paradigm shift in the operation and management of the manufacturing company. Upgrading software is therefore as important as upgrading the hardware. For instance, the deployment of edge computing – the processing of data near their origins (i.e. fabrication equipment) – optimises data transmissions between the factory and the cloud platform that oversees the plant. This in turn raises the efficiency of hardware at both ends. Another example in the software area is artificial intelligence (AI). Effective AI and data analytics tools can parse through vast amounts of information uploaded from factories and find new ways to improve the fabrication process. In sum, the integration of hard- and software is crucial to the development of smart manufacturing solutions.

Numerous companies across IT and manufacturing supply chains have already entered the market for smart manufacturing solutions, including major global brands such as Intel, Xilinx and Microsoft. Active Taiwan-based market entrants include Advantech, HIWIN and ICP DAS. The diversity of solution providers again reflects the importance of hard- and software integration. As the number of vendors increases, TrendForce projects that the size of the global smart manufacturing market will grow at a CAGR of 12.5% from 2017 to 2020.

The integration of cyber-physical systems in manufacturing is very advantageous in such a scenario along with application of various other computer-science based entities like machine learning and future ready programs.

IJARSE
ISSN (O) 2319 - 8354

II. BACKGROUND

Integration of physical processes and computing, of course, is not new. The term “embedded systems” has been used for some time to describe engineered systems that combine physical processes with computing. Successful applications include communication systems, aircraft control systems, automotive electronics, home appliances, weapons systems, games and toys, for example. However, most such embedded systems are closed “boxes” that do not expose the computing capability to the outside. The radical transformation that we envision comes from networking these devices. Such networking poses considerable technical challenges.[3].

Necessity is the mother of all inventionThe early dominance of mechanical industry as the hub of engineering posed a serious question whether can it be further amalgamated with other forms of engineering. By the mid-20th century we had developed an age of mass development and innovation in the mechanical hemisphere. Production systems were at a high and post-war situation had accelerated the need for better manufacturing systems. The world was clearly divided between countries based on their technical industries and efficacy in the technical hemisphere. But this also required new and better systems to control the production and make it better, faster and more independent of human control. The use of CNC and other computer controlled machines was therefore set into motion. Such a stimulus set forth an entire wave of opportunities. The growing IT, Computer and electrical industries were now convinced to be forming pillars of a more advance and starter manufacturing and mechanical industry. Industry 4.0 but it was only till early 2000’s that someone pitched the term.

With the advent of mechanical manufacturing and processing systems we have seen the rise of a generation of machines that have a smarter interface for humans and can do things more presentably. The control in these generations has been an exemplar of innovation and progressive-development since the 1980’s . With the advancement in computing technologies and electronics industry we could see these effects having positive impact on mechanical systems at the same time. The introduction of infrared control and wi-fi in the early 1990’s had first enabled controlling CNC machines over wifi and infrared control. Over a period, with ever major advancement in computer softwares, embedded systems, electrical components, and better security handling of computer systems, we could see a simultaneous advancement in the mechanical hemisphere. We now have machines that can be controlled from the phone and can be easily accessed from distant places. The introduction of application development program on various mobile and computer operating systems like windows and IOS. there are control application available on these platform that easily guide machinery into desired actions. The development of the application by TRANE commercial HVAC for control of their HVAC system in the late 2000’s was a milestone achieved by the technical systems to further explore new options in the advancing age. For the next generation of cyber-physical systems, it is arguable that we must build concurrent models of computation that are far more deterministic, predictable, and understandable. Threads take the opposite approach. They make programs absurdly nondeterministic, and rely on programming style to constrain that nondeterminism to achieve deterministic aims. Can a more deterministic approach be reconciled with the intrinsic need for nondeterminism in many embedded applications? How should cyber-physical systems contend with the inherent unpredictability of the (networked) physical world?

