ILI 2018

Intelligent Lighting Institute | Edition 9, May 2018

/ A light cooperation

/ Moving light

/ Exploring the psychology of lighting

/ ILIAD 2017

/ The Fontys design masterclass

/ And more....

TU/e Technische Universiteit **Eindhoven** University of Technology

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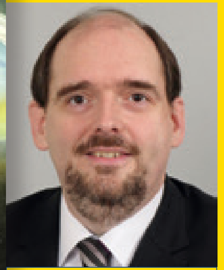
Intelligent Lighting Institute

Harold Weffers | Operational manager



Harold Weffers //
Operational manager ILI // Coordinator External Partnerships & Relationships of Department of Mathematics and Computer Science TU/e

Welcome

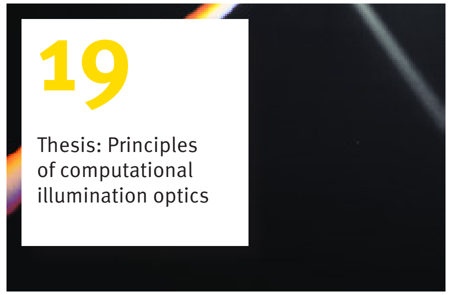
I am extremely pleased to present to you another new edition of our ILI Magazine. Since the last edition in November 2017 much has happened and I hope that after reading the various contributions in this magazine you will agree with me that once again many exciting and promising developments have been 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 excellent examples of collaboration between ILI and industry in the context of R&D (Postdoc/PhD projects), education (TU/e Innovation Space) and valorisation (Mosa and GLOW).

Pleasant reading!

ILI2018 CONTENT



Editorial // ILI Magazine 2018 is a biannual edition of ILI for ILI members, colleagues, collaboration partners, policy makers and related companies // ILI Magazine 2018 is published in May // Editorial Staff - Harold Weffers, Marlies Bergman // Design - Volle-Kracht concept, ontwerp en organisatie // Illustrations - ILI, Photography - Bart van Overbeeke Fotografie, Philips Communications, Satyaki Chaudhuri // Article contributions - Moesasji & 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 gains visibility

In the first eight years of its existence ILI mainly focused on being visible at the regional level. We invested time and effort in creating a research community within TU/e, bringing together scientists from six different departments and combining the related disciplines to create intelligent lighting solutions. During the last years ILI's research program focused on strategic alignment with Philips Lighting, our main industrial partner in research, situated near us at the High Tech Campus of Eindhoven. Together with our partners we established new (research) lighting infrastructure at the TU/e campus, such as the Groene Loper, the Markthal, AnTU/enna, GLOW installations and later this year the renovated Atlas building.

All these activities are now running smoothly, and so ILI is ready for the next step, spreading its wings. Our ILIAD outreach event already broadened its scope during the last two years, offering a full-day program including international invited speakers, and this has resulted in an extension of our network and in new international research collaborations. We were offered the opportunity to have a booth at the big international Light & Building fair last March in Frankfurt. We accepted that offer, since we are convinced that it will improve our visibility to the international lighting community even further. Our increased visibility is already evidenced from the more frequent external requests to visit ILI. As an example, we hosted on April 13 a delegation from Lighting Metropolis, a program of lighting projects in nine cities of Denmark and Sweden. And, for some years now, ILI representatives, more particularly Prof. Rosemann, are the linking pin between the International Commission of Illumination (CIE) and the community of Dutch lighting designers. In relation to this, Prof. Rosemann organized a CIE information day at our campus last January.

Ingrid Heynderickx // Scientific Director ILI // Dean Department of Industrial Engineering & Innovation Sciences TU/e // Professor Applied Visual Perception TU/e and Guest research professor Southeast University of Nanjing (China)

In the future we want to spread our wings even further. Our lighting (research) infrastructure receives increased attention, and we currently explore options to collaborate with third parties, as such augmenting the efficiency of the use of the infrastructure. Also for our research programs, we actively explore options to enlarge the eco-system. Obviously, Philips Lighting will remain an important strategic partner, but together with them we want to broaden the collaboration network, as such improving the chance of bringing relevant intelligent lighting solutions to society.

Calendar

May 2018 – November 2018

May 16, 2018 International day of light, World-wide (UNESCO)

International Day of Light 16 May

May 23, 2018 OpenAIS Consortium will present its project result *Location: De Witte Dame, Eindhoven* Please register on **www.openais.eu**

June 12 and 13-14, 2018 CIE Division 2 Seminar and Annual – and TC meetings *Location: Eindhoven*

June 18 & 19, 2018 FEI Europe - ILI PhD candidate at Philips Lighting Research Kati Brock is keynote speaker Light The Way For Smart Cities: Lessons in Business Model Innovation From Philips Lighting *Location: Clarion Hotel Stockholm, Sweden*

August 16-17, 2018 LumeNet 2018: a research methods workshop for PhD students of lighting, color, daylight and related subjects. *Location: Copenhagen, Denmark*

August 26-30, 2018 International Ergonomics Association (IEA) 2018 *Location: Florence, Italy*

September 9-12 LICHT 2018 NSVV *Location: Davos, Switzerland*

September 12-15, 2018 Metropolis: by Light International Conference & Living Lab Tour *Location: Malmö, Sweden*

September 18, 2018 Mini-symposium on Monge-Ampere equation *Location: Eindhoven University of Technology*

October 20-28, 2018 Dutch Design Week *Location: Eindhoven*

November 10-17, 2018 Glow festival, Eindhoven

November 13, 2018 ILIAD Public Outreach Event 2018 *Location: Campus TU/e*

A light cooperation:

Mosa and the Intelligent Lighting Institute of TU/e

Philip Ross of ILI and Mosa create an award-winning communication campaign

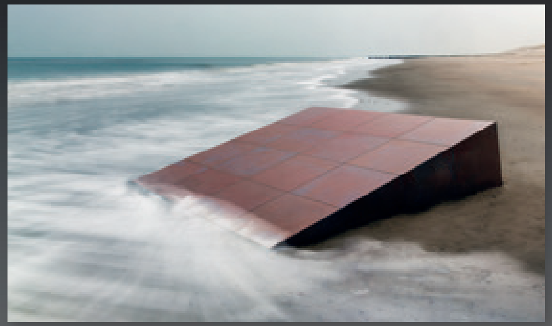
Simon Platz // Market Manager at Royal Mosa // Project leader for the international product introduction of Mosa µ

