ILI GLOW

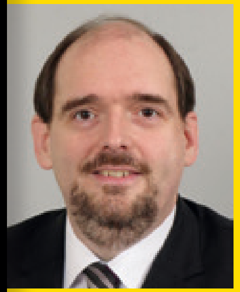
Intelligent Lighting Institute | Edition 8, November 2017

Technische Universiteit
Eindhoven
University of Technology

TU/e Technische Universiteit Eindhoven University of Technology

Intelligent Lighting Institute

Harold Weffers | Operational manager



Welcome

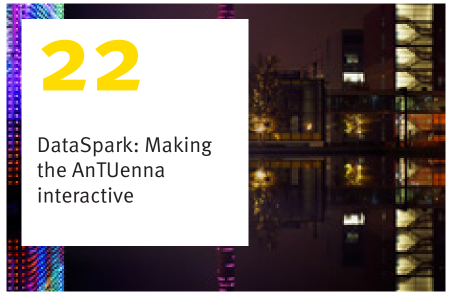
I am extremely pleased to present to you the eighth edition of our ILI Magazine. Since the last edition in May 2017 much has happened and I hope that after reading the various contributions in this magazine you will agree with me that many exciting and promising developments have been happening.

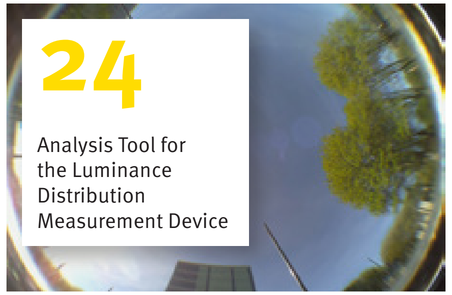
Amongst others you will be informed about some of the latest relevant developments in our R&D programs, our R&D infrastructures and our strategic partnerships, basically forming the basis of our new (methodologies & technologies for) scientific discoveries & technological innovations.

In particular you will be informed about some of the latest results of our research programs and about the developments with respect to our various research infrastructures annex Living Labs and our installations at the GLOW Light Festival.

Pleasant reading!

ILIGLOW CONTENT





Editorial // ILI Glow Magazine 2017 is a biannual edition of ILI for ILI members, colleagues, collaboration partners, policy makers and related companies // ILI Glow Magazine 2017 has been published in November // Editorial staff - Harold Weffers, Marlies Bergman // Design - Volle-Kracht concept, ontwerp en organisatie // Illustrations - ILI // Article contributions - Moesasji & ILI // Photography - Bart van Overbeeke Fotografie, ILI // Contact - P.O. Box 513, 5600 MB Eindhoven The Netherlands T: +31(40)247 5990 E: ili@tue.nl //

Ingrid Heynderickx | Scientific Director

ILI GLOWs again

Since most people enjoyed it last year, we again organized our outreach event ILIAD in the week of GLOW Eindhoven (from November 11 to 18), more specifically on Tuesday November 14.

Also this year's program combined a mix of internal and external speakers. Our ILI program leaders presented progress in their program, with special attention for the increased opportunities we see by crossing the boundaries of the programs in our research.

The external speakers shed light on trends in lighting related to the ILI program lines. In contrast to last year's program, we included more time to allow our PhD community to present itself. For some of these PhD-students this was their last ILIAD event as a PhD. We initiated the Flagship collaboration with Philips Lighting about five years ago with a research program co-funded between Philips Lighting and TU/e. This Flagship collaboration was started up with a research program including 16 PhD-students. Many of these PhD-students now approach the end of their contract, and are thus finalizing their thesis. As a consequence, we expect many PhD-defenses from ILI in the first half of 2018. This also implies that the core-team of ILI currently explores options for funding to prolong our research programs with new PhD-students.

ILI was also present at GLOW again this year. In this magazine Bert Maas describes the installation that Philip Ross and his team of colleagues and students from TU/e and Philips Lighting together build for the current edition of GLOW. The installation consists of two parts, where the first part explores interactivity with light, whereas the second part measures to what extent people are affected in their behavior by light. Especially, the huge amount of visitors that each year visit GLOW allows ILI to investigate the impact light may have on guiding crowds.

As scientific director of ILI I'm each year looking forward to ILIAD and GLOW. These events allow the ILI team to meet many colleagues and friends from the lighting community. It also makes me proud to showcase our progress, and I'm always eager to hear and learn more from others that attend both events.

Calendar

November 2017 – May 2018

November 9, 2017
NSVV Workshop Lichthinder
Location: Ede

November 8-10, 2017
Preparation course for European Lighting Expert
Location: TU/e

November 11-18, 2017
Glow 2017
Pay special attention to "Moving Light" the ILI/Philips Lighting installation (number 19 in the route, Stationsweg, in front of The Student Hotel) and to "Switch", an interactive expositon/explanantion on daylight in collaboration with Light Architect Har Hollands and TU/e students under supervision of Mariëlle Aarts (NRE-Nachtegaallaan)
www.gloweindhoven.nl

November 14, 2017
ILIAD Public outreach event 2017
Location: Metaforum, MF 11 and 12 TU/e

March, 18-23, 2018
Light and Building Fair
Participation of ILI with several other European universities, Frankfurt

April 16-17, 2018
OpenAIS Symposium
www.openais.eu

May 20-25, 2018
SID's International conference Display week Los Angeles
Gosia Perz – in kind PhD student at Philips Lighting – will speak at Display Week. She will give an overview on "Visibility of temporal artefacts in LED lighting"
Location: Los Angeles, USA

Expected Spring, 2018
Dutch Commission of CIE (International Commission on Illumination) Info Day, Eindhoven

Smart lighting in a smart society

Authors: Elke den Ouden & Rianne Valkenburg,
TU/e LightHouse

In earlier issues of ILI magazine we reported on the vision and roadmap for urban lighting in 2030 that was co-created with the city of Eindhoven as well as the procurement process that took place as a result.

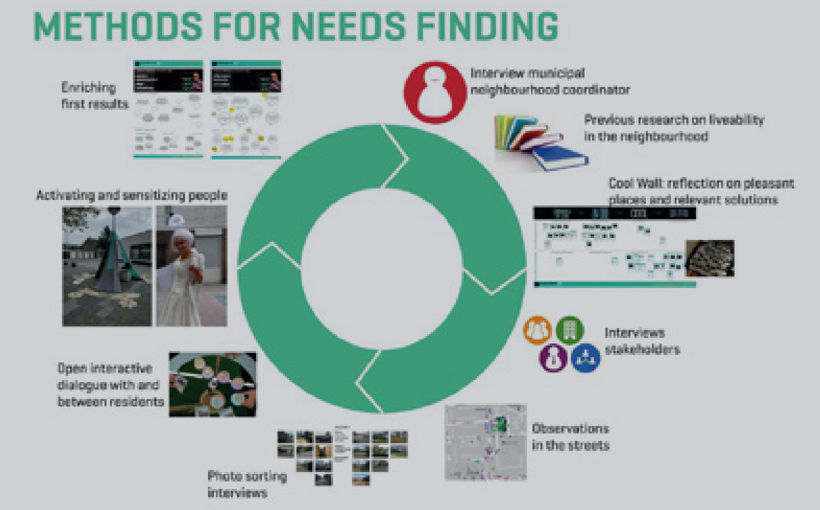
“After a public tender, the project to implement five Living Labs was awarded to a consortium of Philips Lighting and Heijmans. In the coming years these labs will host continuous innovation in co-creation with citizens, local stakeholders, knowledge institutes, SMEs and creative companies.
A connected, sustainable LED lighting grid will be built in each Living Lab as basic infrastructure. These grids will serve as open platforms for new solutions and services provided by the consortium and others.

