Whitepaper

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Lighting meets Artificial Intelligence (AI) - a way towards better lighting

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Introduction

Artificial Intelligence is developing at a very fast pace, influencing multiple industries and technologies. The lighting industry, however, has so far been slow to adopt this technology. “LED-ification” and the first attempts at implementing wireless solutions have already stretched the capabilities of the lighting industry.

These pressures have inhibited the development of AI solutions for lighting and our understanding of the business opportunity that AI presents. However, there is a huge opportunity at hand as plenty of luminaires are still only switchable and most of the current solutions in use could be classed as “dumb” rather than “intelligent”.

A basic sign of intelligence is the capability to learn and that characteristic is clearly not present in today’s lighting solutions. This will change. The lighting systems of the future will use AI to varying extents and in different formats. Learning will happen through sensing and combining other data into logical conclusions.

The amount of sensors in commercial spaces is predicted to grow significantly and as the data gathered moves into cloud-based platforms, learning and related activity will develop in several areas e.g. utilising presence sensor data from a lighting system to control room temperature. As a result, lighting will have a more significant role in the construction and real-estate business than it does today. New businesses will grow and replace existing ones.

By embracing AI the lighting industry will stay ahead of the technology curve and reap the benefits of future business opportunities, in particular the continuous improvement of the wellbeing of end-users.

In order to discuss the progress of AI in the lighting industry, we shall review some vital questions on lighting and lighting control and how that impacts the adoption of AI.

Why do lighting projects deliver sub-optimised solutions?

Lighting in many buildings does not operate very well. In some instances, problems originate at the very beginning, at the design phase, and on other projects there may be an issue in the commissioning or installation phase. It is very unlikely that, over the lifetime of a lighting installation, it will always operate at an optimal level.

Design phase problems might originate from the limited resources of the designer and/or whether the project owner has enough information about the end-users in the building. In order to design very good lighting, a lot of information is needed: "How will the area be used? How will it be equipped (for example, what furniture will be used)? What is the profile of the users (age, gender, etc.)? What are the preferences of the users?" The designer often does not receive enough information to create a comprehensive and well-designed lighting scheme.

The installation and commissioning phase of the project may also pose a significant challenge. Installers and commissioning personnel may also be working with a lack of information on the function of the space and the users, similarly to the designers, and may also have limitations in the skills required for installing an advanced lighting solution.

After the design and installation phases, occupants of the space may not be trained to use the system properly, which results in a lot of operational issues, even though the system may be designed well and installed and configured as planned.

The third stage is the period in which, after the lighting has been installed and commissioned, it is actually used by occupants of the space. Even with the perfect execution of the design and installation stages, optimal use of the lighting system during this time may not be achieved. The main challenge during the time it is in use is that aspects of the building may change.

The function of the building might change, tasks might change, people get older or maybe different people will start to use the premises. The furniture, walls and carpets might also be renovated, which can influence lighting conditions. It is also possible that the performance of lighting may decrease over time, although most users may not notice the change. Some parts of the lighting might even break down or fail.

Why is lighting control not ubiquitous?

Lighting control is essential to develop and explore the possibilities around AI. However, a significant proportion of the luminaires installed in commercial projects are still only controlled by on/off switches, even in new installations.

The most important factors for designing switch control are obvious: ease of design & operation, low cost for the initial investment and lack of knowledge. Initial cost is a powerful argument against lighting controls as an on/off luminaire is a very low cost solution and keeps the necessary investment very low. However, the long term Total Cost of Ownership (TCO) is, in many cases, much higher than for a controllable solution.

The ease of designing on/off lighting with wall- mounted switches eliminates the positive effects that good lighting can have on users.

Fortunately, the knowledge and understanding of the benefits of good lighting is growing. Lighting control systems need to increase adoption rates by being easier to be designed, to be installed and configured. They also need to bemore intuitive to use or intelligent enough to be able to work automatically with continuous auto-commissioning.

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Is a human mastermind the way to get better lighting?