Author | Simon Platz

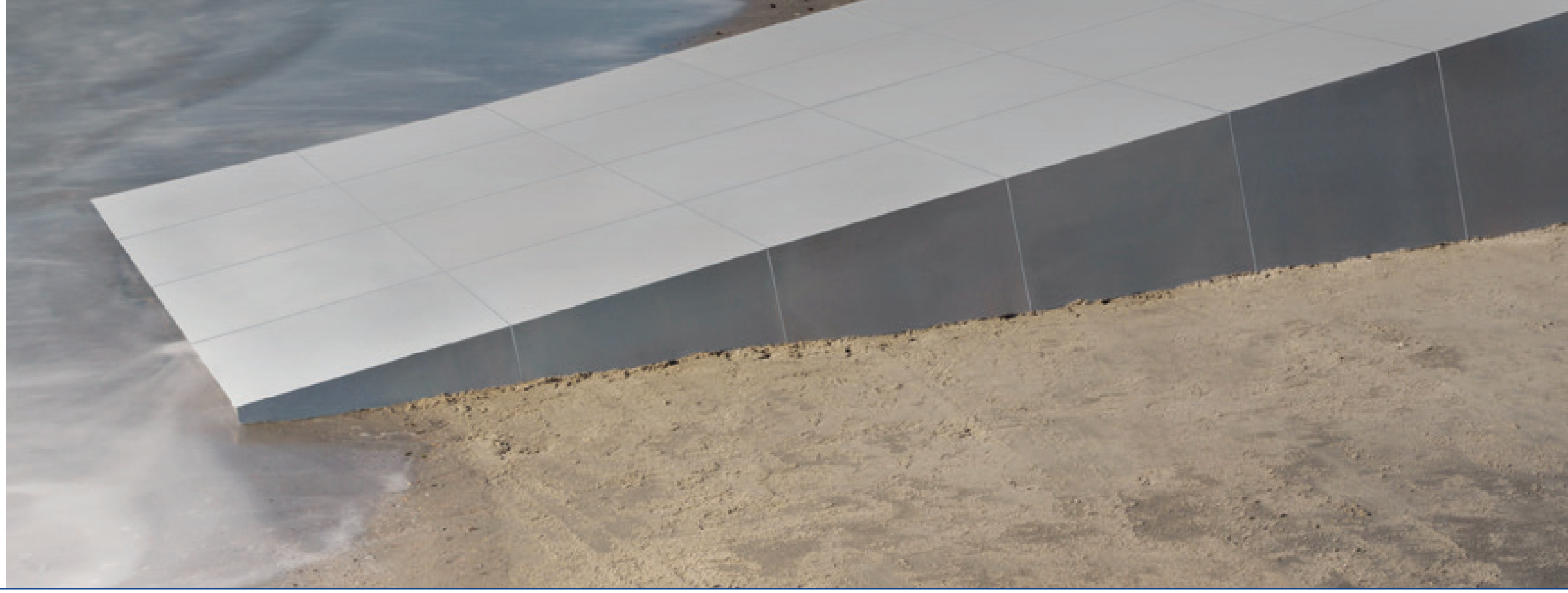
Mosa µ [mu] is a very special tile series. Each tile changes its appearance depending on the light that hits the tile. If the light changes during the day or if a cloud hides the sun, this will result in a different look of the tile. With this play of light, Mosa µ always looks slightly differently and creates a very special, very lively effect in the room. But: How do you communicate this effect in a brochure or on the website other than explaining it in words? How do you produce this effect without being dependent on the natural development of the light during a day?

Mark Trommelen, Industrial Building Product Developer at Mosa, remembered his time at TU/e and made the connection between Mosa and Philip Ross, Interactive Lightning Designer. Philip is a project leader for the Intelligent Lighting Institute at the university. He took the challenge of creating a lab scenario which could re-create the effect that light would have on the µ tile during the day.
For Philip as an interactive lighting designer, design starts from the impact that the lighting has on space and on people. Mosa µ is a product that could stand proof of this philosophy. Already in the first meeting it was clear that Mosa, Philip and the Intelligent Lighting Institute would be a perfect match. Philip created a scenario which exactly mimicked the change of light during the day. It shows the lapse of time over 24 hours – and the effect that the changing light has on the look of the floor. Within the solution, it was important that, although everything now happened in a "controlled" environment in the lab, it still showed a natural and realistic effect. What sounds rather easy now was actually a very complex task, which needed at lot of attention to small details.

Leandre la Fontaine, Brand Manager at Mosa: "This was a real challenge for us. The subtle effect that light has on Mosa µ is key to the overall product. Therefore, it also plays a major role in our communication. Our aim was to create an effect that is as close to the real-life situation as possible. Philip has done a great job in achieving this."
Now, the visualizations that Philip created are part of the brochure, flip books and the Mosa website. The brochure and the website feature the time lapse of 24 hours. In addition, the website shows the changes in µ tiles depending on different viewing angles and different environments.



Architects and designers as well as prospective customers can get a very good impression on how the µ tiles will subtly change their appearance during the day.
Since the launch, Mosa µ tiles and the communication about the series have been a success – which has not the least been proven by winning the renowned ret dot award for the tile as well as the brand design. As the jury committee put it: "Starting from the name-giving letter µ of the Greek alphabet, the entire communication is aimed at visualising both the underlying inspiration and the experimental aspects."
This inspiration - born out of Mosa's deep understanding of the world of ceramics, comes from the extraordinary relationship between illumination and the colour spectrum. Nature, art, and trends in architecture, as well as ancient Greek philosopher's vision on colour and light, played a pivotal role in the creation of µ.
Inspiration and experiment: Those two words are not only a good description for the communication about µ and the tile itself. They are also a good description of how the cooperation between Mosa, the Intelligent Lighting Institute of TU/e and Philip Ross went. Without inspiration and the willingness to experiment to get to the best result, this project would never have come to life.



Perception of temporal light artefacts

Modelling the visibility of flicker and the stroboscopic effect

Gosia Perz // PhD candidate Human Technology Interaction of the Department of Industrial Engineering & Innovative Sciences TU/e // Scientist at Philips Lighting in the group Lighting Experience

Author | Gosia Perz
Promotors | Dr. Dragan Sekulovski, Dr. Ingrid Vogels, and Prof. Ingrid Heynderickx

The world of artificial lighting is now being transformed to solid state lighting (SSL), primarily based on light emitting diodes (LEDs). While the key motivation behind the rapid replacement of conventional (incandescent and fluorescent) sources with LEDs is energy-efficiency, the versatile capabilities of the latter bring entirely new functionalities to lighting systems, changing the ways in which we use light. LED-based sources can be very small, they have bright light output, the spectrum of which can be almost arbitrarily tuned, and the light output can be changed at a very fast rate. The consequences of this rapid change rate is the focus of my PhD project. I expect to finalize my thesis in 2018.

LEDs respond almost instantaneously to the driving current, implying that a modulation of the current is converted into a modulation of the luminous output. This allows for unique functionalities, for instance one can transfer data via LED light output, a method known as visible light communication. However, modulated luminous output can also result in unwanted visible effects, such as flicker. Different kinds of unwanted changes in the luminous output can occur, and collectively they are called temporal light artefacts (TLAs). Studies in this area show that exposure to TLAs not only impacts our perception of lighting quality, leading to annoyance and irritation, but that it may also have a negative impact on our well-being; for instance, it can lead to fatigue, and it can trigger migraines. It is known that TLAs can be prevented by suppressing the modulation in the light output of LEDs, however this typically requires a trade-off with aspects as cost, size, lifetime or efficiency. As a result, there are many low-quality-lighting LED products available on the market. The challenge is to find out which modulations of the luminous output do not give rise to visible TLAs, and at the same time, do not compromise on these other aspects. Therefore, this PhD project aimed to understand the occurrence of two different TLAs, namely flicker and the stroboscopic effect, and to model their visibility for conditions representing a realistic worst-case scenario of a typical office environment. Whilst the concept of flicker is generally well understood, the definition of the stroboscopic effect is less obvious. Figure 1 shows the set-up used in the perception experiments to measure the visibility of the stroboscopic effect. The left image shows a static disk with a black surface and a white spot. When the disk rotates and is illuminated by

Figure 1: (left) A disk with a black surface and a white spot, (middle) an impression of the appearance of the rotating disk under non-modulated light, giving rise to the perception of a blurred image, and (right) the rotating disk under modulated light, resulting in a visible stroboscopic effect.

a constant light output, the white spot appears blurred (as in the middle image). However, when the rotating disk is illuminated by modulated light, a row of multiple dots may be perceived, which is known as the stroboscopic effect (as in the right image).

