A Call for Artificial Intelligence Tools to Support Manufacturing Innovation

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(Based on an ICTAI 2013 Keynote Address)

We are in the midst of a renewed interest in manufacturing. Developed economies in the West are increasingly concerned about the decline in manufacturing in their countries, and have linked that decline to high unemployment and low economic growth. In simple terms, they have come to the realization that they have to make things to make it in the 21st century. They also realize that old forms of manufacturing are not coming back to their rescue. So they are turning to manufacturing innovation to bring new ways of making things to their shores. They sense that recent advances in information, communication, and network technologies may provide a vigorous platform to launch such innovation in manufacturing. There is considerable evidence that this may indeed be possible.

A new era in manufacturing

In April 2012, the Economist magazine proclaimed that the Third Industrial Revolution is well underway in the guise of digitization of manufacturing. By their count, the first industrial revolution began in Britain in the late 18th century, with the mechanization of the textile industry. The second industrial revolution came in the early 20th century, when Henry Ford mastered the moving assembly line and ushered in the age of mass production. In the third industrial revolution currently under way, manufacturing is going digital.

A year later, using a slightly different epoch counting scheme, the German manufacturing industry came up with the moniker Industrie 4.0 to name the current era in manufacturing. By its count, the first three industrial revolutions came about as a result of mechanization, electricity, and information technology. Now, the introduction of Internet of Things and Services into the manufacturing environment is ushering in a fourth industrial revolution called 'Industrie 4.0.' The German manufacturing industry predicts that in the future, businesses will establish global networks that incorporate their machinery, warehousing systems, and production facilities in the shape of Cyber-Physical Systems (CPS).

Whatever counting scheme we may choose to use, it is clear that a new manufacturing era is upon us and it is driven by information – a lot of information, more popularly known nowadays as 'big data.' In an opinion piece in a recent special issue of the Economist, the chief executive of IBM argued that data is the natural resource for the 21st century – just as steam power was for the 18th, electricity for the 19th, and hydrocarbons for the 20th. She predicted that a new model of the firm will rise in 2014 using data as the natural resource, and called it the 'smarter enterprise.' One may surmise that smart factories, and indeed smart manufacturing, will be driven by this new natural resource.

Public investment in manufacturing innovation

While the private sector is preparing itself to profit from new opportunities in the new manufacturing era, many countries are investing in public-private partnerships to accelerate manufacturing innovation and get ahead in the new game. The United Kingdom has set up a

string of Centres for Innovative Manufacturing, which number about 16 by last count and are growing. They range from Additive Manufacturing to Ultra Precision. The German government, manufacturing industry, and academia are teaming up under the 'Industrie 4.0' umbrella and are investing to preserve their manufacturing leadership. Several Fraunhofer Institutes have successfully demonstrated the German model of public-private partnership to bring scientific ideas to industrial practice.

Since 2012, the United States of America has embarked on a major investment in a national network for manufacturing innovation, starting with a National Additive Manufacturing Institute. More such institutes are expected to join the national network soon. Several national research laboratories, including the National Institute of Standards and Technology (NIST), are investing in manufacturing-related research and development projects. In particular, NIST is investing in Smart Manufacturing, which is characterized by a heavy use of information, communication, and network technologies as befitting the needs of the new manufacturing era.

Artificial Intelligence tools for manufacturing innovation

So it is quite natural to ask what Artificial Intelligence (AI) tools can do to support manufacturing innovation. This question was raised and discussed during a keynote address at the 2013 International Conference on Tools with Artificial Intelligence (ICTAI). It started with the basic premise that several AI tools have shown their usefulness in various application areas, as chronicled in the proceedings of ICTAI meetings and AI journals. Manufacturing innovation should be one such application area, because the new era of manufacturing is driven by the type of information, communication, and network technologies that are all too familiar to the AI tools community. With this in mind, a two-step strategy was proposed in the keynote address to engage the AI tools community:

(1) *Apply and adapt existing AI tools*. It is time to take an inventory of current AI tools and their capabilities, with an eye towards applications in manufacturing. The time is ripe because many countries are investing in manufacturing innovation, as outlined above, and the AI tools community can team up with manufacturing innovation institutes and other laboratories (e.g., NIST) on specific projects. Applying and adapting existing AI tools will help accelerate manufacturing innovation, and bring these two research communities together.

(2) *Develop new AI tools to meet special manufacturing needs*. It is very likely that manufacturing may pose new challenges that require new AI tools to be developed. A workshop, under the sponsorship of the likes of the U.S. National Science Foundation, may be required to identify research opportunities and challenges for AI tools to support manufacturing innovation. In addition, it will be useful to organize special tracks in future ICTAI and other AI meetings to address manufacturing innovation.

In a discussion that followed this proposal in the keynote address, one topic emerged as a potentially fertile field for AI tools. Manufacturing is full of heuristics to guide engineers and managers through various best practices, planning and re-planning, failure modes and diagnostics, common sense rules, and empirical/experimental data. AI tools may provide a better intellectual means to organize, analyze, and apply such heuristics. There are bound to be other such applications, and methodologies beyond heuristics, that will be mutually beneficial to the manufacturing and AI tools communities. It is time to seize this opportunity.