A similar approach is taken in the five Living Labs, following three steps:

- Identifying the ‘needs & opportunities’
- Generating ‘directions & solutions’ to meet the needs of residents and local stakeholders
- ‘Realisation & learning’ to implement the innovations and reflect on their impact

However, involving people involving people in thinking about innovative lighting solutions is challenging and requires innovative research approaches as well. ILI and LightHouse are developing new methods for this context.

The first Living Lab is in a residential area with a mix of private and social housing: Woenselse Heide West. Citizens are engaged in discussion of the needs and opportunities for smart lighting solutions using a co creative process.
Different methods ensure good representation of citizens and stakeholders and their engagement in the discussion. For example, possible solutions are shown to inspire and create awareness of what the smart lighting grid can do. Interviews were held with social housing corporations staff, local businesses, neighbourhood watch teams and the municipal area coordinator. Pop-up actions in the shopping centre were used to raise awareness of the project (part of a Master graduation project at Industrial Design). Dialogues were held with citizens in the community house and primary school using photos of the neighbourhood to discuss which areas are considered pleasant or less pleasant. Student teams observed the activities in the area during day and evening hours (part of a bachelor course at Industrial Engineering & Innovation Sciences). Some possibilities of smart lighting were demonstrated to let people indicate which solutions they found interesting. Interactive tables with lighted icons enabled creative and interactive dialogues between groups of residents



Note: A more elaborate version of this article was presented at the PLDC Conference in Paris, 1-4 November 2017.

For more information:
www.jouwlichtop040.nl or
www.tue-lighthouse.nl

on what makes a place pleasant, and how that relates to the area (part of a PhD research at Industrial Design).

The findings were analysed and clustered to identify the stakeholders’ needs. These are directly linked to specific areas with improvement opportunities. The identified needs and opportunities are presented in a uniform format, enabling stakeholders to reflect and prioritise. This format described the main theme, enriched by quotes from residents. Each theme is supplemented by specific examples or areas as improvement opportunities.

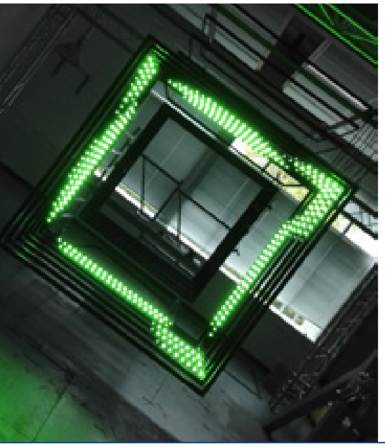
The insights into the specific needs and opportunities in this residential area are taken to the second step in the Living Lab, and used to explore innovative solutions and added-value services. The insights are also used to create a set of selection and ranking criteria for the process of selecting innovations to be implemented in the Living Lab. Here again, residents and stakeholders will be involved in sessions to reflect on the collected solutions and ideas. Their feedback enriches the solutions to better fit the needs. Implementation is not the end of the project – the grid will be used for continuous trials of new services, to adapt to learnings and to extend services. In the next phases and other Living Labs, ILI and LightHouse will further development research methods for smart lighting.

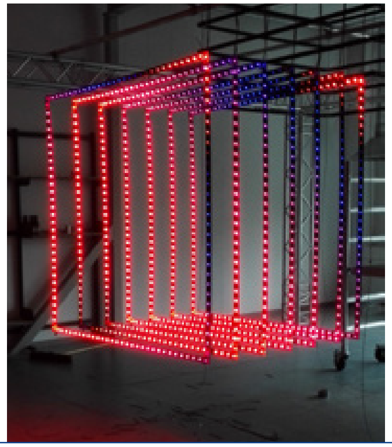
Moving Light @ GLOW 2017

Author: Bert Maas

Light has a large impact in our lives and it affects us on many different levels. Can light move us or influence our decision making?

Last year we presented a GLOW installation called Influx. During GLOW this installation facilitated research on the effect of light on crowd flows. This research was a great success (results will be published soon) and prompted another iteration at GLOW 2017. This time the project will be grander as it will be a collaboration between Philips, the TU/e Intelligent Lighting Institute and the TU/e Crowd Flow Research Group. The collaboration between the various disciplines originates from the common belief that light has great impact in our daily lives. GLOW Eindhoven is the perfect opportunity to deploy a ‘living lab’ in which belief could become knowledge.