Since the temporal behaviour of the luminous output of LEDs can widely vary, virtually an infinite number of different kinds of temporal modulations may occur. Therefore, quantifying the visibility of TLAs requires a fundamental approach that starts from human visual perception. Under the assumption that the human visual system behaves linearly in the proximity of visibility thresholds and based on the results of over 10 psychophysical experiments, three measures to quantify the visibility of TLAs have been developed and validated. Basically, they consist of the following two steps: (1) applying a human vision filter to the luminous output, and (2) summing the energy in the filtered signal, where the latter is computed either in the frequency or the time domain. The exact definitions of these measures can be found in several journal and conference publications. The visibility measures developed in this PhD project can be used to objectively quantify the visibility of flicker and the stroboscopic effect, and as such to support the design of LED light sources that balance good temporal light quality with optimal other aspects, such as cost or efficiency. It is worth emphasizing that, resulting from joint efforts with a standardisation project, the stroboscopic visibility measure (SVM) is now recommended by the International Commission on Illumination (CIE) to quantify the perception of this effect. It has also been implemented in a few, commercially available products, like the UPRTek, shown in Figure 2. This is a device that measures the modulation in the light of an environment, and indicates the related SVM.

References:

Perz, M., Vogels, I. M. L. C., Sekulovski, D., Wang, L., Tu, Y., & Heynderickx, I. E. J. (2015). ***Modeling the visibility of the stroboscopic effect occurring in temporally modulated light systems. Lighting Research & Technology, 47(3), 281-300.***

Perz, M., Sekulovski, D., Vogels, I., & Heynderickx, I. (2017). ***Quantifying the visibility of periodic flicker. LEUKOS, 13(3), 127-142.***

Perz, M., Sekulovski, D., Vogels, I., & Heynderickx, I. (2018). ***Stroboscopic effect: contrast threshold function and dependence on illumination level. JOSA A, 35(2), 309-319.***

Figure 2: An example of a commercially available product, (UPRTek) which implemented Stroboscopic Visibility Measure (SVM).

ILI Short

New ILI PhD - Lotte Romijn

“After completing my Master’s degree in Applied Mathematics at the University of Melbourne, Australia, I moved back to the Netherlands and started my PhD at TU/e in Eindhoven. My work is in the field of illumination optics and involves the design of free-form reflector and lens surfaces using inverse (Monge-Ampère based) methods.

The main goal of my research is to calculate the optical map that transforms a given energy distribution at the source to a given energy distribution at the target. Currently I am extending existing algorithms to calculate the optical map for a mirror/lens that transforms the energy of a point source to a desired far-field energy distribution.

Another aim of this project is to look at the relation between calculating an optical map with the `optimal mass transport problem’. To each optical system we can attribute a different cost function for the rearrangement of the source energy or mass into the target energy or mass. The goal is to generalize current algorithms to a wide set of optical systems by taking as input the corresponding cost functions in the optimal mass transport problem.”

Mariska Stokkermans' all female graduation

We congratulate ILI PhD graduate Mariska Stokkermans on her doctorate "Atmosphere illuminated: the interplay of light characteristics, light perception and atmosphere". Mariska got her PhD from Prof. dr. Ingrid Heynderickx and was supervised by Prof.dr.ir. Yvonne de Kort and dr. Ingrid Vogels. The committee members were Prof.dr. Sylvia Pont S.C. (TU Delft), Prof. Dr. Joyce Westerink and Dr. ir. Martine Knoop (TU Berlin). Mariska is the first TU/e PhD graduate supervised by three female supervisors and assessed by a committee of three female experts.

Visit of Lighting Metropolis to ILI

A group of 25 Danish and Swedish lighting designers, smart city experts, city planners, researchers and other professionals within lighting and smart city development visited Eindhoven from 11-13 of April. They chose Eindhoven because it is, as they call it, one of the most interesting cities in the world within the fields of lighting for people, smart city lighting, biological lighting and climate and environmental lighting After their visit of the municipality of Eindhoven and Philips Lighting, they stopped at TU/e and listened to presentations of Ingrid Heynderickx, Philip Ross, Alessandro Corbetta and Harold Weffers.

ILI present at Light & Building Fair 2018

For the first time ILI participated at the Light & Building Fair in Frankfurt. We had a joined stand with several European universities. Elke den Ouden, Rianne Valkenburg and Rajendra Dangol manned the ILI booth.

Alexander Rosemann

Alexander Rosemann has become co-convenor for the Joint Technical Committee of CIE and ISO: ISO/TC 274/JWG 1 “Energy performance of Lighting in buildings”. This standard will be applicable World-wide and is also in line with strategic goals of TU/e department of the Built Environment as it will help towards a Sustainable Transformation of the Built Environment.

ILI PhD defense

Carmela Filosa - May 30, 2018 Thesis defense: ‘Phase space ray tracing for illumination optics’

Marielle Aarts

ILI in the media

In the December edition of **ALLICHT** Mariëlle Aarts talked about the possible cooperation between the NSVV and SOLG (Stichting Onderzoek Licht en Gezondheid). Aarts is chairwoman of SOLG (a group of volunteers who deals with medical-scientific knowledge on the importance of light for the human well-being). *ALLICHT, December 2017 page 27-29*

22 January, 2018, **Elsevier Connect**, “Elsevier actively supports programs that foster international collaboration, among which the prestigious Fulbright Scholar Program. It gives PhD candidates an opportunity to study with the top research teams in the US for six months. Christel de Bakker was one of the two 2017’ recipients; in an interview she explained that she went to the US to study the influence of office culture on lighting perception.” *www.elsevier.com/connect/helping-phd-students-collaborate-internationally-with-fulbright-elsevier-partnership*

In February, 2018 Alex Rosemann was interviewed for **Insights**, a trade magazine that highlights developments in several industries and provides an insight into trends and solutions in businesses as well as the care and (semi-)public sector. Alex gave his vision on what the consequences of smart lighting are for installation companies. *http://insights.goomedia.nl/de-groot*

Exploring the psychology of lighting

Tom Bergman // Principal Scientist at Philips Lighting Research // Masters Physics and Chemistry University of Leiden // Interdisciplinary researcher with a wide variety of granted patents // **Yvonne de Kort** // Full professor Environmental Psychology of Human-Technology Interaction at TU/e // Program manager Sound Lighting ILI // Current research focuses on how light impacts mental and physical health, vitality, cognitive performance and social interaction

Interview | Yvonne de Kort and Tom Bergman
by Michiel de Boer of Moesasji

With the emergence of LEDs, lighting systems are entering a new era. Through programmable digital controllers or even the Internet, artificial lighting has evolved from being a functional aid to a source that can influence our state of mind. ILI and Philips Lighting join forces in exploring the 'psychology of lighting', specifically in the field of enhancing relaxation. Can lighting schemes help humans relieve stress? And what are the characteristics of such lighting systems?

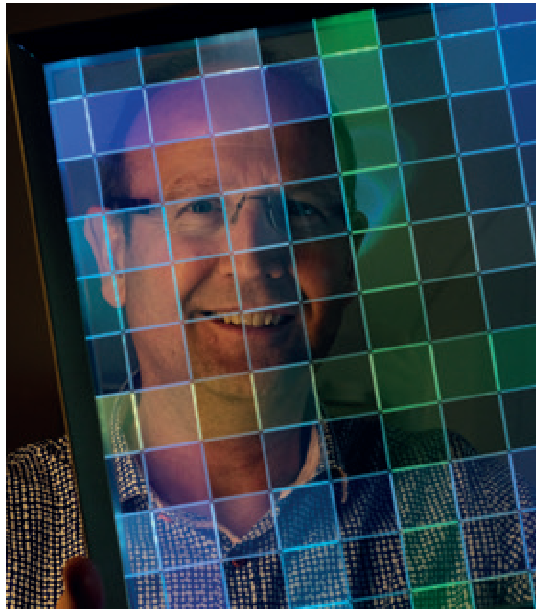
Tom Bergman, principal scientist at Philips Lighting: "I met Yvonne and ILI a couple of years ago in the 'Snoezel Project'. Snoezelen is an original Dutch word, which is even not translated in international literature and describes the pleasant but soft activation of one's senses, used in mental health care. We have developed - together with students - a box with relaxing lights, shapes and sounds to help induce relaxation in people suffering from dementia. The box was tested in different settings with a number of patients and their caregivers. The outcomes were promising and form a good starting point for further investigation in this area. What makes a Snoezel good? And what can this mean for other lighting systems?"

