Intelligent Lighting Institute | Edition 17, November 2022

ILI GLOW

> OPTICS NETHERLANDS

> TEAM IGNITE: UNITE WITH LIGHT

> 25 YEARS OF LIGHT&LIGHTING LABORATORY

> THIS IS HOW YOUR PHONE KEEPS YOU AWAKE

TU/e

EINDHOVEN UNIVERSITY OF TECHNOLOGY

Content

ILI Magazine is a biannual edition of ILI for ILI members, colleagues, collaboration partners, policy makers // ILI Magazine GLOW edition 2022 is published in November //

EDITORIAL STAFF Harold Weffers, Marlies Bergman DESIGN Volle-Kracht concept, ontwerp en organisatie ILLUSTRATIONS ILI PHOTOGRAPHY Bart van Overbeeke Fotografie, Photografer Martijn Willems: Yoram Diamand

ARTICLE CONTRIBUTIONS Moesasji and ILI CONTACT P.O. Box 513, 5600 MB Eindhoven The Netherlands - +31(40)247 5990 - ili@tue.nl

HAROLD WEFFERS | OPERATIONAL MANAGER

Welcome

I am very pleased to be able to present to you the 17th edition of our ILI Magazine. Since the previous edition in May of this year much has happened and I hope that after reading the various contributions in this magazine you will once again agree with me that many exciting and promising developments have been happening.

Amongst others you will be informed about (the outcome of) recently completed and on-going projects in our R&D programs and our R&D facilities and infrastructures annex Living Labs, which form the basis for our new scientific discoveries & (technological) innovations related to Light and Lighting for various application domains. We also provide you with information on a new national initiative towards bringing together all relevant stakeholders in the domain of Optics and we also provide you with a preview of some of our installations that will be on display during this year's edition of GLOW.

Pleasant reading!

Harold Weffers
Operational manager

NOVEMBER 2022 - NOVEMBER 2023

Calendar

12-19 November 2022
GLOW
Location: City of Eindhoven

26-29 March 2023
LICHT2023
Location: Salzburg, Germany

18-20 September 2023
CIE 2023 Conference and 30th Quadrennial Session
https://slovenia2023.cie.co.at/welcome-cie-2023
Location: Ljubljana, Slovenia

ILI PhD thesis Erratum

Shared control in office lighting systems - Tatiana Lashina (TU/e Building Environments), May, 2022.
Advisors: prof. dr. ir. Evert van Loenen and dr. Juliëtte van Duijnhoven

"Are you related to the research domain and therefore interested in joining the consortium, just contact us!"

Ingrid Heynderickx, Scientific Director

INGRID HEYNDERICKX | SCIENTIFIC DIRECTOR

ILI invites you to participate

To a far lesser extent than decades ago research funding at the national and European level stimulates projects of individuals that deepen their own scientific knowledge. Instead, research funding focuses more and more on big consortia of public and private partners that combine many different perspectives to address an industrially or societally relevant challenge.

These big projects do not only have to focus on advancing scientific knowledge, yet at the same time they need to have a sound plan for creating impact by implementing this knowledge in the complex real world. Such consortia typically have 10 or more partners, ranging from performing fundamental or applied research to having expertise in real-world implementation. Since ILI is already intrinsically multi-disciplinary, and is the place to be for coordinated research on creating impact with light on humans, we are taking the initiative to set up such a big national research project called Light4Life.

ILI will use its yearly outreach event ILIAD to announce the Light4Life project and to invite attendees and their companies or institutes to participate to the project. The project will focus on intelligent environments, featured with lighting, and probably extended with sound and haptics, that should enable improving the performance and well-being of humans. We have three application areas in mind, being (1) caregivers, (2) patients, and (3) offices and schools. To design these intelligent environments, we will research three domains, including (a) the effect of light, sound and haptics on human beings in the contexts mentioned above, (b) the intelligence and control needed to create the smart environments, and (c) the societal and economic impact for the whole ecosystem. The current ILI Magazine and its previous editions show that ILI has expertise in these domains and application areas, and hence can form the backbone of the project. However, ILI also sees many benefits in extending the consortium with additional public and private partners, in this way increasing the impact of the research outcomes for the outside world.

So, are you and your company or institute related to the research domain described above, and therefore interested in joining the consortium, just contact us, so that we can welcome you.

By Michiel de Boer (MOESASJI)

INTERVIEW | MARTIJN ANTHONISSEN, MCS TU/E, COMPUTATIONAL ILLUMINATION OPTICS GROUP

Speeding up virtual prototyping for illumination optics

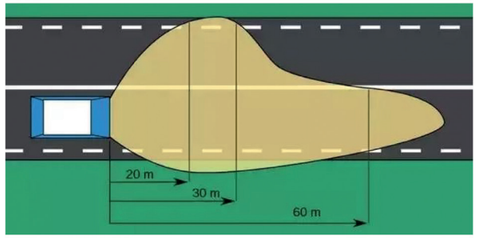
photo Yoram Diamand

"What pleasantly surprised me at entering this field, is that there is a lot of complex classical mathematics involved in describing the characteristics of optical systems. This makes it an excellent area for the virtues of scientific computing," says Martijn Anthonissen. "Within the Computational Illuminations Optics (CIO) group we have developed an inverse method to directly compute a required optical system."