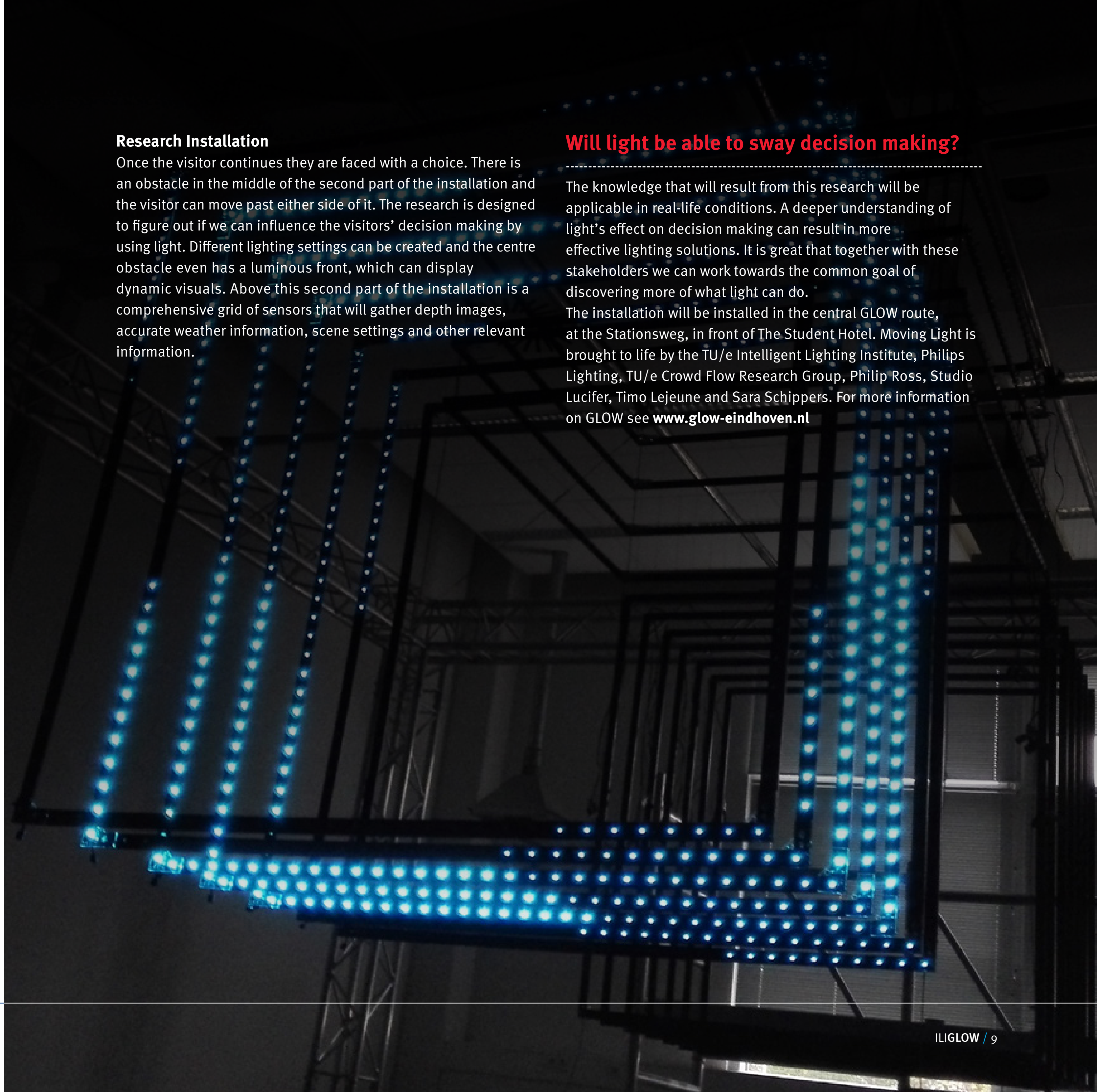
What makes this project unique is its ambitious scale. A research on crowd flow in the middle of one of the largest lighting festivals in the world. This means it will produce unprecedented amounts of data but it also means it is required to be on par with the other lighting installations.

The installation

The installation is called Moving Light. It is over 20meters long, over 5 meters high and designed to accommodate very large audiences. The installation consists of two different parts.

Interactive Experience; Tesseract

The first 11 meters is an interactive experience that lets the visitors move light in a dynamic and playful way. The shape of the interactive experience is inspired by the form of a tesseract or hypercube. A hypercube is a hypothetical concept of another spatial dimension, which in this installation is made dynamic by light. Visitors get to influence this additional dimension through their movements. This massive hypercube is suspended above the visitors and exists of over 350meters of custom LED strips. The complexity of the structure makes for an interesting sight from all angles. The interactivity of this installation is designed in such a way that it works for larger audiences. All visitors can influence the Tesseract’s dynamics. The idea is that this interactive experience will segment the crowd flow and increase the amount of data points in the research.



Research Installation

Once the visitor continues they are faced with a choice. There is an obstacle in the middle of the second part of the installation and the visitor can move past either side of it. The research is designed to figure out if we can influence the visitors’ decision making by using light. Different lighting settings can be created and the centre obstacle even has a luminous front, which can display dynamic visuals. Above this second part of the installation is a comprehensive grid of sensors that will gather depth images, accurate weather information, scene settings and other relevant information.

Will light be able to sway decision making?

The knowledge that will result from this research will be applicable in real-life conditions. A deeper understanding of light’s effect on decision making can result in more effective lighting solutions. It is great that together with these stakeholders we can work towards the common goal of discovering more of what light can do.
The installation will be installed in the central GLOW route, at the Stationsweg, in front of The Student Hotel. Moving Light is brought to life by the TU/e Intelligent Lighting Institute, Philips Lighting, TU/e Crowd Flow Research Group, Philip Ross, Studio Lucifer, Timo Lejeune and Sara Schippers. For more information on GLOW see **www.glow-eindhoven.nl**

ILI Short

OpenAIS pilot installation at Witte Dame, Eindhoven

The OpenAIS consortium is pleased to announce that a pilot installation of an office lighting system, implementing the OpenAIS protocol, will be realised at the Witte Dame building in Eindhoven, in the office of GGD Brabant-Zuidoost next year. This installation will prove innovative work that will bring IoT, Interoperability and Open System architecture to the lighting, building automation and IT industries. ***More info: www.openais.eu***

Studies on shared lighting interaction

Two PhD candidates from Industrial Design, Karin Niemantsverdriet and Thomas van de Werff, have recently completed a study a longitudinal study in the office-lighting living lab at the LaPlace building. By evaluate three different user-interfaces for lighting control they investigated how use and coordination with a shared system can be influenced by designed interface characteristics. *More info: vimeo.com/twerff/sharedlighting*

ZonMw-Off Road

Karin Smolders, Assistant Professor at the faculty of Industrial Engineering & Innovation Sciences, has received funding of ZonMw for an Off-road project “Light to fight addiction”. The project is a cooperation of TU/e, Novadic-Kentron and Philips Lighting.

Course European Lighting Expert

In August 2016, the European Lighting Expert Association was founded by the four lighting associations of Switzerland, Germany, Austria and the Netherlands (see www.europeanlightingexpert.org). This association defines the title European Lighting Expert as a European-wide coordinated level of competence in lighting technology and lighting design. Interested individuals can take the exam offered by the ELEA-member organizations. Each country offers supporting lighting education courses to help preparing for the ELE exam. So far, such courses have been offered in German and Dutch. The Building Lighting group of TU/e has put together the first ELE course in English. This 3 day preparation course addresses all topics relevant for the theoretical part of the ELE exam. The Dutch lighting association NSVV offers exams in Dutch and English. The first course is scheduled for November 2017.

For further info please contact ele@tue.nl

ATLAS project

A new project has been started with subsidies from OP Zuid. The intention of the project is linked to the renovation of the TU/e ATLAS building that has earner the BREEAM certificate “outstanding’. The project will address the challenge of integrating different technologies in the overall building management. Researchers from the Department of the Built Environment will investigate means how to successfully integrate innovative technologies by carrying out validation, optimization and effect studies. For this, four PDEng positions will be created. One of the candidates will look into the lighting situation at the workspaces considering the contributions of daylight from an innovative façade system and electrical lighting from an innovative lighting system.

Workshops, Conferences and Symposia

Alex Rosemann becomes Council member for Lux Europe

The Dutch lighting association NSVV appointed Alex Rosemann as representative on the Council for the European lighting conference Lux Europe. The council supports the organization and planning of this international lighting conference. Lux Europe 2017 took place in Ljubljana, Slovenia with a strong participation from ILI members (5 papers and 1 poster presentation). The next Lux Europe will be organized in Cluj Napoca, Romania in 2021. The conference chair will be Dr. Dorin Beu from the Technical University Cluj-Napoca.