In general, present lighting control systems are built on the belief that we know what will happen now and in the future, i.e. somewhere there is a mastermind (the specifier or designer) who is able to develop rules governing how lighting should work in different situations.

The reality is that there is no such person in any professional lighting project. The problem has been solved so far by re-commissioning or re-configuration, for which an expert is needed. Lighting systems are getting more flexible, which might mean that they are also becoming more complex to setup and require special knowledge and more resources.

Quite often end users either do not notice or do not understand that lighting could and should work better. This means that an expert is invited only when the problem is severe (e.g. the lights will not turn on or the lights are flickering).

An expert would have to monitor lighting, space, users and their tasks all the time to be able to ensure the optimal lighting solution at all times. Unfortunately this is not affordable or practical in most situations.

Artificial intelligence

A basic and essential sign of intelligence is the capability to learn. Any technology without the capability to learn cannot be considered intelligent.

A system or an individual part of a system that can learn itself, without the continued assistance of a human programmer or a user, can be called self-learning or machine learning. Software algorithms can be used for learning and making predictions based on data.

This means that three things are needed to actively start using artificial intelligence in controlling something: data, intelligent software and the ability of the technology to react. The current buzzwords for the physical infrastructure behind this is the Internet of Things (IoT).
IoT needs AI and AI needs IoT.

Data means information to analyse. The more inputs or the more data we can gather, the easier and the more precise our conclusions and predictions can be. This also means that it is crucial to be able to store as much data as possible.

The better the analysing processors and software algorithms are, the faster and more reliable the conclusions. We could stop here and let AI make suggestions and predictions, and not execute any actions.

However, to really take advantage of the possibilities offered by AI, we should give it the ability to control the possible technology in a more reliable and more cost efficient way than pre-set rules made by human beings.

Artificial intelligence in other industries

Other industries have faced similar challenges of human performance and costs and they are now heading towards an AI-integrated industry, some at a faster pace than others. The manufacturing industry has used robots, automated testing and predictive analyses for years.

The more data, the more automated processes and the more machine learning they have, the faster manufacturing gets and the fewer errors occur. Computers have been used in cars since the 1980s to monitor the status of the motor, fuel consumption and safety features, among many other data points. On-board computers have also been assisting drivers with ABS and EPS for several years, as well as navigation systems which give the driver instructions.

We are now beginning to see more advanced computer and AI supported features like predictive automatic breaking, self-parking and alerts like driver dizziness. Cars are connected to the cloud at all times and can call for assistance themselves in case of an accident.

The next steps are driverless cars, which are currently being tested and some elements of driverless technology are already in use. The automotive industry is pushing through these developments to increase the well-being and safety of the driver and other road users.

Artificial intelligence and lighting

Self-learning algorithms equals continuous auto-commissioning and machine learning have the potential to serve as an "expert on-site" and to help grow the adoption of controllable lighting. They may also be able to make lighting control operation "easier" and "less costly". However, self-learning algorithms and machine learning can achieve much more than this. Since lighting and related sensors can be present throughout a building, lighting can serve as the backbone of intelligent buildings.

AI solutions can be designed in such a way that they are as easy to install as simple on/off systems but operate automatically. This will remove barriers in designing, installing and using lighting control.

AI can collect and analyse data on behaviour patterns and predictions to help designers improve building environments and lighting, generating significant benefits and value to both the property's user and owner. Having more data will turn the focus of design onto the people that occupy the building rather than the building itself.

This will benefit all users, leading to better buildings, which is ultimately more beneficial financially for building owners. AI can also help to make the initial configuration of the lighting system much easier and more effective which is a significant benefit for maintenance personnel and, more importantly, it can provide options for automatic or semi-automatic re-configurations, as well as tools to enable predictive maintenance. It is clear that in both the use and maintenance of lighting, AI will accelerate the development of solutions and services.

A continuous flow of data from lighting and other environmental sensors, users, events on the site and data from other external sources will create circumstances where "an expert" is monitoring and tuning conditions all the time. It creates greater transparency and brings light to the true value of information.

