Neuron – Digital console innovative by Arup

Felix Chan¹, Tony Lam¹

¹Building Sustainability Group, Arup, Level 5, Festival Walk, 80 Tat Chee Avenue, Kowloon Tong, Hong Kong, China

Felix.chan@arup.com; ngan-tung.lam@arup.com

Abstract. At the age of digital era, supervised / unsupervised machine learning, sharp data analysis and neuron network are some of many ways to formulate optimization problems with millions or billions of variables. Classical building system and environmental optimization algorithms are not designed to scale to instances of this size; new approaches are needed.

The Digital Platform developed by Arup – Neuron is an innovative console which embodies 5G, IoT, Big Data, Cloud Computing and AI technology for smart building with advanced data analytic capabilities. It can fully integrate with the existing Building Management System as well as various data sources generated from the IoT sensors, enabling prompt and adaptive response to dynamic environment, serving as a foundation for buildings to consolidate and connect data from disparate equipment and devices to provide customised insight and machine learning models for built environmental management and improvement, new building design, operation and asset management, energy monitoring and optimisation.

One significant success achieved with our integrated digital platform is that it has been adopted by multiple clients in the East Asia region in managing their building. With full implementation and other appropriate energy saving and/or retro-commissioning practices, Neuron is expected to save up to 30% total HVAC energy consumption for a typical existing commercial building. Apart from energy saving, Neuron also focuses on creating a better indoor environment, which could significantly improve employees’ productivity.

Neuron, as a smart building console, is set to have a momentous impact on Hong Kong, not only for a better built environment, but also a game changer for the East Asia region to excel in the era of digital economy. This paper elaborates how Neuron could help in digital transformation of new and existing buildings in the new era. The challenges and experiences of projects will also be discussed. Start your abstract here…

1. Introduction

In the urbanised city of East Asia region, building accounts for 90%¹ of electricity consumption, compared to a global average of 40%. In turn, this high energy consumption level accounts for 60%¹ of the city’s greenhouse gas emissions.

While in Hong Kong, only a fraction of over 40,000 buildings in the city are energy efficient buildings, over 50% of our building stock are, indeed, ‘sick buildings’ – those expose occupants to health issues and discomfort due to building-related factors such as poor ventilation or indoor...
temperature being too high or too low. Sick buildings impose a serious impact in terms of resources efficiency, and more importantly, the productivity of occupants.

Therefore, there is a need of total solution that not only help buildings achieve energy savings, but also creating a better indoor environment that focus on the health and wellbeing of the occupants. With the domain experts and leadership in digital technology in the building industry, therefore Neuron were developed and introduced to provide digital transform opportunity for the East Asian countries.

Neuron addressed three UN SDG targets:
- Goal 3: Good health and well-being,
- Goal 9: Industry, innovation and infrastructure, and
- Goal 13: Climate action

2. Creativity of Product and Service Concept
The Digital Platform (Neuron) is an innovative console which embodies 5G, IoT, Big Data, Cloud Computing and AI technology for smart building with advanced data analytic capabilities. It can fully integrate with the existing Building Management System as well as various data sources generated from the building, enabling prompt and adaptive response to dynamic environment, serving as a foundation for buildings to consolidate and connect data from disparate equipment and devices to provide customised insight and machine learning models for building performance management and improvement, new building design, operation and asset management, energy monitoring and optimisation.

When first develop Neuron, operational data of difference equipment, outdoor and indoor condition were collected to obtain a general relationship between each factor.

Figure 1 Neuron data structure set-up
The algorithm were also cross reference with the equipment’s performance cure to make sure the equipment could would on their best COP under the predicted condition, figure 3 below shows the relationship between cooling tower operation vs the outdoor wet blub temperature.

Figure 3 Operation strategy VS outdoor condition

Neuron is characterised by the following features:

2.1. IoT-enabled building control
IoT sensors and web platform can be easily be installed and connected through wireless approach (LoRa / NB-IoT / Wi-Fi) and apply to both new and existing buildings. The building users and the facility management can use the platform to monitor and control the current building resources use and system.
For example, IAQ sensors will detect the indoor air quality level, the IAQ information will be displayed on Neuron and will be available in a web platform format. Once the air quality turns bad, the IoT platform will send an “on” signal to the actuator, an air purifier will then be turned on and purify the air, and energy-saving strategies will be advised by Neuron according to the current energy usage situation. Analytics algorithms were built into the platform and could be upgraded or fine-tuned according to the actual usage and different functions.