Thematic afternoon: Ergonomy and Light on May 31st, 2017

The Dutch association for ergonomics, Human Factors NL, and the TU/e organizations Intelligent Lighting Institute (ILI) and the Center for Humans & Technology have co-organized a thematic afternoon on Light and Ergonomics with the title “Light in broad perspective – lighting design for all”. This event was held in Dutch and focused on various topics

related to the ergonomics of light. More than 70 participants signed up for the event and represented a good mix of students and researchers from TU/e, members of the Dutch (HFNL) and Belgian (BES) ergonomic organization and guests from private companies.

ILI in press

Alex Rosemann gave an interview (in Dutch) on the findings of the Healthy Homes Barometer 2017 study.
The link is: *https://www.duurzaamgebouwd.nl/interviews/20170721-licht-en-ventilatie-horen-geen-bezuinigingspost-te-zijn*
The interview has been published in July 2017

Video interview with Alex Rosemann by the German journal LICHT (published in April 2017) (in German)
https://lichtnet.de/intelligente-lichtloesungen/#.WVZgwbkUmUl_blank

The Internet of Lighting: download and play!

Interview | Walter Werner interviewed by Michiel de Boer of Moesasji

"It was around 1996 that we at Zumtobel received the first request to connect luminaires to the Internet. Back then it was totally out of reach. It is coming close now," says Walter Werner. The past three years, Werner led the architecture team of the European research project OpenAIS. "I am happy to say we have created an architecture that allows for various types of lighting control, with each single node connected to the Internet."

OpenAIS is an EU-co-funded Horizon 2020 research project, aiming at setting the leading standard for inclusion of professional lighting applications into IoT, with a focus on office lighting. The project brings together a strong collaboration of the leading lighting companies Zumtobel, Tridonic, and Philips, and the major players in Internet of Things-technology ARM, NXP and Dynniq (formerly Imtech). Consortium partner Johnson Controls represents the end-user, and academic knowledge on ICT and system architecture is present through TU/e and TNO-ESI.

Control and atmosphere

Werner: "Internet of Things is all about controls and data, whereas lighting is all about providing an environment and atmosphere. Up till today there was no way to bring these worlds together. OpenAIS was tasked to create and showcase that IoT can be used to provide lighting controls in more or less the same quality as heritage lighting controls, adding the benefits of the internet.
We faced quite a challenge. Internet communication is strictly working one-to-one. If you look up a webpage on your cell phone, it talks to a single server. Of course the Internet has many servers, but the communication is to each individually. With lighting, you want to be able to switch or dim a (large) group of lights at once. To serve lighting best, we had to create group communication that is based on multicast technology. Furthermore we had to cover security, because multicast doesn't support that standardly. We also looked into the negotiation aspect of Internet communications. Again, if you request a webpage on your phone, it will negotiate with the cell tower how to transfer the page (e.g. LTE or 4G) and with the server in what browser and what resolution. Only after this is arranged, the data stream is created to serve the device best. You have to make sure your architecture works on all these levels.
So we worked hard to tackle all the aspects and I think we have covered most of them in a very future-oriented and decent way. We have developed an architecture with building blocks that allows the vendor to build precisely the application he desires. It is like building a bridge: Is it small or large? How much pillars do you need in between? Or should you make a suspension? The range of applicability is as wide as possible but still the architecture gives the rules to achieve interoperability, making sure that it works in the end, across vendors, and that it provides what you want. I am happy that we were able, with experts of so many different companies, to create a common view and common document for a future-oriented architecture. I think that is unique!"

"I am happy to say we have created an architecture that allows for various types of lighting control, with each single node connected to the Internet."

Enabler

Are we ready then for the Internet of Lighting? Werner: "We are progressing steadily. The architecture is published, as well as a database with examples on how to use it. This is open to the public. But in the end we will have to see, if, and when the market, the lighting community, will pick it up. Our approach and architecture have to gain awareness and recognition first. In January 2018 we will showcase our demonstrator. In the Witte Dame in Eindhoven we will feature a project of considerable scale: Some 400 luminaires and 400 sensors, all together more than 1200 functional points, will be controlled in multiple groups over the internet. It is a decent large deployment of both wired and wireless connections, working seamlessly together, including building management integration. The functionality will be alike to what heritage lighting control can do: scenes, switching, dimming and regulations, but strictly based on internet communication to the final node."

Play

What will change by IoL? Werner: "The main development I see is, we can disconnect controls, business and development from the luminaires business. Let me clarify: If I was an engineer that wanted to develop a very specific kind of control, for example a system that follows persons with a spot light, this would be a very specific case for a lighting manufacturer. They rather focus on standard hard- and software, that is industrially efficient, easy to install, to maintain and so on. Today, you are either large enough to build, market and sell your own complete system, or you can forget it. But with IoT you could sell the controls algorithms only, and this way add a specific expertise to the standard offer. You can make it available on top of existing luminaires, you can even place your controls in the cloud and connect them to all systems that are interested in using it. That's what Internet provides. Today's lock-in into larger organizations or standardized technology is gone. IoL provides a completely different way of achieving variety in lighting systems, and it surely will boost ideas we can't even think of at this moment. We will have an AppStore for lighting controls in the future. Just download and play!"

OpenAIS Pilot in De Witte Dame

Authors | Harm van Essen and Thomas van de Werff

The OpenAIS[1] project aims at developing a standard for inclusion of modern LED office lighting into the Internet of Things era. In this way, all the luminaires – with integrated presence and light level sensors – in buildings, are directly connected to the Internet as an IP end-node, allowing for control of individual luminaires from anywhere, using any "Thing". This enables a transition from the currently existing closed and command oriented lighting control systems to an open and service-oriented lighting system architecture.

The vision of the research project is to create an open ecosystem of suppliers of interoperable components and a market for apps and services that exploit the lighting system to add value beyond the lighting function and allow easy adaptability to cater for the diversity of people and demands. Added value can be related to more efficient use of the building, reduction of energy consumption, and increased comfort and wellbeing.

The project brings together a collaboration of the leading lighting companies Zumtobel, Tridonic, and Philips Lighting and the major players in IoT technology ARM and NXP. Consortium partners Dynniq and Johnson Controls represent the installer and the end user. Academic knowledge on system architecture, integration, and user interaction is added by TU/e-ILI and TNO-ESI.

