Expectations of New Technologies for Instrumentation and Control Engineering

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In the fields of instrumentation and control, the trends toward more advanced and diverse technology have progressed dramatically with the development of peripheral technologies for communications, information processing, semiconductors, and so on. In the instrumentation field, applications of sophisticated electronic instrumentation technology have advanced, and the objects to be measured are also becoming more diverse with measurements in the life science field, measurements of the environment, measurements of human sensations and behavior, etc. Moreover, in the control field, there is increasing demand for control technology for high-speed and high-precision temperature control and positioning control, and the like, at manufacturing sites, and in consideration of safety and energy savings, the requested control technology is also becoming more diverse. Additionally, regarding the underlying control theory that supports control technology, control systems are evolving from conventional techniques, such as optimal control, robust control and adaptive control, to such techniques as hybrid control, quantization control, formation control, and so on, that expand the range of applications. In recent years, environmental and energy related applications such as smart grids have also been pursued actively.

In this paper, from among the instrumentation and control engineering topics exhibiting such various developments, I want to describe the topics that I myself am watching. In recent years, there has been interest in big data science that effectively uses large amounts of data sent over the Internet, and in the control and instrumentation fields as well, research into data driven control that directly utilizes data that has been accumulated in manufacturing processes has attracted attention as a recent new trend. In contrast to the research for convention control system design, which is separated into a phase for identifying a system model using data obtained from a real system and a phase for designing the control system using the system model, the data-driven controller design approach aims to utilize directly the data obtained from the real system for control system design. From the perspective of a user of control technology, the performance of the controlled system is diagnosed using observed data, and the effect of the developed control technology is evaluated according to data obtained as the result of the application of the control. In other words, from the diagnosis of the control performance until the evaluation of the control results, the data obtained from the control system provides the information for making a determination, and therefore an approach focused on data is appropriate for the onsite needs. Moreover, data processing technology is common to engineering in general, and the intensive utilization of and fusion with information and communication technology (ICT), which has exhibited remarkable development in recent years, is also anticipated. Analysis and design based on mathematical models and physical models is, without a doubt, important and necessary, but technology focused on data to be handled directly by the user ought to be watched as a technology that will expand in the future.

The development of virtual instrumentation technology, such as software sensors and virtual metrology, is also worthy of attention as a technology related to both the instrumentation and control fields. The objective of this technology is to estimate variables that cannot be measured in real-time from variables that can be measured online, and practical applications are being advanced in various fields such as petrochemicals, steel, semiconductor manufacturing, pharmaceuticals, and so forth. To accomplish this objective, a model that provides a quantitative relationship between variables that are measurable online and estimated variables is needed. This model may be based on physical and chemical laws, or may be a statistical model derived from measured data. The latter is positioned as a data-based measuring technique since, as with the data-driven control introduced above, data accumulated during the manufacturing process can be used directly. Additionally, virtual instrumentation technology is also considered to be a technology related to estimation and prediction based on dynamic simulation, and it is thought that virtual instrumentation technology will play an important role in relation to state estimation theory, typified by Kalman filters, and to computer simulations of large-scale systems.

Lastly, I want to discuss technology that improves the stability of processes. At chemical plants and the

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like, the plant is maintained in an appropriate state and the operating safety is ensured based on instrumentation and control technology, but in cases where the plant state can no longer be maintained at an appropriate level, an alarm is issued and the operator is requested to take action. If the alarm setting is not suitable, however, the alarm will be generated frequently, and the operator can no longer be expected to appropriate action. For this reason, an approach to alarm management that aims to operate the alarm appropriately and to maximally leverage the excellent response capability of the human operator is important. In this approach, in addition to instrumentation and control engineering, the excellent human properties of resourcefulness and flexibility are utilized with an aim to realize a resilient system. While instrumentation and control engineering are expected to continue to evolve in the future without slowing down, how human elements can be incorporated therein has become even more an important theme. We look forward to new ideas and concepts for the theme as future technology.

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