III. IMPLEMENTATION

There have been various doubts on the implementation of CPS and Machine learning on a broader perspective and whether it is suitable to replace current traditional systems. The fallbacks of the system have been scrutinised for a long time exposing it to more scope of improvement and over-hauling. After such a progressive growth, the use of CPS and Machine learning has been made sustainable in a lots of places, but manufacturing systems as a whole has been a corner that hasn't been explored to it's full potential yet. ***This paper exposes the various sectors and places where CPS and machine learning could supersede traditional machinery, process and mechanism for production and design.***

For that we need to understand the functioning of the CPM in reference to our context as a complete mechanism and not just a small component in a process. The following flowchart explains the same in brief.

The explanation of the flowchart itself serves the purpose of this paper. It clearly shows the various aspects of the implementation and how beneficial such an execution to prove to any manufacturer to provide a good competitive edge and leadership in the same. CPS are fundamentally feedback systems that are real time, intelligent, adaptive and predictive in nature. These can be understood by the fact that they control certain parameters just like any other control system to provide a required output. With control system you can only control a process and its output. With the use of mathematical processes and analysis you can control the mean of the product or a process flow such as six-sigma curve but with the help of CPS, a user is enabled to control a product as well a process and an entire mathematical function based on the network of inputs and controlling factors that it can present to the user. The user interface plays a much wider part in the same. The use of a networked and distributed feedback system with the help of wireless sensing and actuation mechanism enable to automate certain process with the elimination of error.

Furthermore for the sake of elimination of error we must look into all the aspects governing any malpractice or malfunction towards this system and should contribute to its safety. Therefore such a system must have the hardware and software dedicated towards cyber security. Such a deterrent system not only defends the working system from terminating but also prevents it from any attack towards privacy and adds to the resilience of the system in case of any such intrusions.

To integrate such a system into real practice will require to integrate computational advancements in mechanical systems. Such a plan would require improved design tools to enable design methodology. A system like that would definitely require a lot of backhand work from the perspective of computational mettle but would provide a greater edge in controlling the mechanical aspects of these systems.

