Transforming Industry towards Smart Manufacturing in the United States

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Abstract

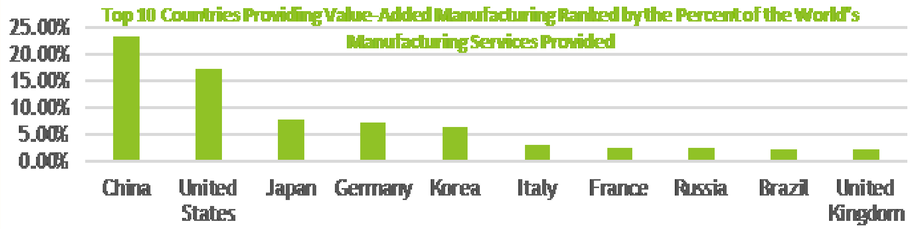
The necessity for educational programs in advanced manufacturing became prominent during the economic crisis in 2007 when the demand of industrial plants was for already trained highly-skilled laborers. To respond to this demand, many advanced manufacturing educational programs, such as mechatronics, were developed in community and technical colleges.

Since it was officially defined in the United States Congress in 2015, ***Smart Manufacturing (SM)*** has increasingly been under the spotlight. However, current efforts in deploying SM technologies in the US do not provide a workforce trained to utilize and perform SM technologies and techniques. Graduates of mechatronics and other advanced manufacturing programs remain mostly unaware of the technologies of Smart Manufacturing, such as Internet of Things (IoT) and Cyber Physical Systems (CPS), Industry 4.0 standards, and the capacity and range of applications of additive manufacturing and high-precision subtractive manufacturing technologies from tooling to end-user products.

The programs currently available do not provide workforce training on SM technologies that target community and technical colleges, which supply a significant percentage of the industrial workforce. In the project ***Smart Manufacturing for America's Revolutionizing Technological Transformation (SMART^2)***, this gap in workforce training is met by providing the needed training to career technical education (CTE) and STEM educators in mechatronics and engineering technology. This project is a collaborative effort among three institutions and provides professional training for faculty of advanced manufacturing education programs and an online knowledge-base platform for educators and manufacturers, as well as on-ground training workshops and educational modules.

Introduction

- In the year 2010, China took the world's lead in manufacturing, and this gap continues to increase [1].
- The European Union followed suit by adopting plans that relied on Smart Manufacturing technologies in order to increase their production [2-4].
- This new generation of industry has been termed "Industry 4.0" and the "New Industrial Revolution" [4-5].
- Smart Manufacturing merges certain technologies and practices with manufacturing factories and companies so that costs, productivity, and energy can be managed in real time.



Technologies of Smart Manufacturing

- **Internet of Things (IoT) and Cyber-Physical Systems (CPS):** interconnection of devices, machines, and equipment over a communication network [16].
- **Cloud Computing:** a computing system that is based on the Internet. It can increase production efficiency by allowing simultaneous access of data to users.
- **Sustainable Manufacturing:** using manufacturing processes with minimum environmental impact, while conserving energy and natural resources" [17].
- **Additive Manufacturing:** Initially, AM was used in rapid prototyping, now it is used in altering production lines, adding a high level of flexibility to manufacturing processes [18], part repair, and direct manufacturing of parts as well [19] [20] [21].
- **Machine Intelligence:** these technologies employing methods that primarily rely on algorithms based on neural networks, such as in intelligent robotics [22] [23].
- **Incorporation of Wireless Transmitters for Continuous Improvement:** significant cost cuts can be achieved. For example, truck engines have recently been equipped with wireless transmitters that relay engine performance and oil temperature to manufacturers and owners, who in turn, can avoid costly recalls and repairs [22].

The Need for Smart Manufacturing

- Electrical energy consumption could be reduced by $25 billion annually if SM technologies were provided to small-to-med size manufacturers [8].
- Additionally, utilizing SM technologies would increase the global gross domestic product by $15 trillion over the next two decades [8].
- There is currently no program that provides workforce training on SM technologies.
- 2.7 million jobs will be needed as a result of retirement of the existing workforce in advanced manufacturing [12] [13] [14].
- 700,000 jobs are likely to be created due to natural business growth.
- Overall, this creates a gap of 3.4 million

Transformation towards Smart Manufacturing

- Transformation and adaptation of current industries towards Smart Manufacturing can be enhanced by providing workforce development tools.
- To properly achieve this objective, a skill set for SM professionals need to be identified.
- There exists a need for establishing an online platform and knowledgebase to link applications of smart manufacturing technologies in manufacturing to academic education.
- There exists a need for technicians that are trained on handling large amounts of data collected from using these technologies.
- In this project on-ground and online training modules as well as a SM repository are developed to achieve these objectives.

Conclusion

- Smart Manufacturing (SM) technologies have the ability to dramatically improve manufacturing by cutting costs and increasing production
- Some technologies used in smart manufacturing include artificial intelligence, Industrial Internet of Things (IIoT), additive manufacturing, and wireless communication technologies.
- and however, in order for this to occur, the workforce has to be adept at using such technologies.
- There exists a skill gap in technicians that are trained to handle data from SM technologies, to reduce this gap, educators of technical and advanced manufacturing programs will be trained on smart manufacturing technologies.
- An online knowledgebase is currently under development to link applications of smart manufacturing technologies to technical education in academic institutions.