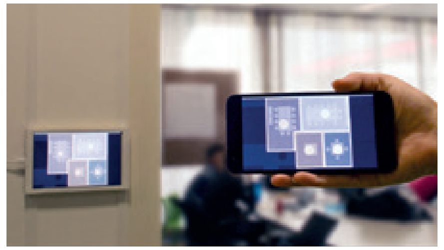
After 2.5 years, a new system architecture is proposed and integration of new hardware components is at full speed. ILI contributed in particular to the development of efficient unicast and multicast wireless communication solutions; referring to addressing a single end-node, and to addressing a group of end nodes all at once respectively. The demands for lighting are high: not only individual luminaires need to be controlled, but often many luminaires need to immediately respond to a single command in a synchronized way.
The OpenAIS design will be validated by a pilot installation in the office of the GGD Brabant-Zuidoost at the 5th floor in the "Witte Dame" (White Lady) building in Eindhoven. This building is a former Philips factory built in 1930 in which light bulbs were made. Renovated by the City of Eindhoven it is now a national industrial monument and in daily use as offices. Other parts of the building house a restaurant, shops, the famous Design Academy and the Public Library.

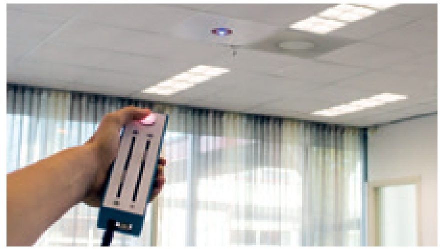
In the last quarter of 2017, 400 LED luminaires of multiple manufacturers, will be installed for a 5-month trial period starting January 2018. GGD can look forward to energy savings, enhanced lighting comfort, and personal controls using apps and dedicated interfaces.

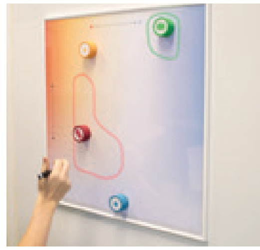
After preliminary studies in TU/e's office labs, ILI will install newly designed user interfaces and personal applications in the OpenAIS pilot installation. The goal is to investigate the opportunities and challenges of personal control for office lighting. Often, personal control in an office is seen as being able to change the light settings of all luminaires individually. But this seems easier than it is: multiple people can interact at the same time, and interactions can change (carefully) selected light settings of others.

Examples of three different interfaces for a shared lighting system that ILI has recently investigated are: (A) an individual smart phone application; (B) a set of distributed remote-like pointer interfaces; and (C) a centrally attached tangible wall interface with tangible tokens.

The pilot at the GGD is a great way of demonstrating and evaluating the newly developed concepts for system architecture and user interaction. One of the next projects for ILI is the installation and actual usage of a similar connected lighting system from September 2018 onwards in the renovated Atlas building at the TU/e campus.







1. *Open Architectures for Intelligent Solid State Lighting Systems. For more information see: www.openais.eu.*

ILI Top publications

Professional Journals

Huiberts, L.M., Smolders, K. C. H. J., & de Kort, Y. A. W. (in press). Seasonal and time-of-day variations in acute non-image forming effects of illuminance level on performance, physiology and subjective well-being. Chronobiology International. *Doi: 10.1080/07420528.2017.1324471*

Smolders, K.C.H.J. & de Kort, Y.A.W. (2017). Investigating daytime effects of correlated colour temperature on experiences, performance, and arousal. *Journal of Environmental Psychology, 50, 80–93.*

Kruisselbrink, T.W., Aries, M.B.C. & Rosemann, A.L.P. (2017). A practical device for measuring the luminance distribution. *International Journal of Sustainable Lighting, 19(1), 75-90.*

van Duijnhoven, J., Aarts, M.P.J., Aries, M.B.C., Böhmer, M.N. & Rosemann, A.L.P. (2017). Recommendations for measuring non-image-forming effects of light: a practical method to apply on cognitive impaired and unaffected participants. *Technology and Health Care, 25(2), 171-186.*

van Duijnhoven, J., Aries, M. B. C., Rosemann, A. L. P. & Kort, H. S. M. (2017). Meinung versus Messung: Wie Nutzer das Verhältnis von natürlichem und elektrischen Licht und die Effekte der Lichtsituation im Grossraumbüro bewerten. *Licht : Planung - Design - Technik - Handel, 69(5), 76-79.*

Maryna Meretska, Ravitej Uppu, Gilles Vissenberg, Ad Lagendijk, Wilbert Ijzerman and Willem Vos (Sep 2017). Analytical modeling of light transport in scattering materials wih strong absorption. *Published in Optics Express (Optical Society).*

Stokkermans, M., Vogels, I., de Kort, Y., & Heynderickx, I. (2017). Relation between the perceived atmosphere of a lit environment and perceptual attributes of light. *Lighting Research & Technology, 1477153517722384.*

Thomas van de Werff, Harm van Essen, Berry Eggen, The Impact of the Internet of Lighting on the Office Lighting Value Network, In Journal of Industrial Information Integration, 2017, *ISSN 2452-414X, https://doi.org/10.1016/j.jii.2017.03.002*

Conferences

Corbetta, V. Menkovski, F. Toschi, Weakly supervised training of deep convolutional neural networks for overhead pedestrian localization in depth fields, 14th IEEE International Conference on Advanced *Video and Signal based Surveillance, 2017, to appear*

van Duijnhoven J, Aarts MPJ, Rosemann ALP, Kort HSM. (2017). Office Lighting Characteristics Determining Occupant's Satisfaction and Health. Proceedings of the LUX Europa 2017 Lighting for modern society, 18-20 September 2017, Ljubljana (pp. 384-388). *Slovenia: Lighting Engineering Society of Slovenia.*

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de Bakker, C., Aarts, M.P.J., Kort, H.S.M. & Rosemann, A.L.P. (2017). Local lighting control in open-plan offices : acceptable or distracting?. *Healthy Buildings 2017 Europe, July 2-5, 2017, Lublin, Poland (pp. 1-2).*

van Duijnhoven, J., de Bakker, C., Aarts, M.P.J., Rosemann, A.L.P. & Kort, H.S.M. (2017). An unobtrusive practical method to derive individual's lighting conditions in office environments. ICNSC 2017 : 14th IEEE International Conference on Networking, *Sensing and Control, May 16-18, 2017, Calabria, Southern Italy Piscataway: IEEE.*

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Atmosphere illuminated

The interplay of light characteristics, light perception and atmosphere

Authors | Mariska Stokkermans and Dr. Ingrid Vogels
Promotors | Prof. Ingrid Heynderickx and Prof. Yvonne de Kort

Artificial light has dramatically changed the way we live today. In western countries, it is available almost anywhere and anytime. However, people are usually not aware of the impact it has on them and, therefore, it is not always used at its best.

Artificial light enhances the visibility of objects, and, consequently, it influences our behavior and performance. At the same time, artificial light influences the subjective impression of a space and the mood of people in that space. Last, it has an impact on biological mechanisms, such as the circadian rhythm. This means that artificial light, when properly used in a space, can make people see better, feel better and perform better. The challenge for light designers is then to create application-tailored lighting designs that fulfill this combination of requirements. They can make use of the tremendous degrees of freedom in LED lighting systems to address this challenge, but to use these extensive possibilities at their best, a solid understanding of the effects of light on humans is needed.