Using this data could, for example, help building owners to optimise energy consumption and, even more importantly, help to create a more human centric approach to lighting and the built environment. Increasing the wellbeing of a building's users is the ultimate driver to use artificial intelligence, machine learning and self-learning to its fullest extent to tune lighting conditions.

What kind of structure will a lighting network with AI have?

One question that must be considered is where the intelligence should reside to generate the maximum benefit in a cost efficient way? Self-learning algorithms can be built into individual luminaires, sensors, room level devices, floor or building level computing systems or even larger networks like computing clouds.

. Room level AI could be used in smaller rooms with a smart, self-learning sensor controlling a group of luminaires, with the number of sensors increasing as the size of the room increases. In this kind of solution the "intelligence" in the lighting system is in the sensor. However, larger scale solutions covering a whole floor or building require a connection to a cloud-based platform to analyse the data gathered by the sensors. Without such a platform, the potential to analyse the data and generate value from it is limited. Floor and building level operating lighting intelligence will not be as fluent as where intelligence is distributed to a network of sensors and luminaires.

Self-learning algorithms based in luminaires and sensors can create an opportunity for easy specification and installation. In many cases, particularly where "real-time" data is requested, this would be the best location for intelligence. These sensors and luminaires may perform simple functions automatically and gather data that is not actually very useful for "higher level" analysis in a cloud-based platform. Awaiting the results of this analysis is often impractical in these smaller applications, where adjustments to the lighting need to happen almost instantly.

A lighting system comprised of a cloud level AI platform that sits above individual luminaires and sensors presents an interesting opportunity to implement machine learning. Adding more data gathered by sensors and additional computing power can make machine learning even more effective and ensure that patterns are easier to detect. We believe that lighting solutions that incorporate AI on an individual device level or that utilise machine learning as part of a cloud-based platform will offer the most comprehensive lighting intelligence systems.

The most likely way in which these systems will operate is with a combination of "intelligent" devices connected to an "intelligent" cloud via gateway technology. Part of the data may be filtered, stored or processed on the building level before it is sent to the cloud to ensure good data transfer speed, data assurance and operational. Isolated room, floor or building level solutions will offer less functionality and value, however, there is a place for these solutions at least in the near-to-medium future.

Another question that we must consider is if the development of intelligent lighting solutions will be based on wired or wireless communication? Today wired lighting control is the overwhelming choice of technology but wireless solutions are gaining more and more market share.

Currently the DALI standard is a significant factor in why wired lighting control is selected for the vast majority of new installations. This is also driven by standardized DALI-luminaires being widely available. In a new installation, the cost of adding two extra wires, often in same cable than mains, is low. However, in retrofit installations it can be easier and more cost-efficient to have a wireless installation if wireless means that cabling does not need to be redone or added.

Therefore, we are seeing the appearance of wireless lighting control systems in commercial real estate. Lighting intelligence with networked devices will form a key part of so called hybrid connectivity solutions, i.e. IP-controlled, wired or on Bluetooth® low energy mesh network wireless technology based solutions.

To generate significant value in commercial applications and provide the very best service to its customers, we believe the lighting industry will adopt a hybrid connectivity solution of wired and wireless technology. This can combine the advanced, autonomous, data-gathering lighting intelligence through wireless technology with a reliable, standardised wired lighting control system like DALI to provide a seamless, robust, secure and high quality lighting control solution.

However, in the future AI and increased cost focus will boost wireless networks. As discussed earlier, in order to be able to run algorithms we need data. To be able to collect data from the property, enabling devices such as sensors are required – the higher density and the more intelligent the better.

Adding wired sensors to different places in the room is impractical in most installations. Even disregarding the challenge of implementing additional wiring, adding, for example, a new wired humidity sensor under a refrigerator or a light sensor on the table would be impractical in most commercial settings. The next generation of sensors will see more and more wireless options which means that advanced intelligent lighting networks will need to be fully or, at least, mostly wireless.