Yvonne de Kort, TU/e professor and program manager Sound Lighting at ILI: "There was an immediate click between us, personally and of course between our organizations. Philips Lighting is a very welcome facilitator for application research via, among others, internships. Together we share a quest in discovering in which way lighting can be beneficial to human wellbeing."

Effortless Attention

Yvonne de Kort has been involved in lighting research for over ten years. With a background in environmental psychology, she tends to keep on looking beyond light. One of the fascinating phenomena she has worked on is Biophilia; the innate tendency of humans to seek connections with nature and other forms of life surrounding us. We all know the calming effect of a walk through the forest, the mesmerizing quality of floating water and flames in a campfire. This effect is caused by something De Kort describes as 'Effortless Attention'. Nature is relaxing because it draws our attention, but not in an overwhelming way. The shapes, smell, light and movement capture eye and thought, yet leave enough space for reflection. Similar to meditation, people tend to have their thoughts coming and going and enter into a more relaxed state when surrounded by nature.

Yvonne de Kort



Tom Bergman

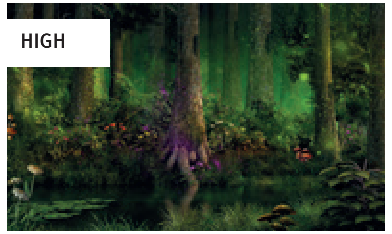
Bergman: "This mechanism triggered me. In designing new dynamic lighting systems I have been and am still looking for a language to properly describe the principles and rules. I think it is necessary to build up the vocabulary to work effectively together on new systems and to be able to make better judgements as to whether a lighting design is good or not. I have been looking towards music, animation, choreography and physics to find out what applies to effective lighting systems and schemes. Specifically focused on systems that could evoke relaxation, biophilia is an intriguing phenomenon. It brings us closer to the rules of beauty!"

Complexity and mystery

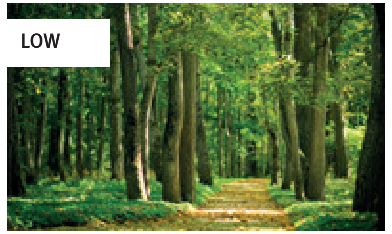
De Kort: "Biophilia shows us there are ground rules that apply to almost every individual. Yet in this kind of research we are also dealing with perception and preference, which is a subjective matter. What works for me doesn't necessarily have the same effect on my neighbour. Moreover, the effect can differ within an individual per day or moment. Compare it to music; Rachmaninov can be a great experience, but you do not always want to deal with that kind of intensity, power and complexity. So what is soothing to you today, might be annoying tomorrow.
In this field it is challenging to come up with valuable input for a design perspective that has a generic use. Tom's questions as to whether we can create the same attentional restoration effect known in nature with artificial dynamic lights effects, inspired me to delve deeper into the subject and to form more concrete hypotheses to build on and test new lighting systems."

Further study shows that Effortless Attention has to do with human needs for understanding and exploration. This can be

Complexity



Mystery



translated into two important attributes: the level of complexity and the level of mystery. If an environment or stimulus is very simple (low complexity) the human mind wanders easily as it cannot learn anything anymore. The same happens when an environment or stimulus is too complex. At first we want to understand what's happening but as soon as we realize we will not be able to figure it out, we choose not to deal with it anymore. This is also the mechanism with the level of mystery. We want to unravel, but only to a certain extent. Nature often seems to strike the right balance for both.

Testing perception

Tom Bergman and his team put this hypothesis to the test. They chose one of the lighting system prototypes - resembling a grid of individually LED-powered tiles - in which the levels of complexity and mystery can be tuned by dynamically mixing light intensity, colours and patterns. Together with (TU/e / ILI) master student Nina Oosterhaven they designed an exploratory test. A panel group was invited to experience the set-up and measured in three different ways: heart rate, viewing time and a questionnaire for a measurement of fascination. The results underscored the hypothesis quite accurately. Bergman: "Our findings indicated that we are on the right track. So together with principles such as movement, rhythm and harmony, the aspects of complexity and mystery provide interesting input for dynamic lighting systems design. Next step is to refine the scale of complexity and mystery in order to be able to measure more accurately and to draw more reliable conclusions."
De Kort: "Combining measurements like Tom and Nina have done is a promising route. Objective, physiological outcomes complement the subjective self-reported answers in a questionnaire." Bergman adds: "Sometimes it is more important what the subjective value is as opposed to the objective value. That you feel happy is more important than what physiological recordings say."
De Kort: "True, that's what makes this kind of research so interesting. Light plays a significant role in the subconscious of human beings. There is a lot of unexplored territory in the way we perceive lighting and therefore the way we could design lighting systems. I am certain we will discover the possibilities of using lighting schemes as a source for relaxation and wellbeing. I am glad that by collaborating we can use the power of both fundamental and application research!"

Light: The Next Wireless Communication Carrier

Jean-Paul Linnartz // Part-time professor in Signal Processing Systems at the Department of Electrical Engineering (TU/e) // Thought leader ILI // Fellow at Philips Lighting research

Author | Jean-Paul Linnartz

The demand for wireless communications is growing rapidly. Every person on earth has already on average more than one smartphone or laptop. Yet, with the growth of the internet of things, in a couple of years also 50 Billion devices will have a wireless connection. The growing wireless traffic will severely congest radio communication networks.

Wireless communication via light promises to become a key solution to mitigate the pressure on the scarce radio spectrum. Lighting installations can become a prime carrier for optical wireless communications. It has become clear that the light itself can carry data, which is often referred to as LiFi. Even the commonly used illumination LEDs can be modulated at bit rates which are more than adequate for HD movie streaming and for hick-up-free video conferencing. A key advantage is that light stays inside the room. Some see this as a major security advantage over WiFi, but it certainly helps to avoid interference and enable uninterrupted high bandwidth connections with low latency.

At the Light and Building Fair last March in Frankfurt, Philips Lighting launched a commercial LiFi solution. Some of the most popular office lighting products, the Powerbalance®, is now equipped with a fully optical bidirectional communication system. This is a clear sign that LiFi is talking off as a ubiquitous communications infrastructure.

On April 25th, Deng Xiong defended his PhD dissertation on wireless communication via LED light. He is one of the four PhD candidates who works on this topic in the ILI TU/e team of prof. Jean-Paul Linnartz, who is also Research Fellow with Philips Lighting. Deng's work created new insights in how illumination LEDs can carry data at high speed, to overcome problems caused by the relatively large diode junction capacity by appropriate design of the electronics and of the modulation schemes used. On the day of the defense, also a symposium with international thought leaders was held at TU/e.

