The use of AI and machine learning in process plant operation and control

1. Executive Summary

Top level briefing/orientation text.

- There is a need for more practical and applied research (and research funding) on machine learning and artificial intelligence to support the effective adoption of these technologies by industry in the UK.
    - ***The government should emphasise practical and applied research funding and for the research funding bodies such as EPSRC to do the same***
- There is currently no regulatory framework in the UK for the safe use of AI and machine learning in process control.
    - ***The government should explore the prospects for regulation in this area, or support the collating and dissemination of good practice as it emerges and develops.***
- There is a present and growing need for people trained in process control, artificial intelligence and machine learning.
    - ***The government needs to prioritise education and (re)training opportunities for people to get into chemical and process engineering to ensure an adequate workforce. As part of this the government should commit to supporting science teachers in schools and research funding.***
- AI and machine learning technology relies on a small number of tech companies. This represents a significant source of vulnerability.
    - ***The government should consider the dependence on AI and machine learning technology as part of its wider assessments of strategic infrastructure.***

2. Introduction and background

Artificial intelligence (AI) and machine learning (ML) are some of the most significant technological developments of recent years and are having a profound impact on the economy and daily life. Policy thinking in the UK regarding artificial intelligence and machine learning has tended to focus on issues such as regulation,[1] its implications for the workforce,[2] and ethical standards for its use,[3]and not focused on what they have to offer to plant operation and control.

[1] https://post.parliament.uk/artificial-intelligence-ethics-governance-and-regulation/
[2] https://www.gov.uk/government/publications/the-potential-impact-of-ai-on-uk-employment-and-the-demand-for-skills
[3] https://commonslibrary.parliament.uk/research-briefings/cbp-10003/

In October 2024, IChemE hosted a roundtable which looked at how artificial intelligence and machine learning are currently being applied in plant operation and control, along with the barriers, risks and opportunities associated with their greater use. It also considered the technologies in the context of the new UK government and its five missions, in particular the mission to kickstart economic growth and the mission to make Britain a clean energy superpower (and associated ambitions on zero-carbon electricity by 2030 and net zero.)

This document summarises main themes from the discussion as well as offering several key conclusions and recommendations.

3. Emerging themes

3.1. AI and machine learning are being widely used for the monitoring and design of processes not just process control

Attendees noted that AI and machine learning are seeing widespread use in the design of chemical plants and processes, associated component, and to monitor processes and to provide early detection of potential issues. In subsequent correspondence, a participant noted that Model Predictive Control was an early and important machine learning success in the process industries. At present, it is much less common to see AI having executive control or autonomous agency in plant operation and control, although there is a clear drive to use it more in this way. There was a feeling that there was significant underinvestment in AI and machine learning in this area, which prevented many of their potential benefits from being realised.

3.2. Mismatch between academic research and the needs of industry

A mismatch was identified between the problems worked on in academic research on AI and machine learning and the current needs of industry. It was felt that academic research overemphasised fundamental research and highly sophisticated problems that were only likely to be relevant to industry in a number of years. There was a feeling that there should be a greater focus on more practical and applied research to ensure that these exciting new technological developments could make a difference in the more immediate future. It was noted that, as with all fashionable topics, there was a certain amount of academic research that was motivated by applying AI “for the sake of applying AI”, rather than a belief that it was the best solution for a particular problem.

It was noted that at present, research funding for more applied work in this area was of low financial value and typically required an industry partner which significantly increased the barriers to entry for new projects. It was felt that there was a need for robust joint industry and government funding, particularly in connection to chemical engineering.

3.3. The lack of a regulatory framework in this area

Attendees highlighted the fact that there was no UK regulatory framework to help people judge how safe a particular piece of AI or machine learning technology might be when applying it to a plant control situation. Some promising developments were noted internationally in this area, such as ISO 42001, the AI management system standard AI which was introduced in December 2023. One promising practice that was noted was applying a HAZOP approach when deploying these technologies and involving the AI software developer in this. A limitation of this approach was that it required a high level of engagement from the developer which might be difficult to replicate at scale.

3.4. Workforce and skills

A recurring theme in discussion was the shortage of people with the skills to work on AI and machine learning in process control. Participants noted that it was hard to keep people who had trained in engineering from going to work in the finance sector where there is both a demand for numerate workers and extremely attractive pay. It was noted that it was particularly hard to find people who had both AI knowledge and the specific understanding of process control. There was some discussion about how interdisciplinary teams could provide a way to bring this mix of skills together, instead of having to have it united in a single individual.

Attendees felt that the government needed to ensure that it was prioritising education and (re)training opportunities for people to get into chemical and process engineering to ensure an adequate workforce. As part of this it was felt that the government should commit to further supporting science teachers in schools and research funding. When participants discussed what skills might be needed in this area in the future, there was a clear emphasis on the need for skills in interrogating the output generated by AIs and skills in posing sensible questions to AI the first place.

Looking to the future, it was speculated that the strongest business case for investment in AI and machine learning in process control might be one where it is deployed to reduce the number of workers a company would need to employ to operate its processes. This would have significant and sobering implications for the existing workforce.

3.5. The need for a conversation about overdependence on AI companies

Although attendees were divided on how best to respond to the issue of AI-related 'existential risks', there was a clear consensus that a very significant risk is presented by our current reliance on a small number of tech companies to provide strategically important AI and machine learning platforms. The recent example of CrowdStrike/Microsoft software issues causing mass disruption at airports was taken as illustrative of the potential for widespread disruption that might result. It was felt that there were clear national interest concerns regarding these technologies and platforms, and important questions for the government to answer regarding how to ensure that individual companies do not get too dominant. (There are related concerns about the health of the market given that innovative new players can be bought by bigger and more established companies, which has a detrimental impact on innovation and competition.)

3.6. Optimism about the role of AI and machine learning in supporting the government's objectives

Participants were relatively hopeful about the role of AI and machine learning in supporting the government's ambitions around clean energy. There was optimism that these technologies would allow plants to be better designed and run, make them more efficient to construct, and help with the invention of new technologies and products. It was suggested that many professionals were putting their faith in AI to work out how to 'solve' net zero in their field.

Looking beyond specific plants and products, AI and machine learning were seen to have a critical role to play in optimising the energy and materials flows of key systems such as the national grid particularly in light of the increasing decentralisation of these systems and complex phenomena such as the changing weather and demand. The UK Digital Catapult was noted as an example of good practice in this space, alongside the Scandinavian countries, the American National Renewable Energy Laboratory (NREL) and Germany.

Conclusions and Recommendations

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    - ***The government should consider the dependence on AI and machine learning technology as part of its wider assessments of strategic infrastructure.***

About IChemE

The Institution of Chemical Engineers (IChemE) is the qualifying body and learned society for chemical, biochemical, and process engineers in the UK and worldwide, with over 31,000 members. Our mission is to champion the input of chemical engineers to create a sustainable future. We support our members in applying their expertise and experience to make an influential contribution to solving major global challenges, and are the only organisation permitted to award Chartered Chemical Engineer status and Professional Process Safety Engineer registration.

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