2.2. BIM integration for building life cycle asset management
Neuron provides a foundational data platform to connect and converge data sources from disparate building systems, equipment, and devices (e.g., HVAC system) into a central repository or common data model. From Figure 4, all the real-time data from building management system (BMS), IoT system, and people counting system are integrated into this platform for Big Data analysis. Through BIM-enabled asset management (AM) system, the platform can improve operation workflows and replace manual processes via digitalisation and automation, see Figure 4.

![Figure 4 - BIM Integration for Building Life Cycle assets management](image)

2.3. AI Machine Learning for building system optimisation
By analysing historical data, it uncovers hidden patterns, better estimates future energy usage and thus allows better planning that supports general building operation. Neuron therefore gives buildings the capability to quickly predict and adapt to environmental changes and learn the best configuration combinations in a way that humans could not. It achieves energy saving and reduces total building energy consumption by optimising BMS and chiller plant settings.

2.4. Preventive maintenance
Neuron makes use of AI to facilitate early detection and timely resolution by identifying anomalies in system data and verifying fault occurrences. Following that, it automatically adjusts the control plan based on characteristics and energy performance of various components such as chiller unit, chilled water, and condensing water pumps and cooling towers in HVAC systems to obtain minimum energy needs. The system also allows predictive maintenance to be scheduled in advance. For instance, it
predicts the cooling load demand for a building based on dynamic factors such as footfall, sunlight, outdoor environment, event modes etc.

3. Digital Transformation and the Challenges in Job Case
A grade A commercial development in Hong Kong – One Taikoo Place takes the concept of smart buildings to a new level and changed the way buildings are designed, constructed, managed, operated and maintained. It has a profound change in the entire value chain of the building industry, from architects to owners and property managers, as it brings a new dimension to asset management, operations and maintenance by creating a digital twin for the building which is absent in the current market. Therefore, One Taikoo Place sets out a good example and defines a new benchmark how AI and technologies can bring benefits and change the building sectors in terms of energy saving, operation optimisation, human comfort and user experience.

As Hong Kong’s first-ever AI-enabled smart building, it addresses the following:

3.1. Limitation of traditional building control system
Since buildings consume 90% of total electricity consumption in Hong Kong, of which mainly by HVAC systems, accurate energy usage forecasts and optimised control of buildings HVAC systems are critical for energy conservation.

The traditional HVAC system is mainly controlled by temperature set points and there is usually a delay effect in cooling propagation resulting in an imbalance between generated and actual cooling load required. It is difficult to find the correlation between the required cooling load and environmental parameter such as people count, outdoor environment, sunlight levels and event modes. Existing technology and products appear to be insufficient to capture the complex interdependencies for accurate predictive modelling. Often, BMS-detected values such as temperature doesn’t match the actual open ambient reading, making it unfeasible to test parametric combinations that maximise efficiency.

In view of the above limitation, the team targeted to solve this issue by leveraging on the application of data analytics and AI technologies on building operation control. Neuron carried out compute energy forecasting and proposed to building operators the optimised control strategy from different HVAC components such as chiller unit, cooling towers, chilled water and condensing water pumps.

With full understanding of a building’s cooling demand profile and performance characteristics of HVAC components, Neuron conduct a more precise control of chiller on/off instances and the number of equipment to be operated in order to reduce the overall energy consumption.

3.2. Empowering smarter building with big data
Owing to the complex ecosystems of modern buildings, at present, in managing and running facilities, operators typically struggle to get up-to-date information on building assets, verify accuracy of operation and maintenance (O&M) manuals, identify equipment operation modes and status, determine building performance and energy costs, and extract meaningful intelligence from tremendous volume of raw data generated daily in their operations such as sensors on equipment, smart meters, weather stations, valves and chiller plant measuring flow, temperature and power consumption.