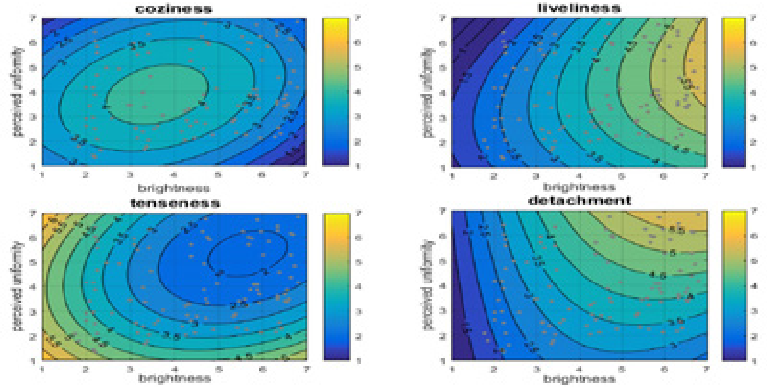


*Figure 2: **Plots depicting the relation between brightness, perceived uniformity, and each of the four atmosphere dimensions (previously published in Lighting Research and Technology (Stokkermans et al. 2017) and re-used with permission).***

An important step in that direction is to understand how light affects the impression of an environment. The PhD project of Mariska Stokkermans, which will finish end of 2017, aims to investigate the effects of light on the affective meaning attributed to a space, also referred to as 'atmosphere'. Literature has shown that people use various terms to evaluate the atmosphere of a space (such as 'relaxing' or 'formal') and that all these terms can be clustered in four main dimensions, namely, coziness, liveliness, tenseness and detachment (Vogels, 2008). Several studies have shown that the impact of light on people's evaluation of the atmosphere of a space can be accurately described by these four atmosphere dimensions, but the relation between light characteristics and the perceived atmosphere is not yet fully understood. To study the relation between light (i.e., daylight and artificial light) and atmosphere in a more controlled and systematic way, high-end computer visualizations (see Figure 1) were used in the current project.

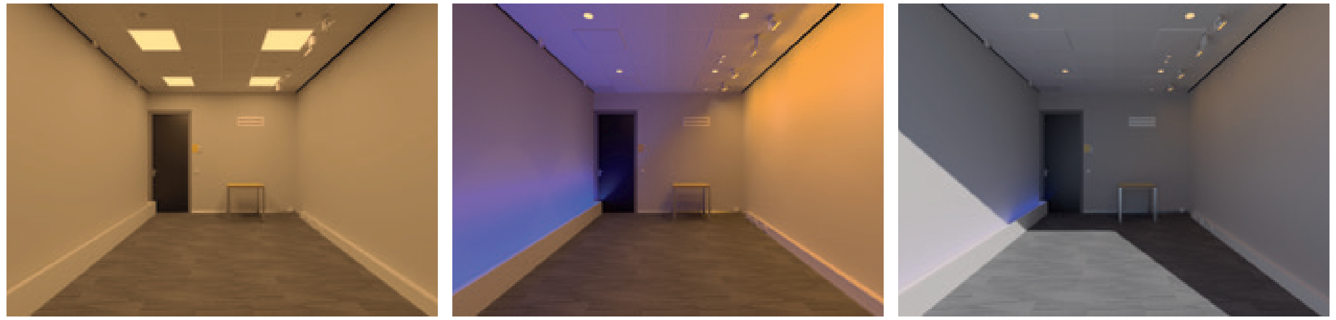


*Figure 1: **Examples of computer visualizations depicting a space with a lighting design.***

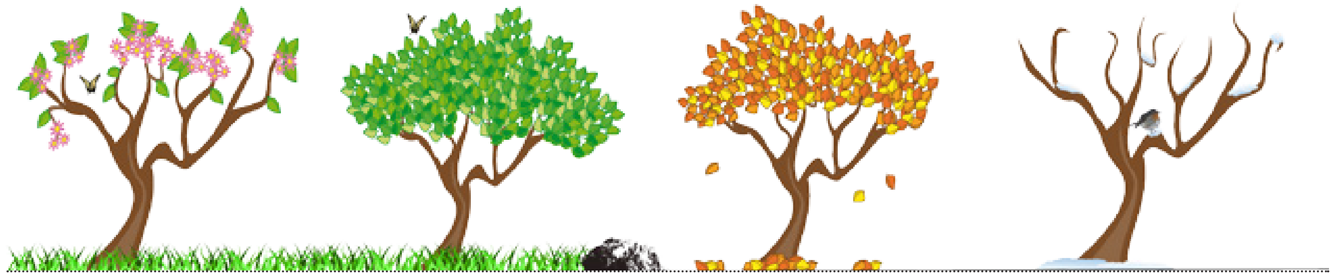
An important outcome of the project is a model relating the four atmosphere dimensions to the perception of light in the space, where the latter is described in terms of brightness (describing the perceived intensity of the light) and uniformity (describing the perceived spatial distribution of the light). This model is depicted graphically in Figure 2, and illustrates that, for example, coziness is a U-shaped function of brightness and perceived uniformity. So, a space is most cozy at intermediate brightness and uniformity values. Increasing the brightness of the light makes the space livelier; making the light perceptually more uniform makes the space more formal (i.e. detached). The model predicts what the light should look like for a given intended atmosphere. However, to actually create a lighting design, one has to know the relations between brightness and perceived uniformity and the physical light in the space. The latter relations also turn out to be very complicated, since several descriptions of the physical light distribution, existing in literature, did not accurately describe our results.

How light is perceived is strongly influenced by the adaptation state of the observer. Adaptation is a mechanism that adjusts the sensitivity of the visual system to the surrounding light. Although light/dark adaptation has been studied for over a century, it is still unknown how the visual system adapts to spatially non-uniform light distributions. Usually, the average of the light intensity in the entire field of view of an observer is used to determine the adaptation state. This PhD thesis introduces a model describing the time course of dark adaptation for non-uniform light distributions falling on the retina; in this model adaptation is more strongly affected by light falling on the retina close to the line of sight than by light in the periphery of the field of view. This is a second important outcome of the work. The model is crucial for designing comfortable and safe lighting atmospheres, in which people can distinguish relevant luminance differences, for example during driving at night. It may also improve the accuracy of describing perceived light in a space.

Therefore, this PhD project has made a significant step in creating application-tailored lighting designs based on human perception of light and atmosphere.

Optimizing alertness and cognitive performance with indoor lighting: **mind the season!**

The study was conducted in a simulated office environment at the lighting laboratory of the IPO building. Savio ceiling luminaires were used to create the desired lighting conditions.



Author | Laura Huiberts

Indoor lighting is something we take for granted. As we spend more and more time indoors, we simply need artificial light for optimal vision, especially when limited daylight contribution is present in a room. Indoor lighting also offers us the possibility to artificially extend our days until after sunset.

