Intelligent Lighting Institute | Edition 19, November 2023

ILI GLOW

> PERSONAL ENVIRONMENTAL CONTROL SYSTEMS

> LIGHT SKETCHING FOR ECOLOGY

> TEAM IGNITE AT GLOW EINDHOVEN 2023

> LIGHT4LIFE INITIATIVE

TU/e

EINDHOVEN UNIVERSITY OF TECHNOLOGY

Content

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EDITORIAL STAFF Harold Weffers, Marlies Bergman DESIGN Volle-Kracht concept, ontwerp en organisatie ILLUSTRATIONS ILI PHOTOGRAPHY Bart van Overbeeke Fotografie

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

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Pleasant reading!
Harold Weffers
Operational manager

HAROLD WEFFERS | OPERATIONAL MANAGER

Welcome

I am very pleased to be able to present to you the latest edition of our ILI Magazine. Since the previous edition in May 2023 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 an in-depth perspective on the role of perception of light & lighting for our work. Next to this, we provide an update on our earlier Light4Life initiative.

NOVEMBER 2023 - 2024

Calendar

11-18 November
GLOW festival
Location: Eindhoven (city center), Geldrop-Mierlo, Oirschot, Best en Waalre

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22-23 November
Future Lighting, organized by NSVV, IBE-BIV, Groen Licht Vlaanderen.
Location: Evenementenhal Gorinchem (in Dutch)

7-11 April
SPIE Photonics Europe & SPIE Optical Systems Design
Location: Strasbourg (France)

Nov 2024
IEEE Sustainable Smart Lighting World Conference
Location: Eindhoven

"Crafting these installations is an inherently creative and innovative multi-disciplinary process, that sparks community building."
Ingrid Heynderickx, Scientific Director

INGRID HEYNDERICKX | SCIENTIFIC DIRECTOR

ILI supports team Ignite

In our latest edition of ILI Magazine, we emphasized ILI's commitment to strengthen its community. Beyond our regular meetings predominantly with scientists and stakeholders, ILI wants to invest in strengthening its ties with students at various academic levels – being BSc, MSc, EngD and PhDs. Therefore, ILI announced that it will initiate regular meetings specifically for the student community.
In these meetings students and ILI staff will create an environment where knowledge on lighting is exchanged, where students support one another in their research endeavors, and where multidisciplinary challenges are approached as a collaborative effort.

What better way to initiate this sense of community than by introducing our students to a lighting-inspired multi-disciplinary student team – Team IGNITE. Recognized for the unique interactive quality of their lighting installations, ILI, the TUe Executive Board and the GLOW organization have recently committed structural funding to this team, and as a consequence the team will intensify its engagement of delivering yearly (a) GLOW installation(s). Crafting these installations is an inherently creative and innovative multi-disciplinary process, that sparks community building. By hosting events for our MSc- and PhD-students in the facilities of Team IGNITE, we hope to expand the community of enthusiasts who are eager to connect to one another, as such pooling their expertise in order to create great lighting innovations that would be unattainable when done in isolation.

We wholeheartedly extend our invitation to our external stakeholders to partake in this student community by providing real-life lighting challenges and, where relevant and interested, guiding our students towards meaningful intelligent lighting solutions. ■

INTERVIEW | TU/E ASSISTANT PROFESSOR JULLIËTE VAN DUIJNHOVEN (BUILDING LIGHTING BE)

By Michiel de Boer (MOESASJI)

Paving the path to healthy light exposure in buildings

Although we cannot see light itself, it has many effects on humans. We need it to wake up and to stay alert and focused during the day.

Lighting in buildings that promotes productivity and supports health; there is much development in the field of Healthy Light Exposure. However, appropriate standards for buildings are still limited. What exactly is healthy lighting? And how do you determine healthy lighting exposure effectively for the individual? A conversation with TU/e assistant professor Juliëtte van Duijnhoven

"I initially entered university to become an architect," Juliëtte explains, "that was my childhood dream. However, I soon concluded that designing beautiful buildings wasn't exactly my thing, I much more wanted to create environments that are pleasant and comfortable for people to live and work in. Gradually, I began to explore the functional side of building physics and focused on light and lighting. That's what I am working on to this day."

