HKIE CAD 18/19 Annual Symposium

Keynote Speech by Ir Alfred Sit JP, Director of Electrical & Mechanical Services

"Innovation and New Momentum in Control, Automation & Instrumentation"

Alain, C.S., distinguished speakers, ladies and gentlemen, good morning.

Yesterday was the Lantern Festival (元宵節) of the Year of the Pig, the Chinese equivalent of Valentine's Day. In the old days, under the first full Moon of the lunar year, young people flocked to the streets hoping to meet their loves. Woe was the cowherd (牛郎), who had to wait until the 7th day of the 7th lunar month, when a flock of magpies would form a bird's bridge (鵲橋), across the Milky Way to reunite him with his lover, the weaver girl (織女). It is sad that the bird's bridge is assembled only once a year, and disbanded the day after.

With the China's Chang'e 4 (嫦娥四號) spacecraft exploration, it is never the same now. Niulang the cowherd has the gift from China that outdoes the once-in-a-year bridge. The bird's bridge is up in the sky all year round. It is in fact the communication relay satellite of Chang'e 4. On 3rd January this year, Chang'e 4's robotic lander Yutu 2 (玉兔二號) successfully landed on the Moon. Unlike all lunar landings attempted before, which were all on the Moon's Earth-facing side and therefore within the direct radio communication of earthbound controllers, Yutu 2 landed on the far side of the Moon, a first for any country. While no direct radio communication can be maintained with the Earth, communication is possible through the bird's bridge, the pre-positioned relay satellite.

This is an engineering marvel for us to admire and celebrate. Chang'e 4 is an engineering milestone on the advancement of space science. Some say this is the culmination of years of space technological advancement since the Sputnik, when the former Soviet Union put the first man-made object into space in 1957, and thence began the mankind's space age. I would rather attribute its achievement to the control engineering, without which the feat of high precision soft landing on a very remote place with no direct communication link would not have been possible.

There is a rich record of what we would describe as control, automation and instrumentation, or CAI, in the modern sense. This is a history of science, technology and innovation for the purpose of improving the productivity and quality of work, and to achieve an optimal outcome.

One of the first feedback control devices on record is the Ctesibius' water clock, in which water dripping at a constant rate raised a float that held a pointer to mark the passage of time. The clock was used in courts and kept more accurate time than any clock invented until the pendulum clock of the 17th century.

In the industrial revolution in the 1800s, with the coming of mechanization, there developed a need for basic control of everything industrial. However, to control something, you need to measure something. Instrumentation was thence developed for measurement. Instrumentation, together with feedback control mechanisms, drove the industrial revolution. The steam engine governor invented by James Watt could be considered one of the first closed-loop control system using instrumentation. Instrumentation then was largely based on mechanical sensors and gauge readouts.

The next phase of CAI development came with the advancement in electrical, electronic and communication technologies. Electrical and later electronic sensors became widely available. Process automation became possible with the development of data processing. Instrumentation at that time was still largely analogue, and communication was done through wired means. Control algorithms were rules-based.

Then came the age of digitization. Measured signals were digitized and thus could be easily and accurately transmitted, stored and processed. Adaptive control became available, but the process had still to be pre-programmed. The large amount of data stored could only be used for post-processing, rather than real time analysis and feedback due to limited data transfer speed and computer power.

How about "now"? The technologies we have for CAI applications include IoT for wireless data acquisition, 5G for fast data communication with minimal time lag, non-rule based artificial intelligence for control, and high speed real time computing and control using big data analytics for process improvement. The game-changers are evident: high computing power and fast communication speed, wired or wireless. These technologies help unbound the production processes and allow them to cater to fast changes in people's behavior and environment. Mass customization at mass production cost becomes possible.

In retrospection, we can see that every significant phase of CAI development was brought about by the innovative application of breakthrough technologies.

As illustration, I will talk about two cases of latest development related to CAI technology, without going into technical details.

The first case is about automation in the garment industry. For years, the automation of garment-making has vexed CAI professionals. Conventional robots excel at handling rigid objects, but not soft and flexible materials with a variety of weights and textures like garment fabric. Many processes in garment production like stitching sleeves and cuffs, or folding fabrics or smoothing cloths for stitching, are highly tactile jobs that require deft hands and keen eyes. These tasks have to be carried out by manual labour and mostly eluded automation, resulting in a tendency for garment factories to flock to low-labour-cost countries as soon as wages rise. The working conditions of these countries are often arduous. No wonder the term "sweatshop" has its origin in garment making.