‘A De-escalate fairy tale’

Indre Kalinauskaite & Anne Schietecat

Indre Kalinauskaite and Anne Schietecat // PhD candidates Human Technology Interaction of the Department of Industrial Engineering & Innovative Sciences TU/e // De-escalate research focused on exploring the potential of light to prevent and/or overcome aggression

Once upon a time in the land of science and innovation, a team of enthusiastic researchers and their partners, among which Philips and the municipality of Eindhoven, set up a project called De-escalate. The initial aims of De-escalate were to investigate psychological pathways through which light could potentially affect aggressive or escalated behaviors and simultaneously explore the ways this knowledge could be applied in a real-life setting to design innovative lighting solutions.

Two young and ambitious researchers were hired to take upon these challenges as their PhD projects and work on separate research lines. The first project was Anne’s – it focused on laboratory research investigating the possible relationship between light and aggression. The second project, that of Indre, was meant to explore light and aggression on Stratumseind. This small article narrates the story of De-escalate, as today the project has come to an end and the two researchers might not feel as young as they feel ambitious. Okay, they still feel both, young and ambitious. So here it goes.

Laboratory

In the De-escalate laboratory, we focused on psychological mechanisms possibly underlying the effects of light on aggressive behavior, in particular cognitive associations. In a series of laboratory experiments, we explored whether associations between aggression and different attributes of light (e.g., intensity of light, color, and dynamics) existed. Our studies suggest a strong influence of the context on associations between aggression and light. For example, brightness as compared to darkness may be associated with aggression when contextual cues in the experimental setting are related to activation (e.g., fast-slow). On the other hand, when contextual cues in the setting accentuate the dimension of positivity (e.g., good-bad), brightness may be associated with calmness, i.e., the opposite of aggression. At the same time, light can also become a contextual cue itself. In our further experiments, we explored whether manipulations in brightness levels affected people’s perception of other persons. We found that portraits of the same person were evaluated differently by our participants if we manipulated brightness levels. In sum, although more research is definitely needed, our findings suggest, first, that light – it’s brightness, darkness, hue and saturation - communicates meaning; second, our studies hint that light might influence how we perceive others – we see them, both literally and figuratively, in a different light; furthermore, we have demonstrated that the context of application is of crucial importance when designing lighting to de-escalate aggressive situations. And all that is relevant for application of our work in real life setting.

Stratumseind

On Stratumseind, we managed to install an innovative, dynamic light installation and we intended to explore possibilities to use it as a contextual manipulation to defuse aggressive situations. However, the complexity of this naturalistic setting and the restrictions of conventional research methodologies influenced and reshaped the original goals of De-escalate Stratumseind. After exploring the setting in our first field study, we shifted our focus to trying to understand how the socio-physical contexts influence aggressive behavior in the context of urban nightlife. We identified atmosphere as a possible mechanism underlying this relationship and directed our further work to designing and testing tools to capture it. However, even though our primary focus was on methodology, we did employ lighting interventions in the majority of our field work. And in our final field study we found small, but significant, positive effects of our lighting scenario on two different measures of the atmosphere – light seemed to be affecting liveliness and business of Stratumseind. Although these results are promising, it is important to note that conclusions about effectiveness of light are still preliminary, as our interventions were made simultaneously with the method development process.

At the end

And so at the end of four years, the two young researchers meet again, with their experiences and results, to discuss how this story ends (in real life they have

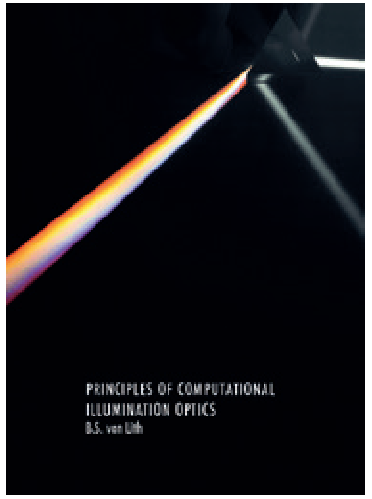
never been separated, as they shared the same office for four years and even became very close friends). What we have learned from De-escalate is that such a setup is extremely beneficial in bringing fundamental science and real life closer together. As such projects similar to De-escalate may aid in making research more applicable and designs more sensible. For example, through explorations of Stratumseind we have learned how complex and multi-layered urban nightlife is and that, in contrast to controlled laboratory settings, not all lighting settings or attributes can easily be manipulated or changed. In addition, aggressive behavior per se, might not be so easily graspable/measurable in the real life setting and thus different dependent measures, such as atmosphere, should be considered in lab research as well. Furthermore, knowledge gained in laboratory studies about crucial influences of context and attributes of light on emotion and behavior became a great starting point for sensible lighting design. All in all, both projects are almost wrapped up, many questions are answered and many more have arisen, but most importantly, everyone lives happily ever after.

Thesis: Principles of computational illumination optics

Bart van Lith // PhD graduate (cum laude) in the Department of Mathematics and Computer Science TU/e // Generated a new, innovative approach that opened a whole new field in computational illumination optics

Author | Bart van Lith

Most, if not all, luminaires have some sort of optic to guide the light to where it needs to go. This optic can consist of mirrors or lenses, usually shaped to aim the light. They can be designed to do various things, such as focussing the light in a tight beam for a spotlight, or spreading it out over a wide area such as with common living room lighting. Current lighting trends focus more and more on LEDs, which come with special challenges of its own



To face these challenges, illumination optic designs have to become increasingly advanced. At the same time, there is a rising demand for customised lighting solutions. Nowadays, certain brand shops even hire lighting engineers to make sure every store in the world is illuminated using a particular feel and style. To cope with the changing playing field, optical design methods have to evolve accordingly.

The main goal of my work was to find faster computational methods for simulating illumination optics. Prototyping can be expensive, while computation can be done much cheaper. Wilbert IJzerman suggested that I look into a field known as Hamiltonian optics. My job was to gain a thorough theoretical understanding of the field and use the knowledge to find practical algorithms.

The thesis covers a wide range of subjects within geometrical optics. There are some results on improved ray tracing, which is probably the most ubiquitous method in optical engineering. There is a contribution to the age-old field of root-finding, something that the ancient Greeks were already interested in. However, what I see as the central concept is following the energy instead of the rays. It turns out that it this can be done a lot quicker. This leads to much shorter computation times and as an added bonus, the answers are highly accurate.

Moving light:

understanding and steering the flow of pedestrian crowds

Alessandro Corbetta // Postdoc in the Turbulence and Vortex Dynamics group, Department of Applied Physics TU/e // Research focuses on physics of pedestrian crowds // Member of the 2017 Glow team 'Moving Light' // **Federico Toschi** // Full professor Computational Physics of Multi-scale Transport Phenomena at the Department of Applied Physics (TU/e)

Author | Alessandro Corbetta and Federico Toschi.

As our lifestyle evolves following an ever-growing urbanization, we spend an increasing amount of time walking in crowded public places such as shopping malls, stadiums or transportation hubs. Guaranteeing highest standards for our safety and comfort as pedestrians is a scientific, technologic and societal issue of escalating urgency. This goal comes with two main requirements: the physical understanding, in quantitative terms, of the motion of human crowds, and the capability of applying stimuli to steer such a motion in accordance to safety and comfort necessities.

For almost three decades, the scientific community has been investigating the dynamics of human crowds aiming at mathematical models for their flowing motion. Modeling lies at the very heart of physical and phenomenological understanding and ultimately unlocks predictive simulation tools. Such tools are necessary, e.g., to improve the design of infrastructure or, even, to anticipate dangerous crowding conditions.
When dangerous or uncomfortable conditions approach, the capability of steering individual choice of routes (crowd management) becomes fundamental in order to restoring order and/or comfort. Countermeasures are generally actuated via barriers or signals and, often, when these are deployed, our comfort has long gone.
Ideally, seamless "stimuli", e.g. based on illumination, may deliver continuous and imperceptible guidance to ensure comfort and safety at all times. For instance, such a guidance may take us to the closest (or optimal) exit of a stadium without ever feeling the pressure of overcrowding.

