Intelligent process optimisation for water treatment

DETAILS

SECTOR | Water

STAGE | Operations and Maintenance

TECHNOLOGIES | AI Augmentation, Data & Analytics, Sensors / IoT

SUMMARY

Intelligent process optimisation for drinking water and wastewater treatment plants provides an opportunity to automate the control of treatment processes and/or provide real-time decision support for treatment plant operators.

Historically, treatment plants have been operated by humans based on scientific guidelines. The challenge is that the quality of the source water (i.e. influent) can vary significantly at each treatment plant and therefore requires different treatment processes and levels of chemical dosing etc. in order to meet the required treated water standards. Treated water must meet aesthetic standards (i.e. taste, odour, and colour) for customer satisfaction. But most importantly, treated water must also meet strict water quality regulatory standards for health and environmental purposes.

The requirement to meet these water quality standards costly, and includes chemicals, energy, and labour. Globally, industries and water utilities and municipalities spend approximately USD 76 billion annually to operate treatment plants[1].

Plant operators can develop significant knowledge that allows them to fine-tune the operations of a plant in order to meet water quality standards at a lower cost. However, this takes time. The efficient operation of a treatment plant relies on the knowledge and judgement of its operators. The knowledge and experience of previous operators can be difficult to document for future operators.

Artificial intelligence (AI) technology and a digital replica of treatment processes (i.e. a digital twin – *see also the Digital Twin Use Case*) provide an opportunity to optimise drinking water and wastewater treatment plant processes to achieve significantly reduced costs. Self-learning AI technologies can analyse historical and current treatment plant sensor data and patterns in real time to control the processes themselves and/or provide real-time decision support for treatment plant operators in the form of performance projections and recommended actions.

As well as improve the efficiency of drinking water and wastewater treatment plants, AI could also improve the reliability of the water quality (i.e. meet water quality standards for a greater percentage of time). For water

[1] Global water market: breakdown by OPEX and CAPEX Global Water Intelligence: Water Data. Accessed 29 April 2020

utilities and municipalities this presents an opportunity for greater customer satisfaction, higher levels of corporate responsibility, and improved environmental outcomes.

The use of AI and digital twins in this space is in its infancy. One major challenge is the creation of a digital twin that can replicate the chemistry of water treatment processes within a treatment plant. Without a digital twin based on sound theory, the AI could potentially provide poor decision support when faced with input data that varied significantly from historical data.

Another challenge is the availability of historical data, which in turn relies on the sufficient sensors throughout the treatment processes. Without enough historical data, the AI will take some time to learn how to best optimise the treatment processes. In the future, developments in sensors and IoT technologies (related to scaling up manufacturing and deployments) are rendering these technologies lower cost, therefore enabling more sensors to be used and therefore more historical data to be provided to the AI. As the AI has access to greater amounts of relevant data, it is able to make better predictions and decisions. Additionally, as research and development continue for machine learning prediction and control algorithms, they will be better able to optimise the treatment processes, selecting better operations that further reduce costs, and doing so with less data.

VALUE CREATED

Improving efficiency and reducing costs:

- Reduced operational costs due to better operational treatment decisions and recommendations being made in real-time by AI.

Enhancing economic, social and environmental value:

- Improves aesthetics of water for society by providing real-time decision support during unusual operating conditions (e.g. extreme water quality events) to reduce human bias and the time required to respond to changes in operating conditions.
- Enables a higher level of service to customers through a consistent water quality
- Can provide more water from a given source. For example, water treatment plants must use some of the treated water to wash treatment plant filters. As a conservative measure, this "backwashing" occurs frequently, but the treated water used for backwashing must be treated again. AI would potentially be able to safely reduce the frequency of backwashing when the conditions were appropriate, and therefore produce greater volumes of treated water.
- Treatment plants that run with a higher efficiency may provide an opportunity to delay capital expenditure on treatment plant expansion infrastructure.

POLICY TOOLS AND LEVERS

Legislation and regulation: Regulation of both water quality and asset management can drive the implementation of these smart solutions. Government regulations, social responsibility, and sustainability targets drive utilities to improve health and environmental outcomes (e.g. a cryptosporidium incident in Sydney in 1998 was estimated to cost it in excess of AUD 700 million, including an increase in the regulatory burden and water quality monitoring[2]). An increase in regulatory requirements increases the cost of treating water. However, this creates financial pressure for water utilities, causing them to seek efficiencies that offset some of the increase in the cost of treating water.

Effective institutions: "Data-smart" institutions such as universities can help commercialise research in AI to technologies and make these tools business-as-usual.