Martijn Anthonissen is a mathematician at heart. He currently works as Assistant Professor in the Department of Mathematics and Computer Science, Eindhoven University of Technology. Martijn: "I love numerical mathematics. If you look at scientific fields such as physics, you can define equations to describe behavior of matter and forces, you can conduct experiments to further understand and test your theories. Within numerical mathematics we tap into a relatively new but rapidly growing scientific discipline: computer simulations. I find it fascinating that a simulation can provide valuable insights about the validity of models, it brings unprecedented opportunity." Having worked on many applications, such as combustion, film cooling and wind-farm aerodynamics, Martijn is now involved in research on the design of optical illumination systems.

DIRECT APPROACH

Martijn: "The basic goal in illumination optics is to design an optical system that turns a given light source into a desired light output. Typical applications are road lights and car headlights. As you can imagine for a road light the desired output is a clear, wide, and even beam of light. While a car headlight has to bring proper illumination for the driver without blinding the opposite traffic: this is a more complex kidney-shaped image. Designing an optical system for these applications is traditionally conducted by creating a design, use ray tracing to test it, change the design, ray trace again and



so on. This is a time-consuming process. Our group has developed a computation method to directly compute a required optical system for set-ups with reflectors and lenses."

NUMERICAL SOLUTIONS

The methods Martijn and the CIO group work on are based on advanced physical models describing the interaction of light with lenses and reflectors. Martijn: "Since the behavior of light in the optical systems is described with complex non-linear partial differential equations, we use numerical mathematics to come up with solutions that work in practice. Our former PhD student Lotte Romijn provides us with an excellent example. She has modified an algorithm that allows to design an optical system to perform a very complex transformation of the light source image. Input is a 'frog' and output is a 'prince'." Recently, Romijn graduated cum laude.

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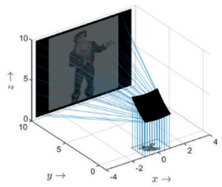
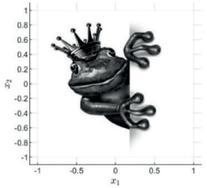
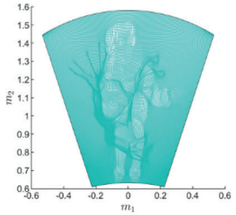
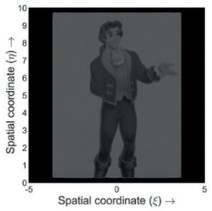


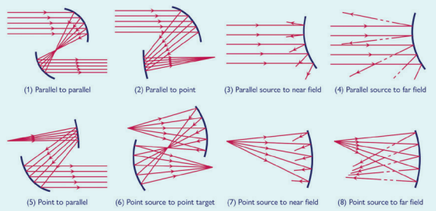




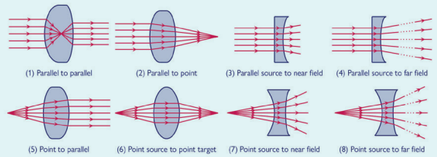


FRAMEWORK FOR PROTOTYPING

"We have now turned our model into a mathematical framework for 16 basic illumination methods (parallel source and point source) using reflectors and lenses. The model can already be used for product development of these basic types."



> *Basic reflector systems*



> *Basic lens systems*

AGENDA

This is a first step in enhancing the design process of optical systems. More complex systems (for example with multiple lenses) require multiple steps. Martijn: "We are currently looking into expanding our framework. On our agenda is among others looking into optical systems that use multiple light sources, the use of laser instead of led light sources and optical systems with a more complex or even variable refractive index (for example used in GRIN-lenses).

In the background we are also looking at the mathematical side. Now, we have a model, a code that performs. But we are aiming to further improve the model to be able to make calculations faster and the model more robust. After all, we are not lighting system designers, for us it is about the methodology, about incorporating the mathematics into simulation tools that can be widely used for virtual prototyping."

ILI Top Publications

Huiberts, L.,Opperhuizen, A. and Schlangen, L.J.M. *Pre-bedtime activities and light-emitting screen use in university students and their relationships with self-reported sleep duration and quality. Lighting Research & Technology, 2022. 54(6): p. 595-608. https://journals.sagepub.com/doi/10.1177/14771535221074725.*

Schlangen, L.J.M., Belgers, S., Cuijpers, R.H., Zandi, B.and Heynderickx, I., *Correspondence: Designing and specifying light for melatonin suppression, non-visual responses and integrative lighting solutions – establishing a proper bright day, dim night metrology. https://doi.org/10.1177/14771535221120350.*

Barion, A., Anthonissen, M.J.H., ten Thije Boonkkamp, J.H.M. and IJzerman, W.L., *Alternative computation of the Seidel aberration coefficients using the Lie algebraic method. Journal of the Optical Society of America A, 39, issue 9, pp. 1603 – 1615 (2022).*