Our team realise the above restriction brought by current building automation and energy management systems which focus mainly on monitoring system health and providing alarm capabilities. Accordingly, Neuron were developed, a central analytics platform which can provide more insight from combined building data. With increasing convergence of building systems, there is a great value in collecting historical building data and in turn providing suggestions on future operation strategies for energy conservation and optimisation of building performance.

3.3. Human-centric well-being design for productivity improvement
Occupants’ health and productivity is also one of our focuses in developing Neuron. For example, the IoT sensors can track and capture data about indoor environment parameters, occupants’ location and
movement across the office premises. Different sensors will then identify patterns in occupants’ interaction and workspace usage, allowing better insights into staff behaviour which helps design a more convenient and healthy workspace, and in turn helps improve staff motivation and productivity.

3.4. Reduced data processing time
In the past, building operators and facility managers had to tackle the complexity in processing massive amounts of data generated by their HVAC systems, critical power equipment, BMS and SCADA systems, IT infrastructure, solar panels and co-generation units. While using the dynamic real-time Neuron platform, customers can quickly retrieve asset information for decision making, control, diagnose problems remotely, and test a proposed fix for a piece of equipment before applying it to the physical component, making them easier to develop energy management strategies and meet occupant demand. A variety of customisable reports also allow our clients to understand and engage with their energy and operational profile, initiate actions to optimise energy performance and prevent excessive energy consumption and operational inefficiency.

3.5. Automated and data-driven approach to enhance operation efficiency
Most of the HVAC systems in current smart buildings rely on predefined scheduling and human experience to operate. The Neuron platform, however, uses AI analysis of events and responding automatically to certain triggers, in turn, human operators are no longer overwhelmed by numerous alerts and alarms from multiple systems and sensors. Data-driven operation automates manual workflows and inefficient models of the past so operators can better monitor, filter and manage alarms and alerts to determine the best course of action for a situation.

3.6. Usage patterns analysis and real-time monitoring of building system parameters
Since HVAC systems are unable to execute more comprehensive analysis or guarantee consistent system performance, our Neuron platform deals with this issue by applying AI and machine learning processes to avoid complicated manual calculation. Through analysing historical data inputs, the model will dig the relationship among various parameters before pointing out the potential energy-saving areas. The model then can be used for real-time parameters prediction and support system setting strategy for our clients, including responding timely to abnormal or threshold triggers, and reducing energy consumption or service interruption. Provided that our Neuron’s offline modelling with historical chiller plant data, environment statistics and recorded energy consumption can derive correlation between system settings, cooling load demand and corresponding energy cost, optimisation of overall energy efficiency can therefore be obtained. Neuron also uses a display portal to show the forecast result and chiller plant saving statistics for the site operator’s further improvement – through consolidation and quantify, building system statistics will be more integrated and transparent for more insights, see figure 5.

Figure 5 - Building KPI and operational data
3.7. Simpler and user-friendly man-machine interface to locate core devices within one click
Considering the large quantity of building assets and practical use requirements from building operators, the team has developed the Neuron platform with virtual energy management interface that presents information in a single, cohesive view. To streamline clients’ building performance data, make them easier to identify operational and process improvements and increase uptime, the team launched an innovative feature of Neuron – the interaction between the building’s 3D BIM model and real-time data captured automatically from BMS and HVAC systems using open protocols including Building Automation and Control networks (BACnet) and Modbus. By clicking on an item in the 3D BIM model, operators can visualise specific parameters and statistics for the item through interactive and responsive dashboards. The model will automatically zoom in to the target device with other components turning translucent, and the model image and relevant manuals, drawings and information of the device are retrieved to provide more comprehensive statistics on equipment performance. Operators can locate core devices through shortcut buttons, for example, the building’s BIM can be subdivided by floors and systems such as electrical system, plumbing and drainage (P&D) system and lighting system to allow the display of an isolated view of a single system on a certain floor.

3.8. IoT and cloud-based platform for smart building
IoT sensors and equipment gateways are widely deployed to construct a network of precise measurement points to fill the gap in building parameters not monitored by BMS. Neuron’s cloud-based platform helps gather building data from BMS, IoT sensors and facility management system for more accurate data analysis, machine learning and better building performance evaluation. In IoT-enabled buildings, owners can differentiate themselves by using the information to identify unmet consumer demands, interact with users, provide more sophisticated services to their tenants and transform tenant and user experience, and contribute to the broader ecosystem.

