SUNGKYUNKWAN UNIVERSITY

Challenge

Efforts to implement machine learning initiatives in industry have been undermined largely by organizations' failure to invest in the statistical aspects of artificial intelligence (AI) development. Students and other newcomers to smart manufacturing are limited primarily by their lack of knowledge around the data science behind the algorithms.

Advancing machine learning from theory to practice

SKKU's InfoScience Lab uses statistical methods in JMP® to craft tailor-made machine learning applications for industry clients, among them South Korea's leading steel manufacturer, POSCO

As companies and governments around the world up their financial stake in artificial intelligence (AI), the race is on to find new applications for the technology. Though financial trends may point to burgeoning interest, many organizations are still at the early stages of putting fully scaled AI systems into practice. Experts agree that the promise of AI has been tempered to some extent by a number of challenges – most notably a lack of understanding around statistical methods.

"Too many businesses have fantasies about AI," says Jong-Seok Lee, PhD, an expert in machine learning applications and professor at Sungkyunkwan University (SKKU) in Seoul. "It is regrettable that the importance of AI's foundation in data analysis seems to be so often overlooked."

Lee argues that the hype around AI has divorced even the most motivated practitioners from the reality of the statistics that drive it. With more focus on the underlying science, he says, organizations will be better positioned to tap the benefits of the technology. He says machine learning – a subset of AI focused on creating algorithms that can teach computer systems to "learn" – has transformative potential in a landscape where modern manufacturers need to automate to remain competitive.

South Korea, with its robust semiconductor, automotive and electronics sectors, is particularly well positioned to become a global leader in AI and machine learning. In the past five years alone, the Korean government has earmarked substantial funds for technology development, and the country's leading corporations – Samsung, LG and Hyundai – have all set aggressive goals for building out their AI operations ecosystems.

SKKU, where Lee now heads the InfoScience Lab, is becoming a visible player in the advancement of AI technologies and their applications. Located in the heart of central Seoul, SKKU has a long and storied history, beginning with its 14th century founding at the start of the Joseon Dynasty. Over more than 600 years, the institution has produced both influential graduates and high-impact scientific research.

SKKU now operates in close partnership with Samsung – a collaboration that produces top-level industry-ready graduates year after year. The proximity of industry partners at SKKU has also served to promote statistical research and learning – skills that Samsung, a leader in both the software and hardware of AI systems, values highly.

Advancements in AI require researchers to first go back to the basics

SKKU's InfoScience Lab capitalizes on the university's groundbreaking relationship with industry by engaging students in study programs, research and consulting projects that address real-world business problems at the intersection of data mining, business analytics and operations research. But driving these exciting applications, Lee explains, is their real focus: going back to AI's roots in statistics.

"We need to understand exactly what our data means, so we can select and apply the appropriate algorithms. I think people will come back to basics when the current hype around machine learning passes," he says, explaining that people are getting ahead of themselves thinking about the big picture of AI without the methodological foundation to back it up.

Lee, himself an expert in data mining and methods for machine learning, has guided the research group as they work to help organizations commit to more evidence-based decision making. For example, he says, he and his team are developing an algorithm that intelligently determines the process commonly referred to as "manufacturing AI" to implement optimal operations. This application aims to solve the long-standing problem of imbalanced data classification, which is used in manufacturing to identify defects.

Recently, Lee has also become interested in transfer learning, a problem within the field of machine learning that aims to store the insight gained from solving one problem and apply it to a different system. With origins in image recognition, the most common industrial application for transfer knowledge today is in preventive maintenance; machine learning models created before factory maintenance is performed can be updated to reflect maintenance almost immediately, Lee explains.

Understanding a project's potential industrial application is key to prioritizing where Lee and his lab spend their energy. And many projects come to them directly from industry. "My aim is to help students learn as much as possible from what I have experienced at corporate project sites," he says.

One of the tools Lee and his students rely on most is JMP statistical discovery software, a package also used by many industry leaders. Not only does JMP help students learn statistics, it enables them to easily explore industrial data sets and practice building models. Interactive data visualization makes identifying data characteristics fast and easy; customizable scripting allows more advanced users to automate repetitive tasks and cut back on analysis time.

"I was very surprised when I first saw the column property function of a data table in JMP," Lee says. "It was so innovative. The interaction between graph and data selection is also a differentiating factor."

A machine learning application saves steel manufacturer POSCO hundreds of thousands of dollars per line annually

One of Lee's most visible recent successes was with POSCO International, a steel manufacturer headquartered in Pohang, South Korea. The world's fourth-largest steelmaker by tons

of crude, POSCO embraced smart manufacturing early on and has invested heavily in AI systems. Part of that investment went to bringing on statistical experts like Lee, whose ground-breaking work contributed to POSCO's recognition by the World Economic Forum in 2019 as a "lighthouse" manufacturing company.