Bertens, M.W.M.C., Vugts, E.M.T., Anthonissen, M.J.H., ten Thije Boonkkamp, J.H.M. and IJzerman, W.L., *Numerical methods for the hyperbolic Monge-Ampère equation based on the method of characteristics, Partial Differential Equations and Application, 3:52 (2022).*

van Roosmalen, A.H., Anthonissen, M.J.H., IJzerman, W.L. and ten Thije Boonkkamp, J.H.M., *Fresnel reflections in inverse freeform lens design, Journal of the Optical Society of America A, 39, issue 6, pp. 1045 – 1052 (2022).*

Jedon, R., Haans, A. and de Kort, Y.A.W., *Challenging current urban lighting policies: case for a shift of focus to alertness, International Conference proceedings: Shaping light for health and wellbeing in cities. Conticelli, E., Marzani, G. & Tondelli, S. (eds.). Università de Bologna, p. 82-84 3 p. (2022).*

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de Vries, H. J. A., Heynderickx, I. E. J. & de Kort, Y. A. W., *From luminance to brightness: A data-driven approach to support brightness assessments in open plan offices, E-pub ahead of print) In: Lighting Research and Technology (2022).*

Gabbana, A., Toschi, F., Ross, P., Haans, A. & Corbetta, A., *Fluctuations in pedestrian dynamics routing choices. In: PNAS Nexus. 1, 4, 9 p., pgac169. (2022).*

Linnartz, J. P., Ribeiro Barbio Correa, C., Bitencourt Cunha, T., Tangdiongga, E., Koonen, A. M. J., Deng, X., Abbo, A. A., Polak, P., Müller, M., Behnke, D., Vicent Colonques, S., Metin, T., Emmelmann, M., Kouhini, S. M., Bober, K. L., Kottke, C. & Jugnickel, V., *ELIoT: enhancing LiFi for next-generation Internet of things, In: EURASIP Journal on Wireless Communications and Networking. 2022, 1, 33 p., 89. (2022).*

Deng, X., Dong, Y., Zou, X., Li, P., Chen, C., Gao, Z., Bitencourt Cunha, T., Yan, L. & Linnartz, J-P., *Quadrature Signaling for Intensity Modulated and Direct Detection Visible Light Communications Based on Kramers-Kronig Relation, 2022 IEEE International Conference on Communications Workshops (ICC Workshops). p. 433-438 6 p. 9814517 (2022).*

Siraji, M. A., Lazar, R. R., van Duijnhoven, J., Schlangen, L. J. M., Haque, S., Kalavally, V., Vetter, C., Glickman, G., Smolders, K. C. H. J., & Spitschan, M., *Light exposure behaviour assessment (leba): a novel self-reported instrument to capture light exposure-related behaviour, In 33rd Annual meeting of the Society for Light Treatment and Biological Rhythms: Light and the Circadian Clock - from Bench to Bedside (2022).*

LUC SCHLANGEN AND LAURA HUIBERTS | TU/E HUMAN TECHNOLOGY INTERACTION

New research insights on screen use, light and sleep

This is how your phone keeps you awake

Evening use of smartphones and computer or tablet screens can have a negatively impact on our sleep. Light exposure during the evening and at night, especially exposure to blue light, produces alerting effects that can keep us awake. That's why some electronic device manufacturers offer blue light filters that give their screens a warmer, orange-like glow. Recent American research (Duraccio et al., Sleep Health, 2021) has indicated that the use of such a blue light filter on a smartphone is not very effective to improve sleep in young adults. A study by ILI researchers Luc Schlangen and Laura Huiberts indicates that under the right conditions, evening screen use can actually be beneficial for sleep.

It is self-evident that electronic device manufacturers sought solutions to improve their users' sleep by controlling the light emission from their screens around bedtime. The human eye uses light for vision, but also contains special daylight receptors that powerfully regulate our biological clock. If these receptors pick up a lot of daylight, they signal to the brain that it's daytime and good to be active and awake. In the evening, when it's sufficiently dark, our body automatically starts producing the sleep-supportive hormone melatonin.

Light exposure during the evening and at night suppresses this natural rise in melatonin levels, thereby impairing our ability to initiate and maintain sleep. Although the daylight receptors within our eyes are responsive to white light, their sensitivity peaks in the blue part of the spectrum. During the last two to three hours before bedtime it is therefore recommended to limit your light exposure, and especially your blue light exposure. As such, it's a good idea to filter that blue light out of your screen in the evening and at night. So why is it that researchers found no effect on sleep when a group of young adults used Night Shift, a blue-light filtering feature, on their iPhones? Luc Schlangen can think of several reasons.

First, the type of activity on your light emissive screen can make a lot of difference. A recent study with Laura Huiberts has shown that watching series or TV on your screen before going to bed can be relaxing and supportive for sleep. On the other hand, social media related screen usage prior to bedtime can have a negative impact on sleep. It can produce stimulating and possibly even addictive effects that result in bedtime procrastination and an impaired sleep onset. In principle, the installation of a blue light filter on your phone, tablet or PC has little to no influence on such effects.

Second, blue light exposure in the evening certainly impacts your ability to fall asleep. However, your phone is usually not the only source of light you have on during the three hours before bedtime. The other room lights that are on in the evening often activate your daylight receptors just as much, or even more, than your screen. Therefore, it is a good idea to dim down your room lights in the 2-3 hours prior to bedtime. In addition, it's good to use room lights with a warmer (yellow/orange) tone, as these are less sleep-disturbing than equally bright lights with a cooler (bluish) tone.