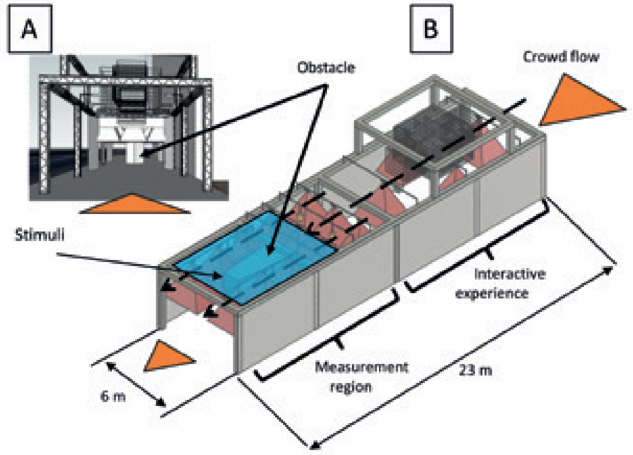


Figure 1. The "Moving Light" real life experiment. The triangle indicates the direction of the crowd flow. (A) Frontal view, as seen by an entering visitor. The central obstacle is visible at the end. (B) 3D sketch. The first half of the facility, with a timed interactive experience, ensures a regular scheduling in the crowd flow, that passes through the measurement zone in "batches" of 1 minute. In the measurement zone a stimulus (arrow-like or illumination-based) changes at random every 3 minutes. (Sketch by B. Maas and A. Corbetta)

As of today, however, almost nothing is known about the extent to which human route choice can be influenced, mostly for the technical difficulties connected to the investigation (mainly the necessity of tracking reliably individuals in space/time while walking in real-life conditions). Even the level to which we can sway a decision as common and simple as passing on the left or on the right side of an obstacle remains unquantified, despite the intuition that a lighted passage would secure higher preferences.
Swaying this simple -yet important- routing decision has been at the core of the "Moving Light", an unprecedented real-life crowd steering experiment that we performed during the Glow Light Festival 2017 (cf. sketch in Figure 1). About 140.000 among the festival visitors walked through our installation in a unidirectional flow. Visitors, while being individually tracked at extremely high resolution, by means of state of the art technology developed in-house (Figure 2), left our installation on the left or on the right side of a central obstacle.
For the entire duration of the festival, we subjected the visitors stream to one among 18 different "stimuli" that encompassed signage (e.g. an arrow pointing at either side) and/or uneven illumination of the paths left and right of the obstacle. Our objective has been measuring the performance of such stimuli at "modulating" the decision of the flow to take either side. In absence of external stimuli, we expect pedestrians to choose either side with about 50:50 probability. Under the influence of a stimulus this changes with non-trivial dependence, among others, on the density level.
At the moment of writing we are still actively analyzing the large amount of data collected (about 5TB of raw depth imaging data). It is however already clear that employing our stimuli we are capable of effectively swaying route choices. Unexpectedly and remarkably, we recorded commensurable steering effects by more "seamless" stimuli (namely, unbalanced illumination) and by more recognizable visual indications (arrows).
Swaying complex route choices in generic and articulated environments certainly builds on the capability of effectively influencing simple choices as going left or right. Therefore,

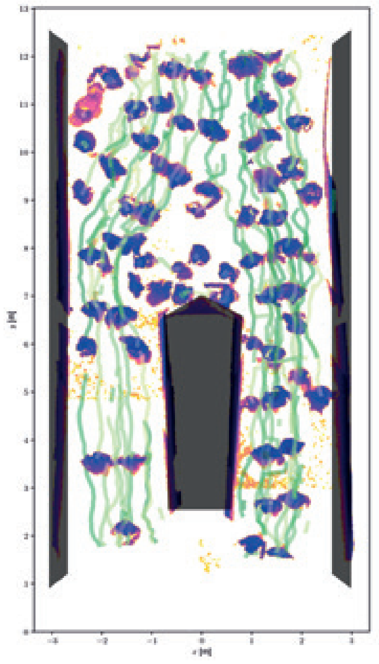


Figure 2. High-resolution Individual tracking at "Moving light". Each visitor has been tracked through a grid of 12 overhead depth-map cameras (Microsoft Kinects) and in-house tracking technology. This enabled highly-accurate recording of their routing decision, yet in a fully privacy-respectful way. (Figure by W. Kroneman and A. Corbetta)

we are confident that "Moving Light" will have a critical role in establishing a base knowledge for future seamless and stimuli-based crowd management.
The Moving Light experiment has been a joint effort of A. Corbetta, W. Kroneman, M. Donners, A. Haans, P. Ross, M. Trouwborst, S. Van de Wijdeven, M. Hultermans, D. Sekulovski, F. van der Heijden, S. Mentink, F. Toschi. The initiative has been supported by NWO, 4TU Federation, Philips Lighting and Eindhoven Student Hotel. The contributions of B. Maas, M. Hoekstra, I. Ioncu, T. LeJeune, R. Nuij and S. Schippers are also acknowledged.

Publications

With the moving light measurements currently under investigation, some preliminary results will be soon available in A. Corbetta, W. Kroneman, M. Donners, A. Haans, P. Ross, M. Trouwborst, S. vd Wijdeven, M. Hultermans, D. Sekulowski, F. vd Heijden, S. Mentink, F. Toschi. A large-scale real-life crowd steering experiment via arrow-like stimuli. Pedestrian and Evacuation Dynamics 2018 (accepted).

The InnoSpace Intelligent Lighting Project

Jolan Hulscher // Project leader for the InnoSpace Intelligent Lighting Project

Author | Jolan Hulscher

On September 14, TU/e innovation Space was opened with great interest in the Gaslab building. It will drive the continued development of TU/e's hands-on education. In cooperation with lecturers, researchers and industry, students will work here on societal challenges. ILI students are going to participate in the InnoSpace Intelligent Lighting Project.

TU/e Innovation Space

At a strategic level, TU/e encourages interdisciplinary collaboration in education by the set-up of the new TU/e innovation Space. TU/e innovation Space is a community that facilitates and supports interdisciplinary hands-on education, engineering design and entrepreneurship. It offers a place where students learn to deal with complex societal and industrial challenges, develop innovative projects with researchers, businesses and other stakeholders. Furthermore, it provides a space where lecturers that develop and offer hands-on courses, are supported to innovate education. Building on the strong scientific collaboration that TU/e has with industry, TU/e innovation Space helps in developing an educational ecosystem to deliver the best engineers for this industry, the “Engineers for the Future”. Hereby TU/e innovation Space strives to contribute forming engineers that are better equipped to the demands of the job market and to serve as a visible and inspiring showcase.
TU/e innovation Space offers facilities to create science-based solutions to real-world challenges. It has a maker space where students can design and create innovative prototypes with technical support and surveillance. Results can be demonstrated in an exhibition space and there is ample room to meet both formally and informally. Beyond a physical space, TU/e innovation Space provides a platform that interconnects motivated students, staff and industry, creating a vibrant community.