Thanks to new development in CAI, especially in computer vision and manipulator powered by precise actuators, it is possible that the "sweatshops" can one day be consigned to history. As reported in the South China Morning Post last year, a Hong Kong garment company is actively researching on the use of advanced robotics to automate its garment production lines. One day, in the company's factories, alongside workers, robotic arms will swish, trimming collar bottoms and pressing plackets. Cameras adapted from military devices use artificial intelligence will scan for flaws in the fabric, automating the QC processes. This will enable the company to unchain itself from the "cheap labour" model, allowing it to produce clothing not only faster and cheaper but with greater customization to meet the fast-changing fashion cycle.

You may notice an uncanny parallel of it to what came before. In the late 18th century, when automated looms were introduced to the garment industry, productivity was vastly improved and business became more competitive. However, the parallel stops here. Instead of burning the automation machines as English textile workers in the 18th century did, workers in the said Hong Kong company help the firm's engineers design mechanisms to do the job better. This illustrates the human feedback loop on top of the machine control loops, with CAI professionals help deliver the automation, and users provide feedback to CAI professionals to improve the automation. This is a paradigm for continual improvement.

The next case is what we in EMSD are pursuing. As many of you know, air-conditioning plant is one of the most energy consuming systems in a building. Previously, conventional discussions on improving air-conditioning plant efficiencies nearly all envisioned the solution as being a simple case of improving the peak efficiency of individual components. However, the energy efficiency of an air-conditioning system is most effectively improved by optimizing the overall efficiency of the entire system, ranging from the chiller operation, distribution of chilled water to the operation of condenser system for best heat rejection in response to the constantly changing load demand.

Years ago, one of our energy saving project was in New Territories South Regional Police Headquarters that deployed the Hartman Loop Controllers to optimize the energy efficiency of the air-conditioning plant. The Hartman Loop is a rule-based control mechanism to optimize the utilization of all-variable speed chiller, chilled water and condensing water handling plants. The challenge of the Hartman Loop technologies is to see through an air-conditioning plant as an integrated system instead of as a group of individual components. We achieved a 3.5% reduction in the air-conditioning energy usage of the venue after installation of Hartman Loop controllers.

Recently, with the advance in technology and using artificial intelligence (AI) and machine deep learning, we can optimize chiller plant operation based on non-rule based machine learning of historical records, cooling demand patterns and with online feedback to and from the operators without modification of equipment. One example of our chiller optimization project is at the Central Mail Centre. The AI Solution identifies the energy-efficient operation point of chillers, cooling towers and water pumps, subject to pre-defined constraints and preference, to meet the constantly changing load demand, and gives recommendations to the operator on plant operation. We instantly achieved a 5% reduction in the air-conditioning energy usage of the venue after introduction of the AI algorithm without modification of equipment.

The beauty of this solution is that originally, the system follows a traditional fixed logic, rules-based air-conditioning plant control algorithm. Now it is AI-based with adaptive control algorithm. With more data, the system possesses potential to squeeze out more energy saving from the already large saving hitherto achieved.

We are now on the cusp of CAI development. The role and involvement of human beings in the control loop have evolved from being “in the control loop”, to “on top of the control loop”, and soon to be “out of the control loop”, i.e. a truly autonomous system, using artificial intelligence. We are creating the momentum poised to propel CAI into the next phase. Breakthrough technologies are the mass, their pace of development is the speed. In physics, momentum equals mass times velocity. With a larger mass of technologies including IoT, 5G, big data analytics, artificial intelligence and machine deep learning and a yet higher speed of technological development, momentum is gathering fast. Moreover, we are also benefiting from the biggest and best educated generations ever produced. With the participation of this large group of educated users, a yet larger mass and therefore a larger momentum can be created. Our period will surely be called by later generations to be a milestone in CAI development. Having said that, low-hanging fruit is all around us, and it behooves us to pick it, but in doing so we must also not lose sight of what lies ahead. We should keep ourselves abreast of the latest CAI technologies and equipped ourselves to forge ahead. Innovation thrives on communication, collaboration and exchange. In this respect, we as CAI professionals, together with the industry, trade, universities, research institutions and startups, should co-create, connect and collaborate for the next CAI generation.

Thank you.

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