Last, it's not just the evening amount of (blue) light exposure that determines your ability to sleep. The amount of light that you get throughout the day can be equally important. Your biological clock is highly responsive to relative differences in light level between day and night. During daytime, outdoor light is 10 to 100 times stronger as compared to typical indoor light levels. For the latter we frequently depend on the electrical light from lamps and screens. When staying indoors during daytime under light levels that are similar to the lamplight in the evening, it is more difficult for your body to tell when night has started. On the other hand, a lot of light during the day, for instance by talking a walk outside or by sitting close to a window, strengthens your body clock. This helps to improve your sleep and makes you more resistant to the sleep-disruptive effects of evening and nighttime light exposures.

In conclusion, for a good night's sleep, the use of blue-light filters in the evening on your screen is not pointless but dimming down the other room lights and doing relaxing activities prior to bedtime are at least as important, next to having enough daylight exposure throughout the day.

Huiberts, L.M., Opperhuizen, A.L. and Schlangen, L.J.M., Pre-bedtime activities and light-emitting screen use in university students and their relationships with self-reported sleep duration and quality. Lighting Research & Technology, 2022. 54(6): p. 595-608. https://journals.sagepub.com/doi/10.1177/14771535221074725

INTERVIEW | **PETER HANSELAER AND FRÉDÉRIC LELOUP, KU LEUVEN**

In September the Light&Lighting Laboratory of KU Leuven (located at Campus Rabot in Ghent) celebrated its 25th anniversary. An excellent moment to tap into the story behind the renowned facility and research group with its founder, professor Peter Hanselaer and current co-leader, professor Frédéric Leloup.

25 years of Light&Lighting Laboratory

Peter Hanselaer started the Light&Lighting Laboratory in 1997 during the societal transition from the conventional light bulb towards energy saving lamps and led lights. Hanselaer: "In the beginning our research was merely focused on energy reduction. With the rise of high quality Leds, this is not the main challenge any more. Currently, we focus much more on the quality of lighting. An interesting field since it comprises severe knowledge and understanding of metrology and of human perception. We deliver education, training for industry and conduct research within four themes: Indoor Lighting, Metrology, Optical Design and Appearance & Perception." This academic year Hanselaer accepted a management position at KU Leuven and will thereby leave the Light&Lighting Laboratory in the hands of among others: Frédéric Leloup.

HARD & SOFT METROLOGY

Leloup: "Within my research domain and as a co-leader for the lab, I will focus on expanding the state-of-the-art hard metrology facilities and soft metrology knowledge in the coming years. Hard metrology contains the measurement of physical quantities and the design of the requisite measurement methods and set-ups. Soft metrology means that we look into the effects of visual perception. The combination of the two enables us to do reliable predictions on the quality of, amongst others, a lighting device."

THE LIGHT-BULB EFFECT

Over the years, the Light&Lighting Laboratory has developed its field of attention towards the intersection of measurement and perception. Hanselaer: "It is

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At the intersection of measurement and perception

By Michiel de Boer (MOESASJI)

interesting to see that the last decade there has risen an understanding that human visual perception is a main influencer for the evaluation of the quality of light. A typical example is the development of a new metric for glare. Regarding the perception of objects, we can refer to a new generation of gloss meters. A gloss meter measures the amount of light that is reflected by a surface in the specular (mirror) direction. However, the visual perception is dependent on several extra factors. If we ask someone to point out which object delivers more gloss in the same background, a black or white object, the majority will choose the black object due to the stronger contrast."

Leloup: "You can imagine that the background and external factors such as different lighting conditions (day, night, fog) can play an important role in lighting design for example for traffic lights, road lighting and more. To be able to make a good prediction of the visual impression we have to take into account the perceptual attributes."

Hanselaer: "True. Next to light intensity also color plays an important role in human perception. To counter the so-called 'light-bulb effect' a couple of years ago we developed the 'Memory Color Rendering Index'. Let me explain. Especially indoors, the light source influences our perception. However, we have a certain image of what - for example - a yellow banana should look like. It is a distinctive sort of yellow that our memory connects to the banana. An effective light source should provide an image that brings out the color of the banana as we expect it to be. Therefore, we ask a number of participants to score the color given to a banana with respect to its expectation. This results in a new index that can give input for measurement (set-ups) and design."

CAMERA-BASED MEASURING

Leloup: "We increasingly use camera-based measurements that enable better capturing of elements such as atmosphere and visual impression. Our hyper spectral camera collects information pixel per pixel offering deep insight in the characteristics of light on different levels. This however brings a lot of data to the researchers and generates interesting discussions on calibration, measurement set-up and analysis of the results. As you can see, our research themes are not silo's but often have an interesting interplay. We can combine high-level measuring technology with perception studies, contribute to the design of optical systems and provide education to KU Leuven students and industry professionals on everything that is required to do so. We keep on investing in our knowledge with the community of students, young and older professionals."

Want to know more?
https://iiw.kuleuven.be/onderzoek/lichttechnologie

ILI New employees

VERENA DE KOK

EngD Building Lighting Group (BE)

I obtained my Bachelor's degree in Psychology and Technology and my Master's degree in Human-Technology Interaction at the Eindhoven University of Technology. During my Bachelor's, I developed a fascination for light and how it affects human well-being. I developed this interest further during my Master's and graduated on the topic of light for people with a consciousness disorder.