Although we cannot see light itself, it has many effects on humans. We need it to wake up and to stay alert and focused during the day. Juliëtte: "It turns out that people have a hard time describing their light preferences. For temperature it might be that they can easily say whether it is comfortable or not, but for light it tends to be more difficult. Moreover, people cannot accurately describe what kind of light they need to work effectively on different tasks. This inconspicuousness makes it very interesting to me. We will have to help building users and building designers to achieve ideal lighting conditions."

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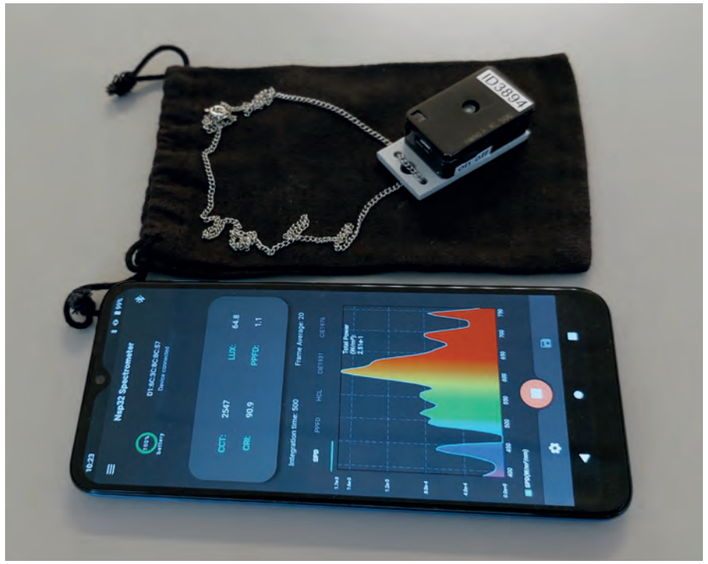


> *Wearable sensors to record the amount and spectrum of light*

Light Exposure Behaviour Assessment (LEBA): Long Form (v1.0.2, 3 June 2022)

Participant Instructions

Please indicate how often you performed the following behaviours in the **past four weeks:**

	Items	Never	Rarely	Sometimes	Often	Always
01	I wear blue-filtering, orange-tinted, and/or red-tinted glasses indoors during the day.					
02	I wear blue-filtering, orange-tinted, and/or red-tinted glasses outdoors during the day.					
03	I wear blue-filtering, orange-tinted, and/or red-tinted glasses within 1 hour before attempting to fall asleep.					
04	I spend 30 minutes or less per day (in total) outside.					
05	I spend between 30 minutes and 1 hour per day (in total) outside.					
06	I spend between 1 and 3 hours per day (in total) outside.					
07	I spend more than 3 hours per day (in total) outside.					

> *Questionnaire Light Exposure Behavior Assessment*

Light for human health and wellbeing

At this moment, research insights and the current standards for lighting design are not on the same page. Juliëtte: "You cannot suffice with a static study of 'I measure this illuminance here' and 'we want this amount of lux per workplace'. People rarely sit still all day in the same light conditions. They move in and outside the building and experience different amounts and types of light at any given time. For example: looking out a window can result up to twenty times the amount of light at eye level compared to what you would have received looking away from the window.
In addition to the image-forming effects of light (being able to see our environment), we must consider non-image-forming effects of light: what does light do to our health and wellbeing? Current lighting design tools are mostly designed for static situations and are still mostly focused on the image-forming effects of light."

Methods to quantify PLE patterns

"I started focusing on light sensing & controlling methods to be used in light effect studies, for example when investigating non-image forming effects of light. For example, we deploy wearable sensors to accurately and continuously record the amount and spectrum of light a person receives at eye level during the day, in other words the Personal Light Exposure (PLE) patterns. This field of wearable light sensors, dosimetry, is developing rapidly. The large datasets that we can gather through dosimetry can provide insights into PLE patterns which we can deploy for better lighting measurement instruments, simulation software, and lighting designs in buildings. Moreover, we use questionnaires to capture behavior of research participants that might impact their PLE patterns.
For this purpose, we have developed a 23-item questionnaire, the LEBA instrument (Light Exposure Behavior Assessment)."