Cooperating with ILI

ILI believes that both initiatives can create synergy in the new TU/e Innovation Space by creating lighting-related labs with the support of an industrial partner within the Lighting Flagship. The research programs of ILI in close collaboration with the Philips Lighting Flagship program provides a unique opportunity to create innovative solutions in interdisciplinary engineering projects. Projects in “Innovation Space Intelligent Lighting” will encourage students to draw from their creative abilities while being trained on a particular project. The lighting domain is particularly interesting as it integrates technological innovation, application innovation, business model innovation and changes in user behavior. The interdisciplinary character is a deep-felt challenge in the industry, and through this project, TU/e can create talents that are prepared for working in such environments.

Creating a continuous innovation process

The current courses in the departmental programs and USE learning lines do address the interdisciplinary aspects, but the impact can be increased through collaboration with TU/e innovation Space and explicit inspiration of the industrial context provided by the Lighting Flagship. This creates a win-win situation for the students (education and insight in an interdisciplinary professional working environment), the university (shaping their education towards the actual needs of the innovative industry) and the partners (identifying talent before graduation). In discussions with TU/e innovation Space, it became clear that this active collaboration with industry and the interdisciplinary approach of ILI would create a challenging and inspiring track.

On February 28, the kick-off event “InnoSpace Intelligent Lighting Project” marked the start of the collaboration between ILI, TU/e innovation Space, Philips Lighting, and Heijmans. In the 2017 Glow edition of the ILI Magazine, Elke den Ouden reported on this project.
With 40 participants including 15 interested students, this was a successful event. The students worked together with Philips Lighting and Heijmans to develop new ideas for the living lab “Tracé de Ring .” In Q4, the students can iterate and build their ideas in TU/e innovation Space to increase safety, quality and accessibility.

The best concepts/prototypes were eligible for extra support from Philips Lighting and Heijmans and possibly live testing in the Eindhoven ring field lab. Students can do this project next to their study, but we aim to let students work on this project in study meaning that they will work out their concepts in a course. “The Secret Life of Light – USE Project” course of Yvonne de Kort will be a pilot case for this new concept. Later, we aim to connect more USE and TECH learning lines to the InnoSpace Intelligent Lighting Project program. For instance, IoT, Data Science, and Smart Mobility courses have tremendous potential as well because it is not just about lighting anymore. In the next decade, we go beyond illumination!

The Fontys design masterclass

How to teach students about intelligent lighting design in three weeks.

Philip Ross // Owner of Studio Philip Ross (design, research and realization in the field of intelligent lighting) // Project leader Atlas Living Lab // Project leader of the 2017 Glow team 'Moving Light'

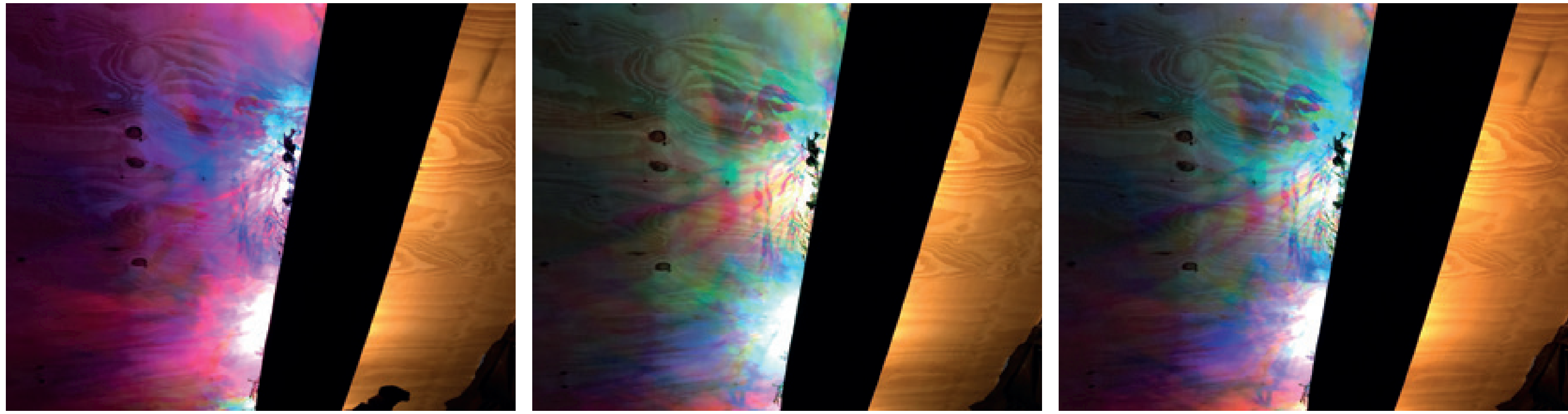
Author | Philip Ross

Fontys, a large university of applied sciences, started a minor for students without design or technical background to learn more about design, technology, creativity and entrepreneurship. It is called ETEC, which stands for Embrace Technology Entrepreneurship and Creativity. Based on my experience as a practicing designer in light and teacher, I was asked to create three-week masterclass for this minor, to teach them about design in general, through my approach to intelligent lighting design. So how to teach design of intelligent lighting in a three-week course to students with no lighting or design background? It turns out that the saying 'it takes a village to raise a child' is very relevant here. What I mean will become clear in the remainder of the article.

But first a bit about the teaching approach. In my view, the best way to learn how to design is through doing it and reflecting on it. No guidebook can substitute that. The same goes for design with light. You need to get to know the medium by experiencing it and experimenting with it. I find it important to consider the influence a design has on human behaviour and experience, and to take that into account in design. This is surely not an easy thing to do, but in my view it is an essential part of designing intelligent lighting systems. And last but not least, I wanted the students to get a taste of what you can do with lighting and sensing technologies and get their hands dirty working with them. Of course, three weeks is too short to gain depth in any of these topics. But it is long enough to learn about what designing may take and what it can bring, and to hopefully be inspired to learn more.

To conduct such a masterclass, materials are needed beyond pens, papers and post-it notes. It requires access to luminaires, control equipment, sensors, software, optical materials, etc. This is where 'the village' kicked in first. Fontys had none of this specialised equipment, so I found ILI willing to open up the LightLab for the students and to lend out large quantities of lighting equipment to the students. This way I could demonstrate different lighting approaches in the LightLab, and the student groups got their own light 'starter kits', with DMX LED luminaires, control hardware, sensors, and software with premade control algorithms.

This series of pictures shows one of the underpass lighting prototypes, shown at DDW 2017. The students aimed to create a friendly environment that could pull a pedestrian briefly out of his daily concerns (and his telephone). They did this with slowly modulating light from separate R, G and B sources from behind plants. This created an attractive light and shadow play that is different every time you look. Downwards, indirect light softly illuminates the pedestrian path without dominating the scene.



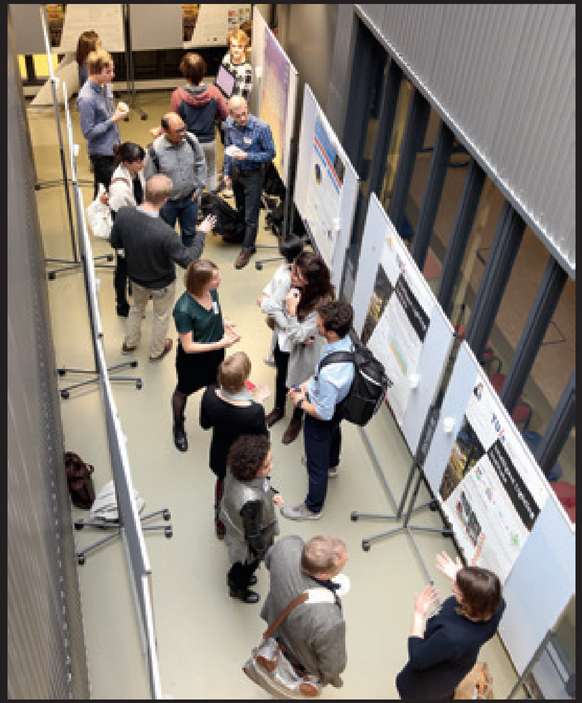
The masterclass has run three times since it started in 2017. In the second run, 'the village' popped up again. Switch Eindhoven, together with Ellen de Vries of Luxlab, asked for new ways to transform Eindhoven's underpasses with dynamic lighting. The students created a number of proposals, which were exhibited at the Switch exhibition at the Dutch Design Week 2017. A great opportunity for students who would otherwise have little chance to show and discuss work at such an international podium. In the third masterclass, the students worked on the Jouwlichtop040 project with Eindhoven, Philips Lighting and Heijmans, which was yet another great way for students to get involved in the latest developments in their city.