As of August 2022, I joined the Building Lighting Group as an EngD trainee. I am involved in a project in collaboration with VELUX in which we focus on light in the home office. Our goal is to develop a recommendation guideline for people working from home to guide them in obtaining lighting conditions throughout the workday that are beneficial for both the image forming-, as well as the non-image forming pathway. At present, we are working on a questionnaire to study lighting conditions in Dutch home offices.

FATIH DENIZ

PhD Human-Technology Interaction Group (IE&IS)

I have completed my bachelor's degree in 'Psychology' at Istanbul Sehir University, where I focused on cognitive psychology. Fascinated by cognitive processes and their applications, I decided to pursue a master's degree in 'Applied Cognitive Psychology' at Utrecht University. During this program, I used psychophysiological measurement tools with multi-modal data collection methods to measure affective experiences and utilized machine learning algorithms to create predictive models.

After my master's, I joined the Human-Technology Interaction group in TU/e as a PhD student in October 2022. My research is focused on the emotional experience of indoor environments and how these experiences are affected by different physical conditions and meaning-related attributes of the environment. We want to examine physical characteristics such as the effect of light, sun patches, and natural elements. With the help of mathematical and AI models, we expect to examine human responses to indoor environments with different physical and meaning-related characteristics at an unprecedented level of detail.

NOORTJE VAN VELZEN | IGNITE TEAM MANAGER
ELKE DEN OUDEN | AMBASSADOR
INNOSPACE LIGHTING

UNITE WITH LIGHT

Over the past years, student team IGNITE from the Eindhoven University of Technology has collaborated with GLOW Eindhoven. Starting from 2018 onwards, Team IGNITE has designed a multitude of varying light installations. As of this year, the team has undergone a complete transformation. In the team's early years, a small group of TU/e students would focus on one GLOW project. Now, the team has rebranded with a new logo, strategy, and organisational structure.

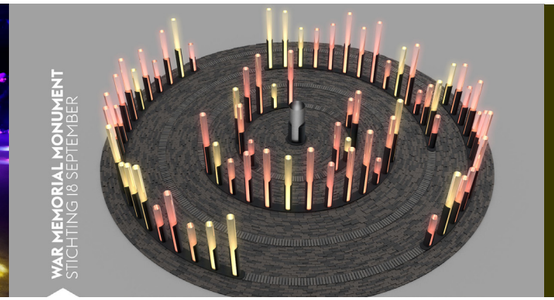
- IGNITE is a student team concerned with showing the world the potential of light and its influence on human behaviour. The team combines light, art and tech in projects to bring people together.
- All projects consist of three elements: bringing people together, focusing on societal challenges, and using technologies in innovative ways.
- IGNITE is also a student community with a management team, multiple design projects and an ecosystem of students interested in lighting. Members help each other out, share knowledge and co-create.

In the past, IGNITE has shown that light can be used to:

- make people dance;
- lead the way;
- to commemorate freedom and to retell war stories.

TEAM IGNITE
Unite with light

BALLROOM
GLOW 2021



WAR MEMORIAL MONUMENT
STICHTING 18 SEPTEMBER

With this 'big data', the researchers developed a statistical Nowadays, student team IGNITE is a light community with 42 team members from Eindhoven University of Technology, Fontys Hogescholen, and the Design Academy. With the TU/e innovation Space light theme, over 200 students are part of the greater ecosystem. The team is still affiliated with the Innovation Space of the TU/e, making it possible to receive professional guidance in their further development. IGNITE has recently been accredited to the TU/e's first Art & Tech team (Yeey!). The team runs seven light projects for GLOW and other partners (fun parks, the municipality of Eindhoven, and an art exhibition). The management team now enables further growth with business opportunities. The team is eager to work with various stakeholders from the Brainport area. In short, one could say that IGNITE is a student design firm for light, art and tech-related projects.

Let's co-create light magical experiences together!

IGNITE'S AMBITIONS

The team's ambitions for the future are:

- Improving the quality of the light installations.
- Incorporating technological innovations by collaborating with the university's research departments.
- Showcasing light installations at multiple light festivals worldwide.
- Organising a series of events which are interesting for partners and students.
- Create a stable and continuous light community of design, tech and management students.

CHALLENGE BASED LEARNING

Team IGNITE, together with ILI, are challenge owners for various challenges in relevant courses. Based on the research programs of ILI and the interests of students expressed in brainstorms and events, a challenge is formulated fitting with the course's learning goals. The students working on the challenge are supported through the network of companies and researchers.

Linked-In Team IGNITE // **Facebook** teamignitetue // **Instagram** teamignitetue // **mail** info@teamignite.nl

JESPER KAPTEIJNS | TEAM LEADER IGNITE
ILANA VAN DEN AKKERVEKEN | IGNITE WAYFINDERS

GLOW 2022 BY IGNITE

IGNITE is a talented study team from the Technical University Eindhoven. It was originally founded by enthusiastic members of the student societies Cheops (Built Environment) and Lucid (Industrial Design) who wanted to make an installation for GLOW together. The team still consists of several students who combine light, art and technology. They are currently working on a large number of design projects and collaborating with various stakeholders, Examples include a collaboration with the Brainport Industry Campus, the municipality of Eindhoven, the Efteling, Paaspop, Vogelfrei, Tesla Divas, SSRE and Fontys Hogescholen.