PLE and Light Guidance Systems

"Whereas with dosimetry we quantify what the PLE is, but ultimately, we want to know which 'settings' can provide building users with the best lighting conditions. A number of factors that influence PLE are important here, including weather conditions, building orientation, window light transmission, shading technologies, daylight levels, and electric lighting systems. But also, people's personal needs and their behavior. This makes lighting design complex and very interesting. Even more when you consider that people find it very difficult to indicate exactly what kind of light they need. That's why we look into ways of supporting them. This can be done actively: by enabling the user himself to adjust the light conditions in a certain room or to stimulate them to exhibit certain behavior, such as: going outside for a moment during lunch. And this can be done passively: by providing lighting applications that automatically support the building occupant, such as a dimmed lamp that does not burden the sleep/wake rhythm when you need to go to the toilet at night."

New standards

In all these areas, Juliëtte is associated with research and standardization bodies, including ILI (Intelligent Lighting Institute), CIE (International Commission on Illumination), ELEA (European Lighting Expert Association) and NSVV (Nederlandse Stichting voor Verlichtingskunde). Juliëtte: "I think it is important to contribute to organizations and jointly work on standards for healthy lighting in buildings. This helps architects and lighting designers to design 'integrative lighting' solutions. This term was introduced by the CIE and describes lighting that considers both image-forming and non-image forming effects of light and thus optimally supports people in their wellbeing at work and in their life. Just as everyone deserves to have healthy food and exercise, adequate light exposure is a prerequisite for health. Every lighting designer should have proper tools in their toolbox!" ■

PHILIP ROSS (STUDIO PHILIP ROSS) | EINDHOVEN, THE NETHERLANDS

Light Sketching for Ecology: a design tool for balancing human experience and ecological impact

BACKGROUND AND OBJECTIVE

The impact of artificial light at night on ecology is an urgent consideration in lighting design. People's needs and wishes for light in urban areas often conflict with demands for minimising ecological impact. For example, in city parks people may desire light that offers a pleasant experience of nature and the feeling of safety, while local fauna may thrive best with no light at all. How to overcome this seemingly unresolvable conflict, especially in hybrid environments like city parks? Light Sketching for Ecology is developed to help balance lighting demands for human experience and reduction of ecological impact.

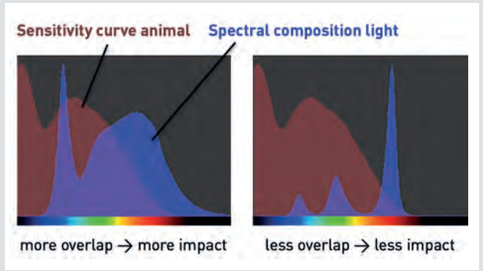
THE LIGHT SKETCHING SYSTEM

The Light Sketching system was initially developed to enable a creative conversation with people about light in their outdoor environment. People sketch light patterns on a tablet interface. These patterns are transformed into real light patterns in the environment through 5 custom designed street luminaires with 38 individually controlled RGBW LED modules each. See *www.lichtschetsen.nl* for a video and more information.

To give local animals 'a voice' in the Light Sketching process, the system incorporates a measure for how impactful the light is to these animals, based on an adaptation of Longcore et al.'s 'Rapid assessment of lamp spectrum to quantify ecological effects of light at night'. The method determines the amount of overlap between the light's Spectral Power Distribution and the sensitivity/response curve of the animal for a range of wavelengths, see Figure 2. The less overlap, the less the animals are impacted by the light. The system reports the sum impact of all LED channels, in a measure called 'Total Effective Irradiance'. The calculations are performed in real-time so we can directly see how each added stroke of light changes the impact on the selected animals.

We selected six animal groups to include based on their presence at the pilot location and their red listed (protected) status: bats, mice, rabbits, butterflies, owls and songbirds. We worked at the level of animal groups

> ***Figure 1:*** *Light Sketching session in a park (big photo) and A Light Sketching luminaire (small photo).*



> Figure 2: *Two different Spectral Power Distributions of light, indicated by the blue curves, in combination with an animal's sensitivity curve in red.*

instead of exact species, because literature did not offer sensitivity curves of the exact species present at the pilot location. So these are approximations.
From literature, we derived three strategies to lower ecological impact of a given Spectral Power Distribution:

1. Lowering overall intensity. Very straightforwardly, less light means less ecological impact.
2. Shift to red. This means decreasing green and blue components of the light, for which animals are generally most sensitive.
3. Metamer colouring. Light from white LEDs with a given colour temperature can be created with a 'regular' white LED or with only narrow RGB peaks. This metamer light has the same colour point, making it hard for people to tell the difference, but it is generally less impactful in terms of Effective Irradiance. Note that there is a trade-off in terms of Colour Rendering Index and energy usage.

