The Future of the Manufacturing Industry

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IMPORTANCE OF STANDARDIZATION

Advanced technologies in various fields have had a significant impact on society. However, since they interact with each other, it is becoming increasingly difficult for even experts in each field to accurately assess the effects. A major challenge for society is how to utilize the benefits of technologies to improve the quality of life (QoL) on a global scale while minimizing the negative effects.

To overcome this challenge, it is necessary to visualize the significance and content of knowledge about advanced technologies, which has been subdivided into various fields among which the relationships are becoming harder to understand. It is also necessary to reach a consensus on a future vision for society that is supported by science and technology. Standardization will play a crucial role in such efforts, which broadly means accumulating and systematizing common basic knowledge, and enabling it to be used efficiently.

CHALLENGES FOR SOCIETY IN THE FUTURE

The most urgent and vital issue for society is how to restore and maintain global sustainability. Recent growth in population, human activities, and industrialization has caused global warming, as well as problems such as resource depletion and environmental pollution. Since these problems are complex and interrelated, it is not easy to identify the causes of damage to sustainability and devise solutions. According to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) published in 2021, "it is unequivocal that human influence has warmed the atmosphere, ocean and land," and "limiting human-induced global warming to a specific level requires limiting cumulative CO_2 emissions, reaching at least net zero CO_2 emissions, along with strong reductions in other greenhouse gas emissions."[1] This report is based on solid academic findings, but its scope is so vast and complex that it is difficult for non-specialists to understand accurately. This example demonstrates how specialized academic knowledge is essential for clarifying social issues but is not readily accepted by the public.

As science and technology develop, modern society is underpinned by elaborate networks of activities. Physical resources, human resources, and product markets are ubiquitous but not evenly distributed, so the networks cannot be self-contained in a small area and must inevitably become global and transnational. However, these networks are vulnerable to changes and abnormal situations caused by the excessive pursuit of efficiency and optimization assuming a peaceful world. These vulnerabilities have been exposed in recent years by various incidents such as extreme weather caused by global warming, major earthquakes, infectious diseases, international terrorism, and battles for hegemony among nations. Under these difficult circumstances, resilience is increasingly important to respond flexibly to changes and abnormal situations. To ensure this flexibility, networks must be constructed based on open and systematized knowledge.

How should humans live in a society with advanced science and technology? Human-machine symbiosis is crucial, particularly in terms of employment. When technologies are introduced based on cost as a priority, only low value-added monotonous jobs are left to people; jobs that require high-level skills and creativity still exist but are extremely rare. We should not leave technologies to progress freely; we need to design a society that proactively takes advantage of the diversity of people with various knowledge and capabilities.

IMPROVEMENT OF RESOURCE PRODUCTIVITY

Global sustainability is a basic requirement for society in the future. Focusing on this goal leads to conserving energy and other resources and reducing environmental pollution, and so is economically rational in the long run. In some situations, however, measures that go against global sustainability may be needed because it is necessary not only to pursue economic rationality but also to design social activities based on new perspectives in order to secure resilience and human-machine symbiosis. To allow such exceptional measures to be taken, we must pursue global sustainability in most situations. We should consider how to improve resource productivity: the ratio of the value added by activities to the resources that are input (energy, materials, human resources, and so on).

Japan has been working on conserving energy and reducing waste for many years to improve global sustainability

and has achieved solid results. For example, the primary energy consumption per unit real GDP has decreased by 25% in the last 20 years. Real GDP increased by about 15% in the same period while the amount of final waste decreased by 80%. There seems little room for further improvement in the industrial sector.

But we should pursue the ideal state of how things should be; when we analyze industrial activities from this perspective and reconstruct them, we will realize that many resources are still being wasted. For example:

- Unnecessary activities are carried out.
- Appropriate resources are not properly allocated.
- Resources are unnecessarily held or moved.
- Resources are unnecessarily discarded.

There are various causes of such waste. Most people do not think their own activities are wasteful because that is what they have always done naturally. This situation can be improved by creating a system that explicitly describes activities and needed resources as knowledge and allows it to be combined flexibly depending on each objective. With this approach, we can share knowledge across domains rather than individual limited domains and can rationalize activities beyond the boundaries of the original domain. For this system, standardization is crucial.

In addition to improving global sustainability, such a system can secure resilience and human-machine symbiosis, enabling appropriate activities to be planned.

DIGITALIZATION AND STANDARDIZATION IN THE MANUFACTURING INDUSTRY

In response to the challenges described in the second section, knowledge about manufacturing and needed resources has been articulated in the manufacturing industry, as described in the previous section. Since technological operations in the manufacturing industry are complex, modeling is particularly important to capture their meaning. Digitalization and standardization are being promoted based on this modeling.

How to model manufacturing activities and needed resources and how to represent their knowledge are interesting issues from the viewpoint of design/production engineering and information science. In addition to basic research, such as model-based engineering, practical CAD systems and production systems have been constructed. Since around 2010, work on system integration, representation of resource data, and their standardization has picked up again. According to their national circumstances, European countries, the U.S., China, Japan, and other countries are developing various technologies, including Germany's Industrie 4.0.

The manufacturing industry spans diverse sectors such as automobiles, aerospace, industrial machinery, precision machinery, information machinery, and electronic equipment. Although each sector has its own specific, sophisticated models, few of them are based on generic knowledge representation. Today, common knowledge representation and models are strongly needed because many of the latest products and services use functions from different sectors and industries.

It is difficult to standardize advanced technology since companies continue to improve their technology to stay competitive. However, it is possible to standardize basic technical knowledge, product representation, interfaces among technical knowledge modules, and product data representation. We need to identify where companies can cooperate and then focus standardization efforts on these areas.

A standard dictionary is also being developed beyond particular sectors and industries to help manufacturers provide services in cooperation not only with other sectors in the manufacturing industry but also with other industries.

Product model data and parts libraries have been accumulated in a systematic approach notably in the aerospace and automotive industries. Under the term "digital twin," the data-driven concept has also been widely accepted. This concept aims to create new value by linking products and the data of lifecycles and services, independent of the applications of each product. Cross-sectoral and cross-regional data infrastructures have also been constructed.

FUTURE OF THE MANUFACTURING INDUSTRY

Through products, people enjoy services from various industries such as communications, transportation, distribution, medical care, welfare, food, agriculture, and housing and urban development. The manufacturing industry provides these industries with products, their functions, and information.

Although the key role of the manufacturing industry is to provide products, it is expected to transform into a social infrastructure industry, which collaborates with other industries and provides the necessary information for their services. Factories may be integrated with urban functions and play a role in energy management and resource recycling.

Meanwhile, the cyber-physical system (CPS) is attracting attention. This is a new society in which the cyber world and the physical world dynamically collaborate to cope with innovative social demands. In Japan, various research and development projects on the CPS are in progress under the banner of Society 5.0.

Information about products and their functions is the core element of the CPS. The manufacturing industry, which is transforming its focus from industry to social infrastructure, will also support the CPS. In this transformation, digitalization and standardization described in the previous section will play a crucial role.

To make services available across the world, it is essential to globally standardize the social infrastructure environment. Such international cooperation is mandatory for both companies and countries, enabling them to compete by leveraging their unique knowledge and assets.

In terms of technology or scale, it is not practical for individual companies and organizations to build this mechanism. Standardization will help build a system that is highly flexible, increases the productivity of global resources, and can respond to the diversity of people.

REFERENCES

(1) Headline Statements from the Summary for Policymakers, Sixth Assessment Report: Working Group 1 The Physical Science Basis, Intergovernmental Panel on Climate Change, 9 August 2021