This year, Team Ignite comes with two installations: Unplugged and Paper Trails.

UNPLUGGED

This installation was made specially for GLOW. It is a floating light bulb in the air with extraordinary proportions. With a giant plug and cable. The power comes from the visitors to GLOW. They can operate the pins of the plug and thus become the energy source for the light bulb themselves. The filament that lights up is not what you would expect. The wires have been replaced by the three 'vibes' that characterize the city logo of Eindhoven.

The piece needs interaction and people to bring it to life. Just like the city itself and the light festival GLOW that need people to sparkle. That's why we encourage you to join in and take part by interacting with the installation. The designers faced a technical challenge with this project. In order to fully integrate the floating plug into the design, the use of a counterweight was not possible, and the diameter of the cable also became a limiting factor. The solution was found in a ground anchor design. With a heavy profile of extra hardened and hot-worked steel, the strength calculations were met without compromising the first design.

PAPER TRAILS

We've all made Paper airplanes. These 'Paper Trails', from the talented group Wayfinders – part of the student team IGNITE – move naturally with you. From one light artwork to the next. You can see them up at the top of lampposts, high above the pavement and right in front of you in the street. They convey a nostalgia and playfulness that is reminiscent of children playing in the street. Without usual directions such as arrows and signs, they manage to find a magical and effective way to guide visitors through the route. And all this without obscuring the streetscape. Visitors don't even realize they are following the Paper Trails, but without this signing, they would easily get lost. An airplane is a symbol for bringing people to where they want to be. They always carry you further.'

Last year, in 2021, the Wayfinders brought a path full of luminescent mushrooms to GLOW. You may remember them. The mushrooms formed an interactive system. Visitors activated a mushroom, so that it started to glow and spread its spores to the next mushroom. This caused a chain reaction all over the Tu/e campus. With this concept, they won the Crowe Talent Awards. This year the LED strips from mushrooms will be reused and the team will provide sustainable recycled greencast plexiglass.

https://gloweindhoven.nl/en/

ILI SHORT

ILI PhD thesis

A next generation Color Appearance Model for self-luminous stimuli

Thanh Hang Phung, (Faculty of Engineering Technology, KU Leuven), October 2022, *Advisors:* prof. P. Hanselaer, prof. F.B. Leloup and prof. P. Dutré

The assessment of the quality and comfort of lighting requires a good knowledge of the correlation between the optical properties of the sources, such as the luminance distribution, and their perceptual attributes such as brightness, hue, and saturation. To this extend, Color Appearance Models (CAM) have been developed. The aim of this doctoral research project is to develop a new generation Color Appearance Model for self-luminous stimuli surrounded by self-luminous backgrounds using an image based approach and inspired by physiological insights. This would represent a real breakthrough in visual perception modelling. Such a model will facilitate lighting design to move forward from the traditional illuminance based design to a luminance based design.
For outdoor applications such as road lighting and signalization, this model will become the tool to explore the limits of energy consumption while maintaining safety standards. In the long term it could become possible to implement the effect of aging and some common visual deficiencies directly into the model which will in turn contribute to a more personalized lighting design. Finally, the availability of a reliable and robust CAM can be used to enhance the experience of Virtual Reality devices.

Eindhoven Engine Festival of Disruption

Özge Karaman Madan, *a PhD candidate at the Human-Technology Interaction group, gave a pitch about the IntelLight(+) project at the Festival of Disruption. The event occurred on 17 October 2022 at Eindhoven Engine on the TU/e campus. The aim was to get to know all 26 projects of Eindhoven Engine and help each other to accelerate their innovation further.*

On behalf of her team, Özge presented the motivation and initial findings of her PhD project and the EngD project of Sietse de Vries. She showed a short video about the positive effects of natural light and the importance of studying the spatial and temporal characteristics of natural light patterns for creating innovative artificial lighting scenarios that would bring positive qualities of nature into indoor environments.

WILBERT IJZERMAN | EINDHOVEN UNIVERSITY OF TECHNOLOGY AND SIGNIFY
ANKE PETERS | DELFT UNIVERSITY OF TECHNOLOGY AND OPTICS NETHERLANDS

Optics Netherlands

Optics is all around us and is a key enabler for societal megatrends as a fundamental element of new technologies and applications.

In recent history, optical technologies with Dutch origin influenced innovation and created new markets. The impact the CD player had on societies in the 80s not only for the enjoyment of music but also for storing and sharing information cannot be overestimated. Even now communication is an essential part of our society and new optical technologies provide steadily increasing capacity for stable and safe data transfer.

The increasing need for data storage and transmission resulted in the conception of ASML, which is highly dependent on optical technologies in its wafer steppers, producing ever-advanced chips that connect our society and ease our daily life.

Optical technology allows Signify to reduce energy consumption by 80% with their LED solutions for their governmental, industrial, and consumer markets. Efficient lighting solutions are also crucial in greenhouse applications. The correct lighting environment for growing plants is beneficial for their health and reduces the need for chemical fertilizers.