The Light Sketching tool allows application of these strategies on people's sketches live, in a gradual way from 0-100%. This way, we can determine how far the strategies can be applied without compromising human experience.

PILOT STUDY IN CITY PARK 'STADSWANDELPARK'

A pilot session in Stadswandelpark was conducted to test the Light Sketching for Ecology system in practice. Many consider this park too dark and eerie, and avoid entering it after sunset. We set-up at a dark entrance path *(Figure 3)*.

> Figure 3: *The Stadswandelpark pilot location with regular lighting.*

Three park users, an ecologist and a public lighting official took part in the pilot.
Here, we treat the results of an elderly woman, living at the edge of the park. The top picture of Figure 4 shows her original sketch, creating a warm atmosphere and providing overview.
The second picture shows step 1: dimming down to 30% of the original intensity. The participant was fine with this reduction.
The third picture shows step 2: Metamer coloring. She could not tell the difference between before and after.
Step 3: shifting to red is shown in the bottom picture. She found dimming Blue to 0% acceptable, but did not want to dim Green beyond 50% of the original intensity. This would make the park look too red.
Step 4, not pictured, went down to 11% of the original intensity. She found this low intensity only suitable for the late night.

> Figure 4: *Pictures of the process of participant 1.*

The Total Effective Irradiance ('impact') reduced considerably after each step. reaching 9% of the original sketch at step 3. Compared to the regular park lighting, the impact was reduced from 515% (original sketch) to 47%. Step 4 lowered impact even further, but the result was considered only suitable for the late night. Large reductions of impact were reached for all participants' sketches.

CONCLUSIONS AND DISCUSSION

The percentages should be treated as indications of how impact on animals alters due to changes in light, not as exact quantifications: The measure should be placed in perspective of other lighting aspects such location, direction and timing.
Despite limitations of the pilot related to duration, participant group, and more, we can draw some conclusions. The impact reduction strategies give promising results. People tolerate lower light levels, especially when glare is avoided and overview is created by alternative light distributions. Applying the strategies gradually on a scale from 0-100%, instead of all-or-nothing, helps achieve significant impact reduction while retaining acceptability. Light Sketching for Ecology demonstrates that incorporating people and ecology in an experiential design process, making use of advanced possibilities of modern lighting technology, is worthwhile, especially in areas of conflicting demands like city parks. ■

Thanks to Niek Rutten and ILI for their contributions. This is a shortened version of the following Light Symposium 2022 paper, containing more detailed information and references: Ross, P. R., & Rutten, N. (2022). Light Sketching for Ecology: A cooperative design tool for balancing human experience and ecological impact. *IOP Conference Series: Earth and Environmental Science,* 1099(1), 012055. doi:10.1088/1755-1315/1099/1/012055

all pictures by Bart van Overbeeke, except Figure 1 small

ILI SHORT

CIE Wyszecki Gold Pin Awardee 2023: Luc Schlangen

Luc Schlangen received a prestigious four-yearly prize of the International Commission on Illumination (CIE), the Wyszecki Gold Pin Award for exceptional outstanding contribution in fundamental research. The award is given for his significant contributions to the development and advancement of the CIE System for Metrology of Optical Radiation for ipRGC-influenced Responses to Light. This system for quantifying light provides the foundation for replicable research and traceable measurements into the effects of light and lighting on a myriad of biological processes and behaviours relating to for instance sleep, mood, circadian rhythms, cognitive functioning, vitality, health and wellbeing.

Read the full article Light Researcher Luc Schlangen receives Wyszecki Gold Pin Award (tue.nl)

GLOW PROJECT

Philip Ross at GLOW

Philip Ross is at Glow 2023 with a new installation: a|rp|ay. It allows people to collectively create music with 19 light beams that respond to touch like wind chimes. This piece is a further development of the interactive light beam art that started with Gibson in 2018 in collaboration with ILI. You can find the installation at the Heuvel in Eindhoven.

'Paper Trails: Two Throws' has gone through many improvements in its scalability, custom elements, and bridging new challenges. Inspired by the simplicity and elegance of paper planes, dozens of lights lead you further while evoking a sense of curiosity.