Concerns around AI

As established, AI means data, connections and giving some elements of the decision making over building technology to software algorithms. Organisations that invest in lighting systems that incorporate AI technology need to consider the implications of something going wrong. What if the data gathered by the sensors gets into the wrong hands? What if AI makes the wrong decision? What if an external party gains control of the lighting system by using networks created for the AI?

There is always a risk in using IT technologies, which should never be underestimated. Taking robust precautions is essential, yet there is also no reason to panic or restrain development due to that risk. It is manageable. With regards to lighting nothing life-threatening will occur if it doesn't work, or if lighting related data is used in other context. However, there are reasonable concerns in situations where lighting is switched off when it is needed, lighting is switched on when it is harmful and when sensor data is used or manipulated for unethical purposes.

Lighting being off when it is needed is a problem that may in fact be solved by AI rather than caused by it. The more intelligent automation we have, the fewer opportunities we have for human error. The more data and data analytics we have, the better, the faster and the more predictive lighting systems will be. When creating sensing systems which have final control it is less likely that the lighting in occupied areas will be accidentally switched off. It is likely that the most common reason for lighting being switched off unintentionally will be the same in the future as it is today: neglected maintenance and electrical faults, rather than any artificial intelligence related reason.

Some areas, where lighting going on at the wrong time could be harmful, are special areas like movie theatres and spaces such as bedrooms, hotel rooms and hospital wards, where people are sleeping. When a system is connected to other systems, such as, data storage solutions and gateway interfaces, the risk of switching on lighting accidentally grows.

Here, the risk of an external party accessing the system and switching on the lighting is more difficult to prevent, and artificial intelligence cannot prevent all these problems. However, AI can help to limit and prevent these occasions from being repeated, by collecting data on the lighting system's typical operational programme, abnormalities and UI feedback, learning and acting accordingly.

Most of the sensor data is quite harmless from a privacy perspective. On a building level, CCTV cameras might be the most questionable "sensors". Many of people do not feel comfortable when they know that they under surveillance. Organisations that use camera technology to gather occupancy and people-flow data need to consider processing that data at the camera level to ensure that unnecessary details are not "visible" when the data is analysed.

However, governments and other organisations are constantly increasing the level of surveillance so that for most people it is a part of their daily lives. Some people have even begun installing advanced security camera systems in their homes that allows the security company to take a series of pictures after the alarm is activated.

Is AI the only thing we need?

Self-learning or machine learning alone is not the only solution for optimised lighting control. There is still a clear need to configure luminaires to certain setting and to control luminaires locally. Local control can be used for supervised learning. In this type of installation the user inputs will teach the system to react correctly and with increased automation in similar situations in the future.

Self-learning can be supported by configuration, supervised learning and local control if and when it is needed. It is clear that an approach to lighting of just self-learning or manual pre-configuration alone will not offer always optimum lighting conditions.

These two approaches should complement each other. It is very likely that in projects completed in medium-term future, the main part of the lighting control solution will be self-learning and some areas will be strictly configured.

However, even in the areas with configured lighting systems, self-learning and machine learning could be very useful for collecting data and understanding if areas should be reconfigured. Re-configurations can be then done by humans or AI.

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Summary

Self-learning lighting technology is not a competitor with manually configured systems. It is part of the evolution of those systems. It might mean that commissioning and configuring lighting will become easier, which can cut down on the time and cost spent on commissioning work.

Increasing the amount of intelligent wireless solutions naturally decreases the amount of cabling and manual installation equipment. This could have a negative impact on cable manufactures and installers; however, it is more likely that good AI solutions, which will boost the wellbeing of users and reduce costs, will create more new business opportunities to replace old ones.

They will open doors for new types of continuous service businesses benefitting all parties in the building and lighting business. This will happen when all parties aim to create the very best user experience and end-user wellbeing, focusing their activity continuously towards that – delivering optimised lighting solutions.

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Lars Hellström joined the lighting industry less than 18 months with a long-term background in mobile/wireless technology, IT & digital service industry and on the premise to contribute to the rapid change in a fascinating industry. Lars is responsible at Helvar for developing the ecosystem for Helvar's Lighting Intelligence.