Preface

Today's Major Challenges and Solutions

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Global warming and an aging population with a declining birth rate are serious problems of our modern society that require multiple measures. The former has a global and longitudinal impact, while the latter manifests itself mainly in developed countries.

Global warming is caused by the emissions of greenhouse gases largely attributed to industrial activities. This point has been almost conclusively established from a scientific point of view. There are broadly two types of countermeasures: the reduction of carbon emissions and storage of greenhouse gases (carbon fixation). These require a diversity of technologies and policies. The sooner the measures to reduce greenhouse gas emissions are implemented, the greater are their effects. These are urgent tasks because the efforts to be made in the coming 20 to 30 years would be crucial for the future. In terms of energy supplies, possible solutions include the use of nuclear power as a base load power source and introduction of combined cycle generation for enhanced thermal efficiency, dispersed generation such as cogeneration and renewable energy such as photovoltaic and wind power generation. To think of the energy demand side, measures include promotion of electrification such as motorization of industrial power sources and conversion to electric vehicles, increase of inverter-fed motor ratio, introduction of heat pumps and induction heating technology, and enhancement of motor and converter efficiency. In particular, motors account for more than 50% of total power consumption. Considering that inverters are not well diffused either in industrial or consumer use, the conversion is expected to have a significant effect.

The problem of the declining birthrate and aging population first became problematic in Japan. It has an aspect of increasing the burden for social security as the elderly population grows, on the one hand, and diminishing labor power as the working-age population decreases, on the other. To address the social security burden, possible solutions include the development and diffusion of devices and equipment that support the elderly's independent daily life and reduce the load borne by personnel engaged in medical care and in long-term care. The diminishing labor power may be countered by wide application of automation technology to improve labor productivity.

In process manufacturing, proportional integral (PI) controllers became available in the 1930s and developed to process automation (PA) thereafter. At around the same time, classic control theory was further advanced to give rise to modern control theory during the 1960s. In the following decade, distributed control systems (DCSs) started a trend for conversion from analog to digital instrumentation. In discrete manufacturing, meanwhile, the 1960s saw the rise of NC machine tools and industrial robots, prompting the development of factory automation (FA). This further developed into design and manufacturing, incorporating computer-aided design and computer-aided manufacturing (CAD/CAM) during the 1980s, and simulation technology started to emerge based on computer-aided engineering (CAE). These were all formed into computer-integrated manufacturing (CIM). In the 1970s, programmable logic controllers (PLCs) were developed to replace relay circuits, growing into key controllers for FA, which became connectible to industrial networks in the 1990s, realizing the capability to connect to supervisory control and data acquisition (SCADA) systems for supervisory control. SCADA made integrative management possible, at least theoretically, by connecting to manufacturing execution systems (MESs) for execution and planning systems such as supply chain planning (SCP) and enterprise resource planning (ERP). The challenge to overcome when forming such systems is the connectivity between devices and software provided by different vendors. Industrie 4.0, announced in 2011, pursues standardization to address the issue of connectivity as part of its objectives. Automation technology is extending its scope of application beyond manufacturing today; we see large-scale automation systems being introduced in logistics, pharmacy and dairy farming outside Japan.

Automation technology was initially adopted to reduce production costs, increase production and economize on human labor, but it has also brought about enhanced accuracy and flexibility in manufacturing. While the labor population in production lines has decreased by 20% for the last two decades, there has been approximately a 30% increase of specialists and engineering experts. One of the reasons behind these changes is considered to be the increasing demand for engineering and system integration for automation system installation.

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To increase the level of overall productivity, it is crucial that these tasks are made more efficient and less labor-intensive. There is a growing interest in machine learning technology such as deep learning, but its application is still limited for the time being. Vertical start-up and high availability are important factors to be ascertained in introducing an automation system, where excessive customization may only slow down the processes. Similarly, introducing it to small- and medium-sized enterprises may present major challenges. Today, engineers are in short supply, and turning their skills into automated systems is necessary, but the automation cannot move forward without a breakthrough in technological advancement. Here, haptic technology, into which research is fast advancing, may offer a solution among others.

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