LIEKE DIEDEREN | PR MANAGER IGNITE

Team IGNITE at GLOW Eindhoven 2023

From November 11 until 18, Eindhoven will host its annual light festival 'GLOW Eindhoven' once again. And after vibrant projects such as 'Ballroom' (2021) and 'Unplugged' (2022), Team IGNITE Eindhoven University of Technology's student team focusing on art & tech will this year again proudly unveil two of their new projects. With their mission of illuminating the boundless possibilities of light, this ensemble of over 30 dedicated students converges their talents to bring forth '*GLOWBLE*' and *'Paper Trails,'* two interactive artworks. Both endeavors exemplify the team's commitment to elevating the light festival experience, transcending the traditional confines of static light projections. These projects are an invitation to engage actively, beckoning visitors to become co-creators of a truly interactive experience and forging connections among themselves. All of this was created over nearly a year of interdisciplinary collaboration, hard work, and with the help of industry professionals and institutions such as the TU/e Intelligent Lighting Institute.

The first of these projects, *'GLOWBLE'*, is a testament to our innate desire to connect with both one another and the digital world through technology. Eager to decipher the sphere's messages, visitors will embark on an acoustic journey engaging in a resonating symphony of sound and light. The sphere, now rooted in the Eindhoven landscape, responds with pulsating light, showing rhythm and colors, intensifying as the exploration of interaction

by visitors deepens. This dynamic interaction between humans and technology is facilitated by the use of acoustic cameras by Eindhoven-based company Sorama, visualizing sound and its behavior, which subsequently transforms it into luminous interactions to be witnessed on the three-and-a-half-meter diameter sphere. With 'GLOWBLE,' Team IGNITE invites introspection upon the boundaries between interaction, fascination, and our role in the interconnected world, seeking a harmonious balance between human connection and the allure of the digital world.

The second creation is a reimagining of their '*Paper Trails*' of light. Perhaps you've already encountered these paper planes at last year's edition of the GLOW or Eindhoven Airport, where they guided visitors along the route to their next destination without the usual signs and arrows. In this iteration, 'Paper Trails: Two Throws' has gone through many improvements in its scalability, custom elements, and bridging new challenges. Inspired by the simplicity and elegance of paper planes, dozens of lights lead you further while evoking a sense of curiosity. In this case, the luminous trail leads visitors from Stratumseind to the Van Abbemuseum following a spiraling line over the water. In two throws, the visitors take a scenic detour and shine a light on the Dommel and the nature flowing through the city center, playing with the always moving and shimmering reflections in the water. With its colors and movement, it has a simple yet magical effect and a playful touch that adds an engaging dimension to the festival experience.

Team IGNITE extends a warm invitation to you to join us in the immersive world of GLOW Eindhoven 2023. As you enjoy the festival landscape, we encourage you to partake in the wonderment of '*GLOWBLE*' and '*Paper Trails,*' where light, art, and creative technology unite. And allow yourself to be inspired by the limitless possibilities of light. ■

TEAM IGNITE
Unite with light

Visit GLOWBLE at Anne Frankplantsoen.
Visit Paper Trails on the banks of the Dommel River near the Van Abbemuseum.

New project LoLiPop-IoT

In June 2023, the EU Key Digital Technologies (KDT) project LoLiPop-IoT started. The 38 European partners focus on Long Life Power Platforms for Internet of Things. Healthy Buildings form one of the use cases. Several Dutch partners, including TU/e, Signify and the IMEC Vitality Hub join forces to create an IoT sensing environment that dynamically optimizes lighting for comfort, wellbeing, and performance. Three departments from TU/e will work on quantifying the effects of lighting to support algorithms.

TU/e LightHouse is now LightHouse - Fellow at TU/e

LIGHT HOUSE
FELLOW AT TU/e

The name and logo have changed, the activities will stay the same: LightHouse - Fellow at TU/e will still collaborate structurally with ILI and its researchers. In projects, we will further build (smart) lighting cooperation with municipalities, companies, and designers.

New Eurotech project "Health illuminated: Quantified effects of light on health."