References

1. "China Solidifies Its Position as the World's Largest Manufacturer," Manufacturers Alliance for Productivity and Innovation (MAPI), Arlington, VA, 2015.
2. M. Rüßmann, M. Lorenz, P. Gerbert, M. Waldner, J. Justus, P. Engel and M. Harnisch, "Industry 4.0: The Future of Productivity and Growth in Manufacturing Industries," Boston Consulting Group, 2015.
3. S. Erol, A. Schumacher and W. Sihn, "Strategic guidance towards Industry 4.0 – a three-stage process model," in International Conference on Competitive Manufacturing, Stellenbosch, South Africa, 2016.
4. "Digitale Wirtschaft und Gesellschaft," Federal Ministry of Education and Research-Germany, [Online]. Available: https://www.bmbf.de/de/zukunftsprojekt-industrie-4-0-848.html. [Accessed 17 August 2017].
5. B. Kennell, "Smart Manufacturing: A Path to Profitable Growth," 2015. [Online]. Available: http://www.huffingtonpost.com/brian-kennell/smart-manufacturing-a-pat_b_7314828.html.
6. N. Malik and J. A, "US expects energy savings through smart manufacturing," MRS Bulletin- Warrendale 41.1, pp. 10-11, January 2016.
7. K. Jung, K. Morris, K. W. Lyons, S. Leong and H. Cho, "Mapping Strategic Goals and Operational Performance Metrics for Smart Manufacturing Systems," Procedia Computer Science, vol. 44, pp. 184-193, 2015.
8. J. Shaheen, " Shaheen Introduces Bill to Enhance Innovation, Energy Efficiency and Economic Competitiveness of Nation's Manufacturers," U.S. Senator, 22 April 2015. [Online]. Available: https://www.shaheen.senate.gov/news/press/shaheen-introduces-bill-to-enhance-innovation-energy-efficiency-and-economic-competitiveness-of-nations-manufacturers. [Accessed June 2017].
9. United States Department of Energy, "Industrial Assessment Centers (IACs)," 2016. [Online]. Available: https://energy.gov/eere/amo/industrial-assessment-centers-iacs. [Accessed 12 June 2017].
10. "Smart Manufacturing Operations Planning and Control Program," National Institute of Standards and Technology: https://www.nist.gov/sites/default/files/documents/2017/05/09/FY2014_SMOPAC_ProgramPlan.pdf [Accessed 16 6 2017].
11. J. Davis and D. Swink, "Smart Manufacturing as a Real-Time Networked Enterprise and a Market-Driven Innovation Platform," Smart Manufacturing Leadership Coalition.
12. "Growing the Impact Economy in Greater Philadelphia," The Economy League, Philadelphia, PA, 2016.
13. C. Giffi, B. Dollar, M. Drew, J. McNelly, G. Carrick and B. Gangula, "The Skills Gap in U.S. Manufacturing 2015 and Beyond," Deloitte Development LLC , 2015.
14. A. Desai, "Economy League's 2014 World Class Summit: Tracking Philadelphia's Progress on Growth and Opportunity," Global Philadelphia Association, Philadelphia, PA, 2014.
15. H. S. Kang, J. Y. Lee, S. Choi, H. Kim, J. H. Park, J. Y. Son, B. H. Kim and S. D. Noh, "Smart Manufacturing: Past Research, Present Findings, and Future Directions," INTERNATIONAL JOURNAL OF PRECISION ENGINEERING AND MANUFACTURING-GREEN TECHNOLOGY, vol. 3, pp. 111-128, 2016.
16. "Internet of Things Global Standards Initiative," [Online]. Available: http://www.itu.int/en/ITU-T/gsi/iot/Pages/default.aspx. [Accessed 16 6 2017].
17. "Sustainable Manufacturing," United States Environmental Protection Agency, [Online]. Available: https://www.epa.gov/sustainability/sustainable-manufacturing. [Accessed 17 June 2017].
18. M. Attaran, "Additive Manufacturing: The Most Promising Technology to Alter the Supply Chain and Logistics," Journal of Service Science and Management, vol. 10, pp. 189-205, 2017.
19. R. Liu, Z. Wang, T. Sparks, F. Liou and J. Newkirk, "Aerospace Applications of Laser Additive Manufacturing," in Laser Additive Manufacturing: Materials, Design, Technologies, and Applications, WoodHead Publishing-Elsevier, 2016, pp. 351-353.
20. J. D. Strickland, "Applications of Additive Manufacturing in the Marine Industry," in Proceedings of PRADS2016, Copenhagen, Denmark, 2016.
21. T. Kellner, "GE, CFM Expect $15 Billion In New Business In Paris; New LEAP Engines Are Giving A Lift To The Aviation Industry," General Electric, 2017.
22. A. Kusiak, "Smart manufacturing must embrace big data," Nature, vol. 544, no. 7648, 2017.
23. M. Berggren, D. Nilsson and N. D. Robinson, "Organic materials for printed electronics," Nature Materials, vol. 6, pp. 3-5, 2007.