Modern medicine heavily depends on ever-advancing imaging technologies for diagnosis as well as surgery and treatment. Since the 1800s scientists have been curious to study the living body from the inside.

> Carla camp

Nowadays surgeons and scientists can rely on high-resolution miniature cameras that provide an instant view for diagnosis as well as surgery, decreasing the recovery time for patients drastically.

Historically the Netherlands is leading in many research and application areas for new innovations in optical technologies. It has given rise to an industrial ecosystem, that not only consists of a few multi-nationals but several hundreds of SMEs that use optical innovations.

To support the optical community, we are installing a new Dutch institute: Optics Netherlands that comprises all optical research and education in the Netherlands on all universities and persists to maintain the close cooperation between the Dutch industry and academic institutes.

The institute has three focus areas: Education, Research, and Innovation:

EDUCATION of new talent is a first focus. Since optics is all around us, we need to educate new talents at all levels from Secondary vocational education (MBO), Higher professional education (HBO) and University education (WO). There is a bright future for a workforce that maintains optical technologies, adapts new optical technologies into the current infrastructure of our ever-increasing high-tech lifestyle and research new optical principles and applications. The first activities have already taken place under the umbrella of the new institute such as a career event for photonics: CARLA camp: *https://carlahub.eu*. Another essential event was a summer school organized by Optics Netherlands where PhD students of four large research consortia were given a glimpse into alternative application areas of cutting edge optical technologies.

RESEARCH focuses on new emerging technologies and creative ideas of using optical principles to solve societal challenges. By combining the knowledge of researchers at all academic institutions and having brainstorm sessions we will develop new ideas for proposals. Participating groups of Optics Netherlands have a successful track record in submitting research proposals such as in NWO perspective calls and in recent months have defended two proposals in the third round as well as submitted a new initiative.

INNOVATION to turn academic research results into products is the third focus area of Optics Netherlands. We need a thriving industry that drives the innovation of new optical technologies. They create economic impact in The Netherlands by applying energy-saving, safe, and high-quality innovations. Startups need not only financial support but also a well-organized community that is easy to navigate for defining new application markets.
The institute is open to all Dutch educational **and** industrial partners and gratefully hosted by the 4TU federation.

> Audience Summerschool Optics Netherlands

ELKE DEN OUDEN | TU/E INNOVATION TECHNOLOGY ENTREPRENEURSHIP & MARKETING (IE&IS)
MARIËLLE AARTS | TU/E BUILDING LIGHTING GROUP (BE)

Mastering Light; Educating the next generation of lighting experts

Lighting design has outgrown the situation where the skill to work with lighting design software programs and the basics about light sources and luminaires is sufficient. Lighting design has developed from a more esthetically pleasing via visual performance to integrated light solutions. The latter considers the different pathways on how light can impact the users, including the visual perception and performance but also the more recently discovered affect that light influences our circadian rhythm (sleep) and therefore our health. Although there are still a lot of questions to be answered considering the user needs and what lighting is best for whom and when, we know that a good lighting design should consider more aspects then merely providing sufficient lighting to enable reading.

In addition, technological development related to light has also advanced. This involves energy friendly, luminescence light sources (e.g., LED and OLED) and IoT or connected lighting. Additionally, sensing technologies have developed and become more affordable, which leads to an inexhaustible resource of light control options. So, due to the digitization, lighting is becoming an important element in the rapidly growing fields of IoT, AI, for its potential to impact energy saving (Smart Buildings), safety (Smart Cities) and the user (Health, experience).

To facilitate the changing lighting market, ILI has taken the initiative to develop an educational programs that prepares future engineers and designers with the knowledge and skills to balance sustainability and user demands for optimized solutions.

STUDENT LIGHTING COMMUNITY

Together with student Team IGNITE we are building an ecosystem of students that are interested in lighting. Students work on (extracurricular) projects, but also on challenges that are offered for interdisciplinary teams in TU/e innovation Space. ILI together with Team IGNITE makes sure that we have a continuous flow of challenges for students to choose.

NEXT STEPS

In addition to the above mentioned, we are exploring the opportunities for offering a life-long learning program to professionals working in the lighting domain.

Master Certificate Program Intelligent Lighting Design

Awaiting formal approval. Expected starting date as of the Academic year 2023-2024.

The Master Certificate Program Intelligent Lighting Design is a multidisciplinary program, offering a challenge-based approach to engineering and designing intelligent lighting solutions. The program is coordinated by the department Built Environment in collaboration with the Intelligent Lighting Institute and with contributions of the departments Industrial Engineering & Innovation Sciences, Electrical Engineering, Mathematics & Computer Science, Industrial Design and Innovation Space. The program has a workload of 20 ec. The program is built up of one mandatory theoretical foundational course (5 ec), one defined elective (5 ec) and a multi-disciplinary design and engineering challenge (10 ec), *see table below.*

Theoretical foundational course					
Lighting technology (7S880), light fundamentals					
Theoretical elective courses					
Capita Selecta Lighting Technology (7LL7M0)	Psychology of Light & Time (0HM200)	Bayesian Machine Learning & Information Processing (5SSD0)	Internet of Things (2IMN15)	Methodology for Business & Product Creation (1ZM130/140)	User Experience Theory & Practice (DDM150)
Multidisciplinary Design & Engineering course					
Intelligent Lighting Design & Engineering Challenge (Master Design Project 7LS0M0)					

European Lighting Expert (ELE)

Awaiting formal approval.
Expected starting date, January 2023.