Light exposure through the eyes has a powerful impact on health. Yet, adopting a healthy light hygiene is seriously challenged in our modern society - with abundant time spent indoors during daytime and screen usage and engagement in social activities in the late evening and at night. These aberrant light exposure patterns may induce serious risks for health, via – among others – dysregulation of the circadian system. Nevertheless, a reliable and valid quantitative description of people's actual – and by extension, optimized – 24-h time profiles regarding light exposure is still missing.
In this project, we aim to employ data mining strategies to enhance the quantification of light exposure patterns monitored in the context of everyday life and advance the mapping of sensor data to human behavior and experiences in the context of light and health. To this end, we will leverage existing data and complement these data with new data collected using light sensor technology that can also accurately monitor the spectral characteristics of light. Capitalizing on an ecological momentary assessment approach combined with advanced data analytics, we aim to uncover which light-related features and aggregations render effective predictions of key health indicators and inform the development of intervention strategies.
The project is funded within the TU/e Eurotech PhD program and performed in close collaboration with the Laboratory of Integrated Performance in Design (LIPID) at École Polytechnique Fédérale de Lausanne (EPFL). Hangyu Liu will start as PhD student on this project in November 2023, under the supervision of Karin Smolders, Yvonne de Kort, and Marilyne Andersen (EPFL).

SOPHIA FRICK | ILI PHD CANDIDATE IE&IS

Attending SLTBR

From May 30th to June 1st this year, ILI facilitated my attendance at the 34th Annual Meeting for the Society for Light Treatment and Biological Rhythms (SLTBR), held in the beautiful city of Lausanne, Switzerland. The SLTBR is a non-profit organization that aims to promote research on chronobiology and light by bringing together experts from science and practice to generate multi- and transdisciplinary knowledge exchanges.

The research presented at this year's conference featured a wide range of interesting topics including chronotherapy and chronomedicine, fundamental science, translational chronobiology, clinical practice, as well as cutting-edge technological innovations in chronobiology and sleep. Alongside the scientific program, participants were encouraged to explore the accompanying art exhibition "Lighten Up! On Biology and Time" which showcased the impressive and diverse ways circadian rhythms impact the life of living organisms through a variety of artistic media. Aside from the opportunity to share my research with the SLTBR community, attending this meeting provided me with a new perspective on my work as it relates to the field at large. While highlighting advancements to the field, being immersed in the most recent developments and current topics also revealed the questions we still need answered. For instance, compared to the large number of laboratory studies presented, it appeared that field research received less attention, suggesting that more research may be needed to understand the impact of lighting in complex everyday settings.

Overall, I was reminded of the broad scope of influence that light and biological rhythms have. Presentations and symposia covered topics ranging from the role of circadian rhythms in diseases such as cancer, to the public opinion on daylight savings time, to improving sleep of astronauts in space via sleep hygiene techniques, and the promising potential of light therapy. The vast diversity of potential applications of light research presented at the SLTBR meeting this year underlines the societal relevance of this exciting field of research.

I would like to thank ILI for funding my attendance at the 34th Annual SLTBR meeting. ■

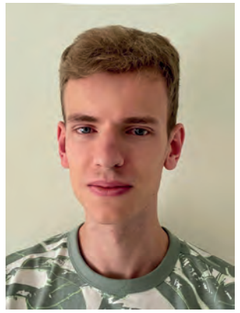
Conference grants for ILI PhDs

For the first year, ILI is launching a conference scholarship for ILI PhD students. Each year 3 PhDs can take advantage of this offer, up to a maximum of 1,500 euros per person.

Are you an ILI PhD and is there a specific conference you would like to attend? Please sign up with a short message to ILI@tue.nl indicating which conference it is, along with a short abstract signed by your supervisor.

If the grant is awarded to you, we in return will ask you to write a piece about your experience in ILI Magazine. To participate for this year, send in your application by 20 November! We will make a new call in the spring.

ILI new employee



Roel Hacking
PhD Computational Illumination Optics group (MCs)

I earned my bachelor's degree in Data Science and Knowledge Engineering from Maastricht University. During my studies, I interned at a computational neuroscience lab, an experience that partly inspired my decision to pursue a dual master's degree in Artificial Intelligence and Cognitive Neuro-science at Radboud University in Nijmegen.

For my Cognitive Neuro-science master's thesis, I conducted research on optical implants designed to restore limited vision to the blind. My AI thesis focused on a project aimed at detecting COVID-19 in patients through a combination of 3D chest CT scans and other clinical features.