Research has already shown that, as a consequence of evening and nighttime exposure to artificial light, we can delay our circadian timing. This means that we sleep in later and wake up later as well. In addition to these influences on our sleep-wake pattern, light can also acutely affect our state of well-being. Numerous studies on these so-called acute non-image forming (NIF) effects of light have shown that relatively bright indoor lighting can acutely increase our alertness and even influence our cognitive performance. However, overall findings are quite inconsistent, showing either null, positive, and even some negative effects of bright compared to more dim or regular indoor lighting on cognitive performance during the daytime. In a large controlled laboratory study we have recently investigated whether the season may influence the strength and/or direction of these acute NIF effects of light.

The hypothesis that acute NIF effects of light on subjective well-being and cognitive performance may depend on the season is not very far-fetched. That is, during the winter period at higher latitudes, many of us can experience light deprivation during the winter period. Days are short, it is usually very cloudy, 'dark' weather, and in combination with spending most of our time indoors this can result in limited light exposure during the day. However, season-dependent, mainly long-term, benefits of bright indoor light exposure have only been tested in participants who showed symptoms of Seasonal Affective Disorder (SAD) using light therapy in winter. Yet, it is not unlikely that also healthy people may benefit from some extra daytime light exposure in winter. Whether season-dependency plays a role in acute NIF effects of light in healthy participants was investigated in our lighting lab located at the TU/e IPO building.

We conducted the same laboratory study testing acute NIF effects of 1-hour bright compared to regular office light exposure in two groups of participants respectively in spring and in autumn/winter. Participants came to the laboratory on two separate days within one season where they were exposed to either regular indoor office lighting (165 lx at the eye) or bright light exposure (1700 lx at the eye). During this hour, participants repeatedly completed a sustained attention task and a working memory task. Moreover, they reported on their state sleepiness, vitality and mood at the end of the light exposure.

In line with our hypothesis, the results of this study revealed that acute NIF effects of the light manipulation were significantly stronger in autumn/winter compared to spring. This was only the case during the morning hours, but not during the afternoon hours. Participants felt less sleepy, more vital and performed better on a vigilance task when they were exposed to bright compared to regular light in autumn/winter. These improvements were not observed in the study conducted in spring, indicating the potential benefits of morning bright indoor lighting in autumn/winter but not in spring/summer. This seasonal influence on the occurrence of acute NIF effects may also partly explain previous inconsistent findings between studies.

The results of this study provide important input for designing healthy dynamic lighting in buildings, especially at the work place where employees generally spend most hours during the daytime. Based on the current findings, it can be concluded that the timing of the light exposure during the day and over seasons is essential to consider in order to establish most beneficial effects of intelligently tuned light settings for well-being and cognitive performance.

DataSpark: Making the AnTUenna interactive

Author | Philip Ross

At the outset of Glow 2016, the old industrial chimney on the TU/e campus transformed into the AnTUenna: a 70m high, LED equipped light beacon showing beautiful animations inspired by TU/e's endeavours into science and technology. Since then it has lit up many evenings and reached numerous people on campus and in the city.

Already at that time, it was clear that the AnTUenna had the potential for more than showing fixed animations. The eventual goal was always to make the AnTUenna interactive. In spring, I worked with a group of Bachelor Computer Science students doing their final Software Engineering Project (SEP) to achieve just this. These bright students created the application DataSpark, which opens up the AnTUenna to a whole new realm of possibilities. In short, DataSpark provides a way to incorporate data from external sources, it offers a platform to create animations responding to that data, and it enables live streaming of those animations to the AnTUenna.

Incoming data can be anything extractable from the TU/e network or the Internet: from general weather data, to real-time energy usage at campus, to data from IoT sensors, to data from social media. DataSpark supports designers to create animations based on this incoming data. For this purpose it includes a number of pre-programmed functionalities in Processing, a programming language that is widely used for creating animations. Before streaming a live animation to the LEDs on the chimney, DataSpark offers a preview functionality. This is an on-screen 3D visualisation of the chimney, with a slider to manually simulate a range of data values. This way a designer can evaluate the animation's behaviour before it is revealed to the outside world. Last but not least, DataSpark includes a scheduling option. This is for the convenience of the current content directors of the AnTUenna, the Communication Expertise Centre. Any kind of content, interactive or standard, can be scheduled for months ahead. As a proof of concept, the DataSpark students made an animation that responds to the Twitter Hashtag #AnTUenna. Every tweet to the AnTUenna was greeted by fireworks. The more tweets, the more visual treats.

With its new functionalities, DataSpark opens up a wide variety of new communicative roles the AnTUenna can play. Honours student Fenna Wit took the concept of the interactive chimney into the TU/e and Eindhoven community and explored with them what kinds of interactions they found valuable. She encountered much enthusiasm from different directions. Some dreamt of the chimney expressing how many people crowd the campus, to allow people to experience the increasing liveliness of the campus over time. Others saw a good way to visualise how much green energy is generated on campus each day. An Eindhoven city marketeer envisioned the AnTUenna to be a thermometer of the 'mood of Eindhoven', based on data from the Social Media analyst company Coosto. A game developer pitched the idea to create an artistic game, in which people all over Eindhoven could make a dynamic artwork together through a web app. The list goes on and on, and many of these concepts are now much closer to reality thanks to the work of the DataSpark team.

I would like to close off by expressing thanks to the involved students for their enthusiasm and efforts. Thanks also to Tonny van Lankveld, Joe Joe Wong and Smartlight for ICT support, and to Lou Somers for organising the SEP course.

DataSpark was created by students K. Akba, J.C.R. Conquet, J. Donners, R.F. Ferrer, L.J.D. Godtschalk, C. Jansen, W. Kroneman, M. T. van Liemt, A.F. van der Pol and E. Sharma, supported by S. Luijten and W. de Ruiter. Computer Science Supervisor was Ö. Babur.

Analysis Tool for the Luminance Distribution Measurement Device

Authors | Thijs Kruisselbrink, Rajendra Dangol, Alexander Rosemann

Multiple applications in building lighting can be optimized using luminance distribution of the surroundings. Existing, and commercially available luminance distribution measurement devices are not suitable for broad application among other things due to their high price. We developed a luminance distribution measurement device, based on a Raspberry Pi and camera system, that is suitable for broad application, we refer to it as the Bee-Eye.

The Bee-Eye makes use of the High Dynamic Range (HDR) technology, because it allows capturing luminance range occurring in real scenarios. The luminance is determined by capturing High Dynamic range images and translating the RGB information to the CIE XYZ color space. The calculated luminance is represented according to established method in the field of daylighting. With this hardware and technology we were able to determine the luminance distribution with an accuracy ranging from 5% to 20% (worst case) which was deemed acceptable for practical measurements and broad applications in the building realm. The Bee-Eye functions autonomously and is accessible from distance by SSH[1]. However, as we have no background in computer science the software was suboptimal. We seized the opportunity to collaborate with the TU/e Software Engineering Project (SEP) that was in need of topics, to improve and add some additional functionalities to our software.