[2] Regulatory Impact Statement for review of the Water NSW Regulation 2013. WaterNSW. Accessed 25 April 2020

Transition of workforce capabilities: Training and upskilling of workers is required to effectively explore the real-time recommendations from AI, sense-check these recommendations (AI cannot truly sense-check in its current form), and action the recommendations if appropriate.

IMPLEMENTATION

Ease of Implementation

Technology companies are already beginning to produce the required AI and digital twin technology (e.g. KOIOS DatalytiX and Createch360). However, the technology is still in its infancy and as such it is not yet common in industry. As AI technology improves and water treatment plants develop larger, cleaner, and more complete sets of historical data, these technologies will be more widely adopted.

A major challenge to implementation is a lack of sensors in treatment plants in developing countries. This prevents the training of AI on historical data. However, as the cost of sensors decreases and sensors become more ubiquitous, this problem will fade. The actual implementation is not complicated once all the necessary pieces are in place.

Cost

Sensors are inexpensive (relative to the cost savings that can be achieved) and are becoming even more so over time. Digital twins of treatment processes may require significant time and cost to develop. However, once a treatment process (e.g. filtration) has a digital twin created, it should be applicable across any treatment plant that uses the same process.

Country Readiness

This technology is most ready to be implemented in developed countries where sensors within water treatment plants are likely to have been operating for some time already, and therefore data is available for training the AI. In developing countries, money is required to obtain sensors and time is required to collect data that can be used to train the AI.

Technological Maturity

Currently, AI technologies require large sets of historical data to understand enough about the treatment plant to adequately provide real-time decision-support to operators. As AI improves, it may require less and less data.

Present-day AI technologies are sufficiently advanced to handle most conditions that drinking water and wastewater treatment plants encounter. However, it is still very important that treatment plant operators are able to sense-check the AI calculations, particularly if the treatment plant experiences unusual conditions. As AI advances, it may be possible for the AI to do this sense-checking, even in never-before seen circumstances.

RISKS AND MITIGATIONS

Implementation risk

Risk: Artificial intelligence is trained based on historical data. However, if the historical data is of low quality (e.g. due to short time frame of data, incorrectly calibrated sensors, gaps in the data, etc.), then the AI is also likely to be of low quality.

Mitigation: Any proper implementation of artificial intelligence requires skilled data scientists, software, and water treatment specialists to analyse historical data and ensure that it is accurate and of a sufficient quantity for the training of the AI. The AI should also be thoroughly validated through trials with operators.

Social risk

Risk: Automation can create the need for re-training of workers to operate, maintain and oversee automated systems and focus on more strategic activities focusing on longer term planning of treatment plant maintenance and operation.

Mitigation: Drinking water and wastewater treatment plant operators should be upskilled to learn how to interpret, make sense of, and action any decision-support that is provided by the AI.

Safety and (cyber)security risk

Risk: Control systems, especially those located in the cloud, are at risk of cyber-attacks that can leave critical infrastructure vulnerable.

Mitigation: Training of AI is generally done in the cloud, however, once training is complete the AI can be easily run on a desktop machine. Therefore, it is possible to have the AI in a desktop computer on-site at the treatment plant and to not have it connected to the internet, or to only have limited access to the cloud.

Environmental and social risk

Risk: Artificial intelligence is trained based on historical data and can be bad at providing decision support if it receives data that is dissimilar to the historical data that it was trained on. This can lead to severe health or environmental risks if water is insufficiently treated.

Mitigation: This can be mitigated through the use of highly skilled operators who can make sense of the decision support provided by the AI and ensure that it makes sense based on their knowledge of the system.

EXAMPLES[3]

Example	Implementation	Cost	Timeframe
Createch360	Optimisation software has applied at the Brembate wastewater treatment plant in Italy, treating 53,600m^3 of waste water a day (236,000 Population Equivalent).	The software resulted in a 19% reduction on energy consumption. With a payback period of 1-2 years.	The system is custom developed for specific treatment plants and operation within 3 months.
Emagin HARVI	The HARVI systems was applied in the City of Calgary, Canada which serves over 1.2 million residents and over 20,000 industrial, commercial and institutional (ICI) customers. Using AI, HARVI generated real-time pump schedule to minimise the cost of operations while guaranteeing compliance and maintenance requirements, by collecting operational data.	EMAGIN was able generate 21% savings relative to baseline operations. This corresponds to a payback period of 3 months.	The AI system is custom built for different treatment plants. The timeframe of implementation is dependent on historical and live data available.

[3] Information for Examples in this use case was gathered via communications with commercial technology stakeholders.