In July 2023, I began my journey as a PhD student at the Computational Illumination Optics group. Here, I am working on enhancing illumination optics design using machine learning techniques. Specifically, I'm currently working on applying artificial neural networks to solve the Monge-Ampère equation for various optics problems and comparing this methodology with more traditional approaches.

MARIËLLE AARTS, JULIËTTE VAN DUIJNHOVEN AND ANTAL HAANS | ILI EDUCATION
ELKE DEN OUDEN AND RIANNE VALKENBURG | LIGHTHOUSE – FELLOW AT TU/E (PROJECT LEAD RENEWAL GASLAB)

MULTI-X periment

What if we bring together people from different organizations, perspectives, disciplines, expertise, and other "x"-es and let them play, experiment, and build applications together? In the Gaslab at TU/e campus, TU/e innovation Space intends to do just that: create an inspiring place where people from in and outside TU/e collaborate on high-tech application development in a way that was never done before. The Intelligent Lighting Institute is one of the initiators and believes in a new and unique way to inspire and learn together. What do we envision?

A place where curious people come together to tinker with high-tech to experience the opportunities of new technology and its applications

A great deal is being conceived, created, and researched at the university. How is that useful for society? What is the impact that can be created? What does that look like in applications? Even if we do not yet know the exact results of any research project, the 'new' Gaslab will become the place where we can experiment with possible applications. To go just one step beyond what we already know, we aim to discover together what could be useful.

A place that initiates unusual and unexpected collaborations

An energizing program to attract a diversity of people will inspire the creation of demonstrations and experiments. A workshop on 'world peace challenges' addresses grand societal challenges to trigger multi-disciplinary out-of-the-box thinking and to inspire the development of applications as real solutions. And this is all to be done with students, researchers, companies, organizations - in short, anyone curious to contribute to a better world.

A place with demos where bridges are built between scientific challenges and practical solutions

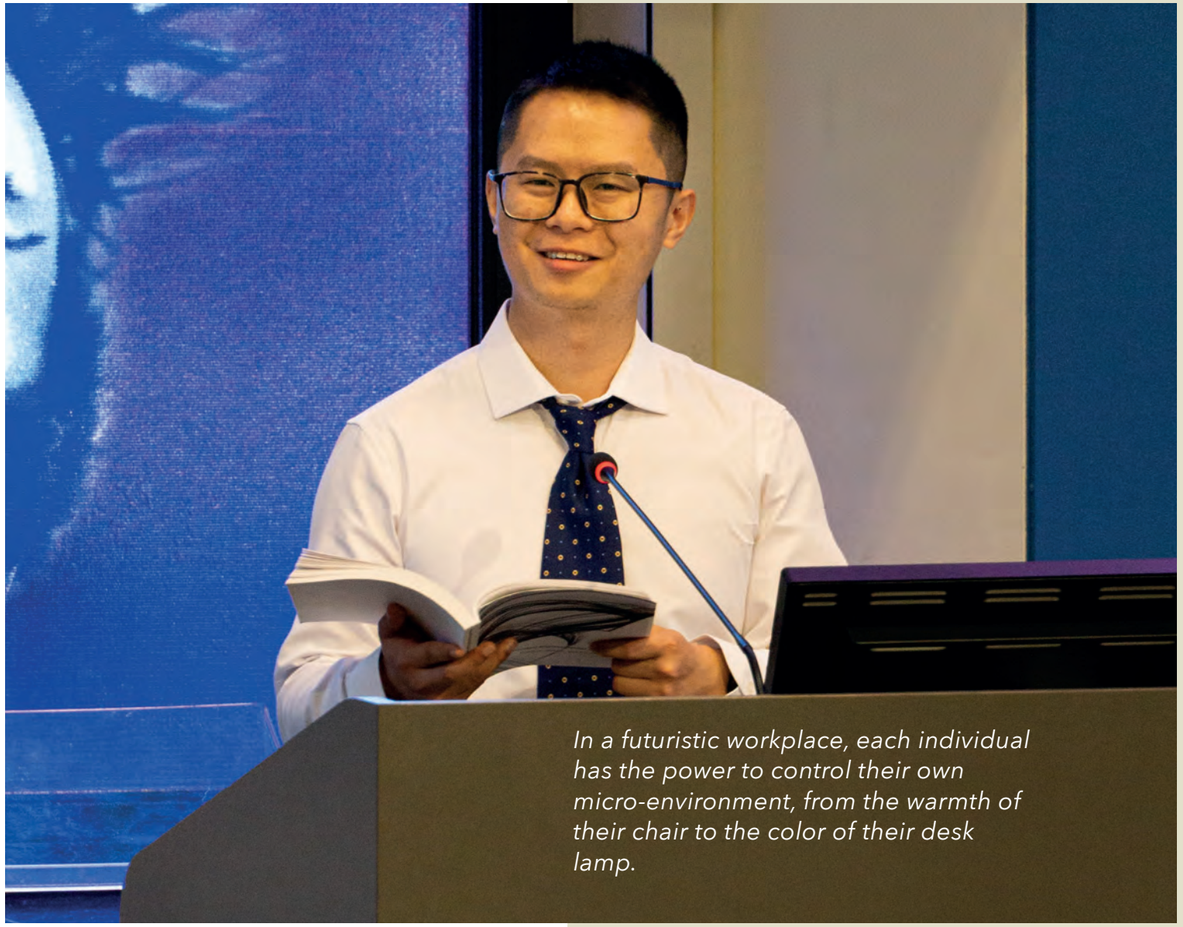
In Gaslab the newest technology will be visible and available to experiment with. Ideas include the use of