Collaboration

During the SEP project 10 students worked for one quartile on improving the source code and adding additional features to the software of the luminance distribution measurement device. The project was called Luminance Analysis Software System (LASS). In collaboration with us the students developed 137 user requirements that were prioritized according to the MoSCoW model [2]. During the weekly demo sessions the students showed which user requirements had been implemented in the previous week and discussed a plan forward for the coming week. In a final acceptance test the developed software was put to a test in order to check whether all requirements were met and whether they worked.

Product

In the new developed software the HDR images are captured with the Raspberry Pi and are subsequently sent to the database located on a server via a Wi-Fi connection. The actual calculations to achieve the luminance values of all pixels are carried out on the server. These luminance values and the original HDR images are accessible by the new web portal (Figure 3). The web interface can plot numerous metrics within a live graph (Figure 4); from there, all the data can be extracted by a single button. With the help of the web interface we are now able to remotely start and stop a measurement or schedule one at a later time. Another new feature introduced during the LASS project is the ability to add free form masks to the measurement device to extract the luminance distribution of a specific area within the HDR images.

Future Use

We aim to use the developed software in long-term measurements in living labs with the objective to develop quantified models for the image forming effects of light as part of the ILI research project OptiLight [3]. The anticipated measurements will take place in office spaces and will continuously record the luminance distributions. The goal is to form recommendations on how to achieve high quality lighting via a big data analysis approach. The measurements allow the inclusion of aspects such as but not limited to absolute luminance, glare, luminance distribution, directionality and the dynamics of lighting scenes. This software from the LASS projects will help us keep an eye on the measurements live but without the need to enter the measurement space. This also enables us to carry out quick first analyses “on the fly”. We like to thank the students (Team LITT) for their enthusiasm and hard work.

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Figure 1: The luminance distribution measurement device, also referred to as Bee-Eye

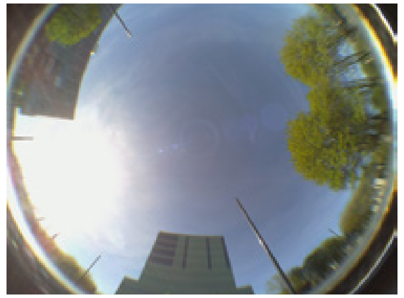

Figure 2: A tone mapped HDR image of the TU/e Campus

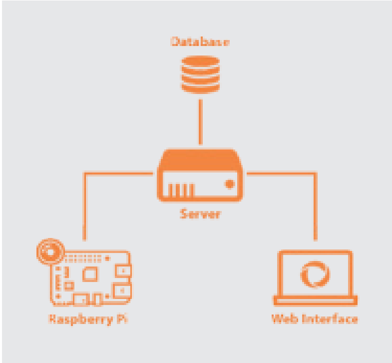

Figure 3: Structure of the new software

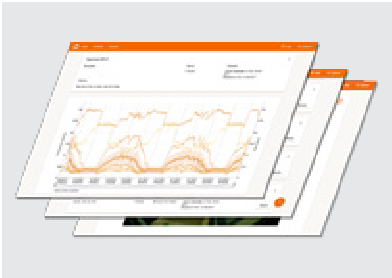

Figure 4: The web interface of the developed software.

ILI Short

Professor Yvonne de Kort Lecturer of the year

At the opening of the academic year, Rector Magnificus Frank Baaijens presented several nominees for the Educational Award Master. Professor Yvonne de Kort and professor Alex Rosemann, both leading senior professors in one of the key research programs related to ILI were both nominated. Yvonne won.

In her pitch Yvonne de Kort spoke about how she has developed as a lecturer. “First of all I had to discover my passion for my field, then I set about turning abstract theories into something concrete. At a later stage I paid more attention to my interaction with students and after that my lectures became more personal. Now I work in a very reflective way, wondering things like: apart from my own enthusiasm, what helps students the most?”

The Master's lecturer of the year feels that teaching is like a live concert. “You can listen to music on a CD, but being present in person makes it something much more special. Together the audience and fans make the experience, just as the lecturer and students work together to produce a good lecture.” ILI congratulates both Alex and Yvonne and is proud to have such good teachers in their institute.

ILI PhD Defenses

Thomas Mayfroyt - November 22, 2017
Thesis defense: ‘Threshold-Based Communication Algorithms for Large-Scale Mesh Networks’

Bart van Lith – December 13, 2017
Thesis defense: 'Principles of computational illumination optics'.

Laura Huiberts – February 8, 2018
Thesis defense: ‘Diurnal indoor light exposure in day-active persons: optimizing effects on cognitive performance and subjective well-being’

Mariska Stokkermans – expected spring 2018
Thesis defense: ‘Atmosphere illuminated - The interplay of light characteristics, light perception and atmosphere’

Bernt Meerbeek best PhD researcher of Built Environment
Bernt completed his PhD degree “cum laude” for his thesis entitled: "Studies on User Control in Ambient Intelligent Systems" in 2016 (ILI Magazine 2017 Spring edition). His promotors were prof.dr. Evert van Loenen, prof.dr. Emile Aarts and prof. dr. Alex Rosemann. Bernt has received the prize best PhD research of the Department of the Built Environment.

Visiting Berkeley

Author: Christel de Bakker

Currently, I work as a visiting researcher at the Lawrence Berkeley National Laboratory (LBNL). Last year I won a Fulbright Scholarship as well as the COINS grand challenge prize, which enabled me to work in this highly inspiring environment. Although I work in a cubicle where my view is limited to its four walls, I do have a very nice view from the roof of my building (see picture).

Unfortunately, daylight does not reach my cubicle, but that gives me reason to go up to the roof several times a day. That same cubicle actually formed the reason why I wanted to spend six months here: to investigate whether office lay-out affects whether luminance changes distract users from their work. I will replicate a field study that I already performed in the Netherlands and compare the results. In addition, I want to work on a project with researchers here. I already have been meeting many researchers to explore where I could fit in, both at the LBNL and at the University of Berkeley. I also visited the California Lighting Technology Center, where prof. K. Papamichael gave me a tour around all their testing facilities. That is like a playground for lighting researchers: they have all the new lighting technologies and measurement devices, very impressive! One day a week I spend with the group Center for the Built Environment at UC Berkeley. They are focusing on users comfort in buildings, which combines perfectly with the energy driven research at LBNL, as in my PhD I tried to find a balance between these two objectives. Every Wednesday a visiting scholar provides a lecture to the group at UC Berkeley, so I get a lot of new insights. At the LBNL there are also regularly lectures from highly acknowledged researchers. All in all, this environment is highly inspiring and I feel lucky that I can work here for another five months!

Picture 1: View from the rooftop of my building at the Lawrence Berkeley National Laboratory (I can see the Golden Gate bridge at clear days)

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