It may be clear by now what the statement about the village raising a child means in this context. A university of applied sciences, a TU/e research institute, two independent lighting professionals, two multinationals, the municipality and the Dutch Design Week contributed to a small, three-week course. The village of course goes by the name of 'Brainport'. The tight network and willingness to help each other in this region really raises the level of activities, even of the small ones, such as a masterclass about intelligent lighting.

I would like to thank ILI, in particular Harm van Essen, Harold Weffers and Jos Hermus. Thanks also to the Fontys team, Jochem Goedhals, Siete Sirag, Erik Frey, Niels Roelofs, and thanks to the students for their efforts.

Links:
Fontys ETEC minor: ***fontys.nl/Studeren/Minoren/EmbraceTEC***
Switch at Dutch Design Week: ***http://switchlight.nl***
Jouwlichtop040: ***www.jouwlichtop040.nl***
Studio Philip Ross: ***www.studiophiliross.nl***





ILIAD 2017

On Tuesday, November 14, prof. dr. Ingrid Heynderickx, Scientific Director of the Intelligent Lighting Institute of Eindhoven University of Technology (TU/e) opened the 2017 edition of our annual public outreach event ILIAD. Representatives from industry and academia in the field of intelligent lighting gathered at TU/e. They listened to talks about recent developments in responsible research & innovation, in science & technology related to light & intelligent lighting and its applications in, for instance, health & well-being.

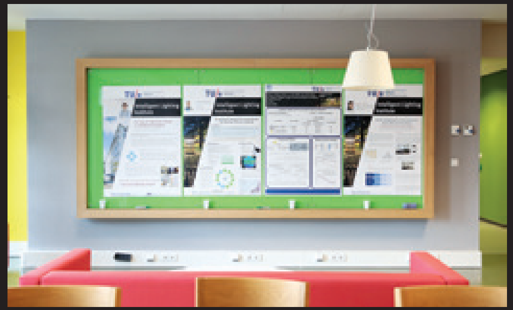
The event was very well attended. With one third attendees from TU/e, one third from Philips Lighting and one third from other companies we had an interesting mix of about a hundred lighting professionals.

During the varied program, the program managers of the ILI R&D programs – Light for Health & Well-being, Bright Environments and Light by Design – spoke about the research that is being conducted within their programs. Invited guest speakers neuroscientist prof. Robert Lucas of the University of Manchester, John Sayer M.Eng. of Johnson Controls, and dr. Gilles Vissenberg of Philips Lighting spoke about specific aspects of light and intelligent lighting from their fields of expertise.

During the event, the audience was also able to get better informed about recent, current and upcoming research & innovation projects in which researchers affiliated with ILI are involved. During the lunch break, 24 PhD candidates and Postdocs presented their research to the audience during the poster presentations, which lead to some very interesting conversations.









Excursions out of the comfort zone

Yvonne de Kort // Full professor Environmental Psychology of Human-Technology Interaction at TU/e // Program manager Sound Lighting ILI // Current research focuses on how light impacts mental and physical health, vitality, cognitive performance and social interaction

Author | Yvonne de Kort

Our newest project DYNKA (a Dutch acronym for Dynamic light and indoor climate for offices) is a project in the TKI Urban Energy scheme of the Topsector Energy. The basic premise behind DYNKA is that both ambient lighting and temperature influence users' experienced levels of comfort. Given the right interaction, we should be able to increase the margins of acceptable temperature margins. This, in turn could quite drastically minimize energy consumption, as mild cold or heat no longer demand immediate heating or cooling.

Dynamic lighting schemes

The project builds on earlier work performed separately on effects of lighting and those of temperature. We have reported on light's promise to support health, healthy sleep, mood and vigilance and vitality throughout the day in this magazine. After initial studies investigating momentary preferences and effects of light exposure and light distribution in the Human-Technology Interaction (HTI) and Building Performance Systems (BPS) groups of TU/e, these groups, together with – and coordinated by – the Signal Processing Group, recently started the NWO-funded Optilight project. This aims to quantify the combined effects of both image-forming and non-image forming based effects of light on users and develop algorithms that will eventually optimize day-long light scenarios for users' wellbeing and energy consumption.

Dynamic temperature schemes

But entirely novel is the collaboration with the group of professor Wouter van Marken Lichtenbelt, Professor Ecological Energetics and Health in Maastricht University Medical Center. This group has investigated health effects of dynamic temperature variations outside the thermal comfort zone and found that particularly mildly cold and warm conditions induce important changes in metabolism, which, in turn may impact obesity by counterbalancing excess energy intake (Marken Lichtenbelt et al., 2017). In their most recent studies they started exploring interactions between light and temperature on comfort and found promising results that might enable us to maintain comfort and yet produce the same beneficial health effects.

The project's consortium

In the DYNKA project, Maastricht University joins forces not only with the HTI and BPS groups of TU/e, but also with Zuyd (applied university), three industry partners – Huygen

(installation engineers), Kropman (installation engineers), Almende (ICT developer) and Philips Lighting – and ISSO (a knowledge institute for installation engineering). The DYNKA project explicitly targets two main goals: minimizing a building's energy expenditure as well as maximizing health and wellbeing. Its ambitious program thus sets out to smartly combine the potential of dynamics in lighting and in temperature to simultaneously serve both goals.

Field tests and living lab

The general plan is that, after initial explorations in laboratories in both universities, insights will rapidly be transferred and tested in field labs. Two smaller scale field labs (one Kropman building in Breda, and a Qeske building in Kerkrade) will host the first evaluations. After this, all insights will be combined to result in a limited number of combined dynamic light and temperature scenarios, to be implemented and evaluated in the Atlas Living lab.

Scientific challenges

Combining both dynamics is by no means straightforward, as different rationales might drive such designs. One is to maximize health and vigilance effects, and explore whether the combination would yield clear additive effects in that sense. A different strategy would be to employ the dynamics in one parameter to compensate for any potential discomfort that would result from the health-promoting dynamics in the other. On top of this, there is the question how much energy might be saved if indeed we learn that 'excursions' outside users immediate comfort zone in terms of temperature – compensated or enhanced by lighting dynamics – are not only acceptable to users, but also beneficial in terms of a reduced need in cooling or heating of the building.

So in this project, the users may not be the only ones who will be nudged out of their comfort zone: the researchers, too, will have to cross new disciplinary boundaries and combine psychological, biological, and technical expertise, and perform both lab work and field work. These challenges will be tackled by two PhD students, one based in Maastricht, one in Eindhoven, in collaboration also with students from Zuyd. The Eindhoven candidate will have Yvonne de Kort and Wim Zeiler as promotors, and with Alex Rosemann also included in the project. We envisage this will be the start of a strong collaboration, one that we hope to grow with additional projects in the near future: our ambitions would easily accommodate for more.

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