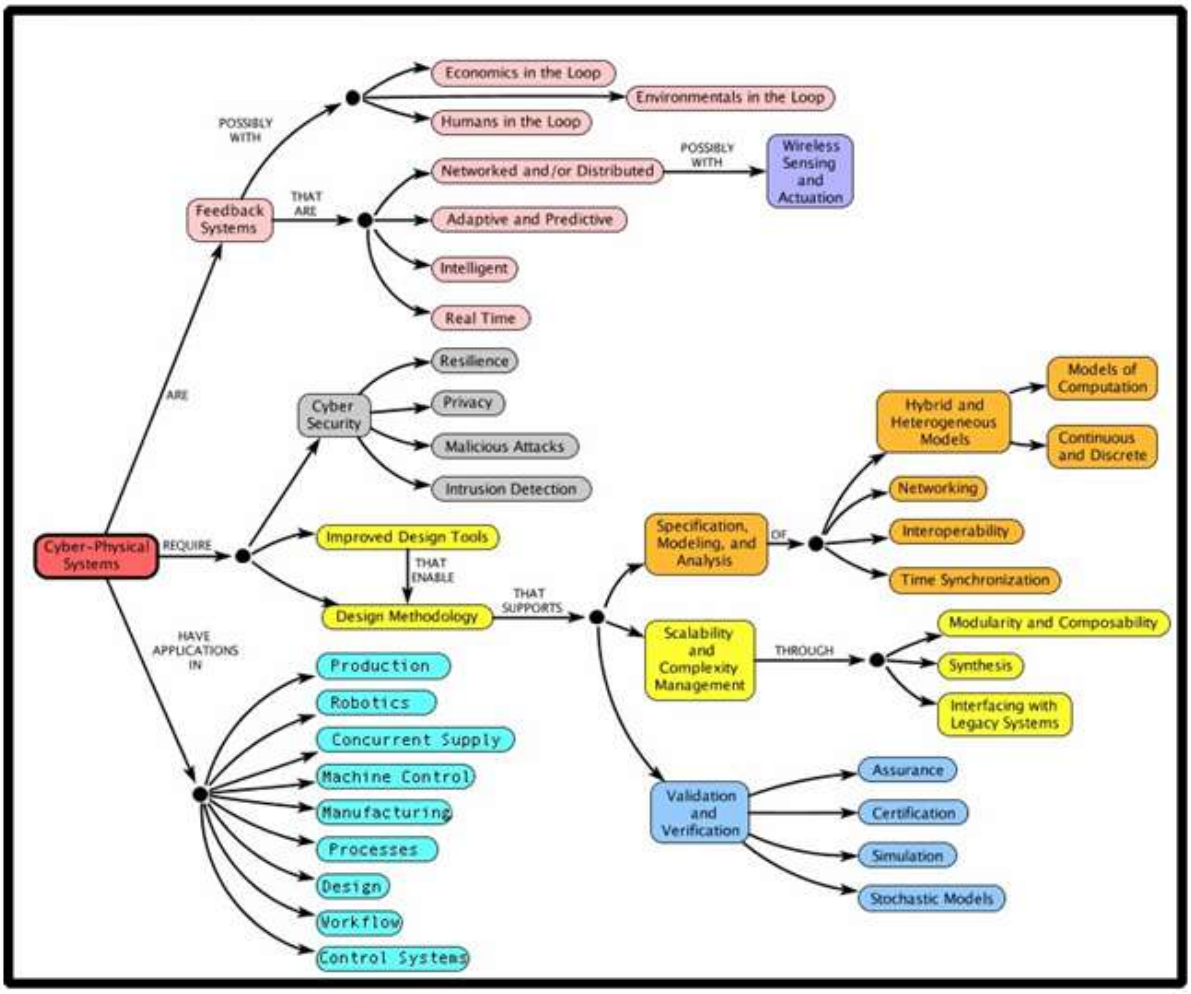

Fig.2, Flowchart explaining the mechanism cyber-physical systems. [8]

An ideal example of such a system can be taken as a bolt-manufacturing production unit. Traditionally there would be either a demand for certain quantities of specified bolts or more generally, a constant production of on-going bolts. This would require an administration to administrate all the other aspects of the production. Including supply of raw material, managing the staff, functioning of machines and all other administration duties. Then this would be conveyed to the required manufacturing personnel which would set things in motion by chain. Every process would certainly be carried out depending on the efficiency of the production unit. To optimise such a production, methods like Justin-time, 5s and others can be implemented which again would be governed by either a management personnel or a dedicated team. The use of control systems could also help to optimise production and reduce losses in manufacturing. Higher accuracy could be gained by the use of high-precision manufacturing. Further more for higher flexibility an agile manufacturing approach could be set in motion which would of course offset the earlier arrangements but then this could be overcome in a certain time. This entire process thus shows the complexity of traditional or near-past manufacturing techniques.

If we have to be future ready then we need to cut short this process to as simple a process as possible. Manufacturing and process planning techniques like 5-s, JIT , agile manufacturing, lean manufacturing have surely proven their worth and their benefits, but such a system too have failed to survive the constantly increasing need to innovate and provide greater output with higher efficiency. In the same scenario now let's consider a cyberphysical system working instead of the traditional or near-past technologies.

Let's consider providing data accessibility to the working atmosphere in the following sense. A program that would be a central control, much like the human brain. By the help of internet of things and cloud computing we could establish a link throughout the manufacturing facility and the management entities. As shown from the flowchart, this program covers every aspect of the graph right from validating to security. The wireless signals provided by every system in the process provides input, e.g. ,By the help of machine learning we could first program the manufacturing machines to develop a sense of judgement that would make them understand the closeness of results that are produced during every individual output and the input that the machine has provided. By the help of electrical components like sensors, relays and loops we can configure the system in a self-governing system, much like a control system. The data provided by such a manufacturing machine would act as input to the central system. The system is programmed to understand the input and all it's parameters and segregate them into different zones depending on various parameters that the quantify the input. These parameters could be of any nature and a transducer would process this parameter into desired input. The processing or the general brain of the system is based on all the aspects of optimum manufacturing. The mathematical model and processes could be fed to the system into a proper manner. After understand the nature and parametric data of the input the system judges it's capability to quantify in any of the follow process that would provide optimum output or best desired value. This process constantly adapts by recognising its closeness to the desired output thus making it better every single time it operates. The output would be commanded to the machines through an array of adaptive signals that would be constantly monitored by the programs internal control system. The entire process could be monitored at a fingertip through any compatible device as set by the computational software.