3.9. Risk reduction
Neuron provides predictive and preventive measures for safe environment, as well as a tighter security brought by real-time surveillance and faster emergency response systems. Real-time monitoring in the IoT-enabled buildings can alleviate security concerns for both owners and tenants. For example, specialised weather sensors can provide advance warnings of adverse weather events. Under the occasions of floods or typhoons, it helps increase disaster preparedness and resilience.

3.10. Health and well-being and productivity improvement
Through combining BMS-captured environmental data with staff movement data from motions sensors, Neuron allows operators to understand the optimal ventilation and temperature levels for a specific day. For example, the building’s HVAC and lighting systems can make necessary adjustments in ventilation and space conditioning. By designing more comfortable and customizable workspaces, it increases staff convenience and provides a healthier environment for occupants, thereby increasing workplace efficiency and boosting employees’ productivity and facilitating collaborations.

3.11. Lower operation cost
IoT-enabled BMS can be used to reduce energy use, repair and maintenance, and administrative costs. Through applying Neuron, property owners can use the data collected by motion and occupancy sensors at a building level to regulate air-conditioning and lighting in real time, thereby lowering operation costs such as energy bills and optimising the internal environment.

4. Achievement
The highly automated analysis process of Neuron makes it feasible for even the unexperienced operators to easily monitor and operate the chiller plant system, saving their labour input. The system improved energy efficiency without sacrificing the comfort level of tenants and users. By implementing optimised strategies, it helps the owner reduce operation cost and achieve sustainable goals. It also reinforces the productivity of building facility management with more intuitive man-machine interface and functionalities.

With full implementation and other appropriate energy saving and/or retro-commissioning practices, Neuron can help the building to save up to 30% electricity consumption for a typical existing commercial building. Apart from energy saving, Neuron also focuses on creating a better indoor environment, which could significantly improve employees’ productivity and thus enhance productivity for clients. From real case example, the cooling load prediction accuracy of Neuron and real operation were within 5% difference, which reinforce the AI ability of Neuron.

Regarding the innovation prospect, the Neuron platform has successfully become a real product and has been implemented in a brand-new triple Grade A office tower, Neuron makes it to become the first AI-enabled smart building in Hong Kong. Not only did the platform incorporate such ground-breaking digital technology, it also adheres to the highest standards of building sustainability and digital strategy in areas such as BIM asset management, big data analysis, and AI model development for energy saving and predictive maintenance. Looking ahead, the platform is also very scalable that it is possible to be expanded geographically by making use of consultant firm’s global network.

In terms of business sustainability, the Neuron platform can be easily integrated into any new and existing buildings, creating new business opportunities for the consultancy services as it can be adopted in a wide range of commercial and residential buildings and tailored to meet different needs. With successful implementation at One Taikoo Place, this platform allows the consultant firm to provide ongoing service to our client and generate ongoing business profits. We will continue to promote Neuron to our clients as a cutting-edge tool for them to optimise production cost, minimise energy usage, and effectively manage building assets. We hope the product can shape the market landscape and be practically installed to any part of the world that shows concern about energy saving, building sustainability and digital transformation.

5. Impact to the Market and Industry
The successful cases of Neuron set a momentous impact on Hong Kong, not only for the built environment, but also a benchmark for the East Asia region to excel in the era of digital era.

On the other hand, the construction industry and all other sectors are all part of the driving force for a more sustainable built environment and a greener future. Neuron can thus offer an opportunity for the business sector to explore new ways in saving energy in their owned properties or rented premises. We hope that the successful and wider implementation of such inventive system will inspire the business sector to embrace more innovative and sustainable facilities operations and management tools and practices.

Neuron also demonstrates a digital future for the entire business as its usage is not limited to one single building but applicable to all smart buildings through customised optimisation. Thus, Neuron can be further applied to many other traditional industries and market sectors as part of their digital transformation journey, bringing new perspectives to their businesses. This could pave the way for the further adoption of smart and intelligence buildings and new business opportunities in various fields from hardware to services.

References
[1] Hong Kong’s Climate Action Plan 2030+, January 2017, Environment Bureau, Hong Kong Government