With POSCO facing a process control issue related to its steel plating facilities, Lee was brought on to develop a machine learning application that could solve the problem in perpetuity. POSCO's plating process involves the spraying of highly pressurized air – a so-called "air knife" – on steel plates to meet the target volume. This process involves controls on both the air pressure and distance between the air knife and plating surface. While the control of the air flow is performed directly above the plating bath however, the gauge measuring plating volume is located about 200 meters away. This differential causes a time lag in measurement, and an opportunity space for machine learning prediction.

"Our task was to calculate appropriate air flow conditions based on a number of variables such as line speed before a plate moves the 200 meters to the gauge," Lee explains. "It was a matter of preemptive corrective action, not feedback, to achieve the quality characteristics in a continuous process running 24 hours a day."

Process control itself began as a feedback method to correct mistakes found during standard monitoring processes, and machine learning is the next logical step. "Machine learning is all about predicting the future based on learning from past data," Lee says. So before digging into the machine learning applications, the SKKU team's first step was to explore the plant's historical data in search of trends and other information.

"We always use JMP for exploratory data analysis," Lee explains. "JMP is fast and convenient when it comes to checking distributions, identifying relevance using Scatter Plot Matrices and checking for outliers. Not to mention, we can do all of this without having to do any coding."

After mining the existing data for insights, Lee and his team created an algorithm to run response surface optimization in real time. The algorithm utilizes process data to learn the relationship between control factors and plating volume with a neural network in JMP. It defines and minimizes a loss function between the learned plating prediction model and the target and calculates air knife pressure and measurement gap in real time.

"With JMP, we were able to quickly find and judge a highly predictive model. We used the Desirability feature of the Profiler, and we also had the advantage of communicating and setting directions quickly with our customers based on the results we got from those models," Lee says.

By reducing deviation in the plating system and creating more accurate controls, the team enabled the facility to operate more closely to its target, thereby dramatically reducing the amount of zinc being scrapped. The ultimate outcome of this project, Lee says, was hundreds of millions of Korean Won (hundreds of thousands of US dollars) in annual savings per line for POSCO.

The path to AI implementation begins with a culture of analytics

Machine learning implementation at POSCO would not have been possible had the team not started with the data, Lee says. It was only through exploratory analysis that they were able to devise the best algorithm. But POSCO is very much a trailblazer – implementing specific AI applications when other companies are still dreaming big but falling short.

"POSCO is a few years ahead of other companies in many ways," Lee says. "The biggest advantage is that ownership of data is concentrated in a single dedicated organization. In other companies, data is usually scattered around in different departments, making it too difficult or too complicated to get the data they need."

POSCO has largely avoided the pitfalls of data siloing by creating a very sophisticated data ecosystem. Lee explains that the key is integration: data collection and management are directly linked with communications, alerts and sensing technology. Perhaps most importantly, leadership at POSCO has worked hard to promote statistics, bringing field managers on board with a united culture of analytics. This ethos, and the digital architecture that came with it, is what Lee says made his job easy.

And JMP was there to help. "JMP dramatically reduced working hours," he says. "If I had used R, it would have taken me about a month to complete the work, but with JMP, it was done within a week."

Lee has also used JMP Scripting Language (JSL) to cut analysis time. Citing a project analyzing automotive parts repair data, he adds: "JSL was useful for pulling in some custom functions that were not available in the standard JMP UI at that time. Also the map function made it easier to identify trends according to the environment by visualizing repair data on Korean and world maps."

SKKU's university-to-industry pipeline produces a generation of talented graduates ready to tackle the challenges of AI

Globalization has brought with it new challenges, and as manufacturers have expanded factories overseas to be closer to their customers' factories, the need for analytics integration is growing fast. "One of the important challenges we now face is how to overcome [the gap in workers' statistical proficiency]," Lee says.

With its focus not just on theory but on industrial applications, SKKU is producing a new generation of graduates ready to meet the challenges of smart manufacturing head-on. Their fluency with the statistical models that guide AI systems will make them attractive new hires in any industry, Lee adds; this next wave of talent is set to soon make the promise of AI a reality.

Solution

Faculty and students at Sungkyunkwan University use JMP, a leading industry software, to study statistical methodologies that, when applied to industry challenges, lead to successful machine learning implementation. With its user-friendly interface, JMP encourages data mining and data exploration, and promotes collaboration with the university's corporate partners and clients.

Results

A team from the SKKU InfoScience Lab deploys machine learning applications in JMP to achieve substantial cost and time savings on behalf of industry clients. In one case, the team's efforts saved preeminent Korean steel manufacturer POSCO hundreds of thousands of dollars per line in annual savings. By using JMP as an alternative to coding-intensive R or Python, Professor Jong-Seok Lee says the team accomplished in one week what would have otherwise taken one month to complete.