Concurrent programming can be done in much better ways than threads. For example, SplitC [4] and Cilk [5] are C-like languages supporting multithreading with constructs that are easier to understand and control than raw threads. A related approach combines language extensions with constraints that limit expressiveness of established languages in order to get more consistent and predictable behaviour. For example, the Guava language [7] constrains Java so that unsynchronized objects cannot be accessed from multiple threads. It further makes explicit the distinction between locks that ensure the integrity of read data (read locks) and locks that enable safe modification of the data (write locks). SHIM also provides more controllable thread interactions [6].

Back in 2008 it would seem very insecure and a great risk to depend on cyber-physical systems for the same. As mentioned in his paper, *Edward A. Lee, Cyber Physical Systems: Design Challenges [8]*, clearly states out the flaws and limitation of such a system, but with the advancement in processors and electrical components and greater control through programming languages it is now easier and much safer to have a much defined control of mechanical instruments and manufacturing systems.

IV.CONLCUSION:

Advocating the use of Cyber-physical systems in the field of manufacturing is the purpose that this paper serves.The existence of near-past technological developments in the field of CNC and CAD/CAM stand as the exemplar for this argument. It can be timelined right from Prof. B.F. Ballaney's [9] book on Theory of Machines that "with the advent of computer, the picture has changed."

RERFERENCES

[1] TrendForce Forecasts Size of Global Market for Smart Manufacturing Solutions to Top US$320 Billion by 2020; Product Development Favours Integrated Solutions, 07 / 31 / 2017

[2] Trendforce Corp 2017.http://press.trendforce.com/data/attachment/ 2017/07/31/377009001501493459.png

[3] Edward A. Lee: Cyber-Physical Systems: Design Challenges, Centre for Hybrid and Embedded Software SYstems, EECS, University of California, Berkeley. eal@eecs.berkeley.edu

[4] D. E. Culler, A. Dusseau, S. C. Goldstein, A. Krishna- murthy, S. Lumetta, T. v. Eicken, and K. Yelick. Parallel programming in Split-C. In ACM/ IEEE Conference on Su- percomputing, pages 262 – 273, Portland, OR, November 1993. ACM Press.

[5] R. D. Blumofe, C. F. Joerg, B. C. Kuszmaul, C. E. Leiser- son, K. H. Randall, and Y. Zhou. Cilk: an efficient multi- threaded runtime system. In ACM SIGPLAN symposium on Principles and Practice of Parallel Programming (PPoPP), ACM SIGPLAN Notices, pages 207 – 216, Santa Barbara, California, August 1995.

[6] O. Tardieu and S. A. Edwards. SHIM: Scheduling- independent threads and exceptions in SHIM. In EMSOFT, Seoul, Korea, October 22-24 2006 . ACM Press.

[7] D. F. Bacon, R. E. Strom, and A. Tarafdar. Guava: a dialect of Java without data races. In ACM SIGPLAN conference on Object-oriented programming, systems, languages, and applications, volume 35 of ACM SIGPLAN Notices, pages 382– 400 , 2000.

[8] Edward A. Lee: Cyber-Physical Systems: Design Challenges, Centre for Hybrid and Embedded Software SYstems, EECS, University of California, Berkeley. eal@eecs.berkeley.edu

[9] Prof. B.L. Ballaney: Theory of machines and mechanism, ch.24,1286. Khanna Publishers, Delhi110006 ,Twenty Third Edition -2003.