The European Lighting Expert Association *(ELEA, https://europeanlightingexpert.org/en/home/)* has established a Europe-wide harmonized educational standard for light and lighting. After passing the examination, you will get a certificate which allows registration with the ELEA as a European Lighting Expert (ELE) in Interior and/or Exterior Lighting. With this certificate you have proof that you have the knowledge and skills to plan lighting projects as well as to assess existing lighting systems.
In consultation with the NSVV (Dutch Light Association) the taxonomy of ELE was compared to two eligible TU/e courses. Both courses were approved. This means that students that have passed the TU/e course Physics of Light and Lighting Design (7HK30) or Lighting Technology (7S880), can register themselves for € 25,- to the ELEA and will become than a European Lighting Expert, interior lighting.

Bachelor Certificate Program Engineering Intelligent Lighting

Active since 2014.

The Intelligent Lighting certificate program is a multi-disciplinary training program for bachelor students majoring in any of the disciplines offered in the TU/e bachelor school and embedded in the Intelligent Lighting Institute *(https://www.tue.nl/en/research/research-institutes/top-research-groups/intelligent-lighting-institute/education/certificate-program/).*

The program contains 5 different light courses:

- Light & experience (0HEUA0)
- Advancing light for human functioning (0HSUA0)
- Secret life of light USE project (0HAUA0)
- Physics of light and lighting design (7HK30)
- Liberation of light technical project (7HK40).

Passing the three regular courses and one of the offered projects plus 5 ec on top of their regular BSc program, entitles students to obtain this certificate. On average, 20 certificates per year are handed over.

Program
ILIAD event 2022

November 21
Glorieuxpark Eindhoven

09:00 **Registration**

09:30 **Opening and welcome** *by ILI Scientific Director Ingrid Heynderickx*

09:40 **ILI joint research proposal Light 4 Life** *by Elke den Ouden and Rianne Valkenburg (ILI TU/e)*

10:00 **Cluster Patients**

11:15 **Area Smart Environments**

12:00 **Cluster Offices and Schools**

13:45 **Area Behavioral Dynamics in the Ecosystem**

14:30 **Cluster Caregivers**

15:30 **Area Effects of light++ environments on humans**

16:15 **Closing** *by ILI Operational manager Harold Weffers*

16:30 **Drinks**

CLUSTER PATIENTS

10:00

How can we leverage the health-promoting potential to support patients during their care trajectories, while minimizing burden and maximizing comfort?

Introduction Karin Smolders (ILI TU/e Human Technology Interaction Group)

Light for neonatal care

Guest speaker Jeroen Dudink, Pediatrician (Neonatologist and Associate professor UMC Utrecht)

10:45

Network coffee break

11:15

AREA SMART ENVIRONMENTS

Designing smart environments with monitoring, data intelligence and lighting technology

Introduction Nirvana Meratnia and Tanir Ozcelebi (ILI TU/e Mathematics and Computer Science, Interconnected Resource-aware Intelligent Systems)

Enabling touch-free sensing with light for the post-COVID world

Guest speaker Qing Wang (Embedded and Networked Systems Group of Delft University of Technology (TU Delft)

CLUSTER OFFICES AND SCHOOLS

12:00

How can we prevent health issues for office workers, teachers, students, and pupils?

Introduction Juliette van Duijnhoven (ILI TU/e Building Lighting Group)

Light innovations in practice

Guest speakers Arjen Raue and Marije te Kulve, lighting & indoor climate specialists at bba indoor environmental consultancy

12:45

Network lunch - *Posters ILI PhDs and EngDs*

13:45

AREA BEHAVIORAL DYNAMICS IN THE ECOSYSTEM

Introduction Bob Walrave (TU/e Innovation Technology Entrepeneurship and Managemen)

Health simulation models

Guest speaker Roland van de Kerkhof (Tilburg School of Economics and Management)

CLUSTER CAREGIVERS

14:30

How can we realize a healthy and strong workforce in the care system of the future

Introduction Mariëlle Aarts (ILI TU/e Light and Building Group)

Light, health and safety in night shift workers

Guest speaker Matijn Dollé (RIVM – Centre for Health Protection, Dutch National Institute for Public Health and the Environment)

15:15

Short break

15:30

AREA EFFECTS OF LIGHT++ ENVIRONMENTS ON HUMANS

Introduction Luc Schlangen (ILI TU/e Human Technology Interaction Group)

Tracking and modelling circadian rhythms in personalized human centric lighting

Guest speaker Jean-Paul Linnartz (Signify and ILI TU/e Signal Processing Systems group)

ILI
INTELLIGENT
LIGHTING
INSTITUTE

TU/e

Visiting address
ATLAS 3.424
5612 AZ Eindhoven
The Netherlands

Postal address
P.O. Box 513
5600 MB Eindhoven

www.tue.nl/ili