a hologram table to create scenarios for generating, sharing, and using sustainable energy or tinker with light and optics to explore what is possible in lighting design.

A place where you can experience something unique

TU/e innovation Space, EAISI (Eindhoven Artificial Intelligent Systems Institute), EIRES (Eindhoven Institute for Renewable Energy Systems), EHCI (Eindhoven Hendrik Casimir Institute), ILI (Intelligent Lighting Institute, and ALT (Academy for Learning and Teaching) are collaborating at the moment to create the first experiences, demonstrations, and modules for tinker kits.

Join us soon at Gaslab! ■



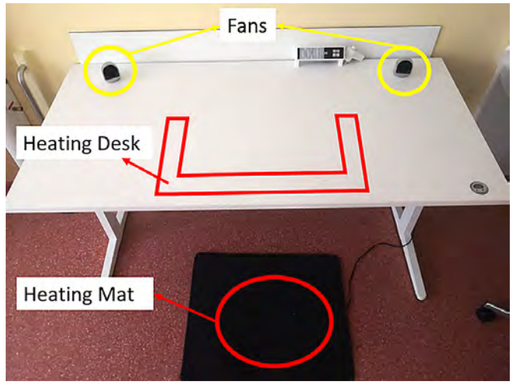
In a futuristic workplace, each individual has the power to control their own micro-environment, from the warmth of their chair to the color of their desk lamp.

PHD RESEARCH | WEI LUO – POSTDOC AT BUILDING SERVICES, TU/E; FORMER PHD-CANDIDATE AT THERMU, MAASTRICHT UNIVERSITY
SUPERVISORS | WOUTER VAN MARKEN LICHTENBELT (THERMU, MAASTRICHT UNIVERSITY), YVONNE DE KORT (HUMAN TECHNOLOGY INTERACTION, TU/E), AND RICK KRAMER (BUILDING SERVICES, TU/E)

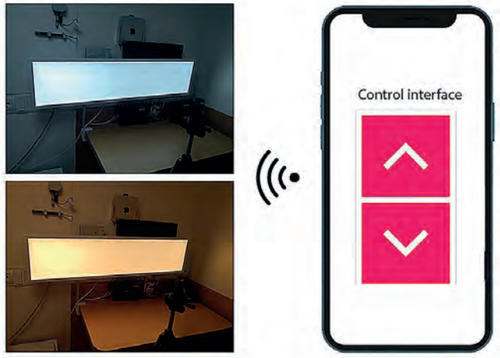
Personal Environmental Control Systems: Comfort, Health, and Productivity in Offices

Imagine an office where you no longer need to engage in tug-of-wars with your coworkers about the settings of the thermostat and the blinds. In this futuristic workplace, each individual has the power to control their own micro-environment, from the warmth of their chair to the color of their desk lamp. These systems are called personal environmental control systems, commonly including a sub-system named personal comfort system for personal temperature control (e.g. adjustable heated chair) and another subsystem named personal lighting system for personal lighting control (e.g. desk light). Such a personal environmental control system may not be as far off as you might think, and it could hold the key to personal comfort, health, productivity, as well as significant energy savings in offices.

In modern offices, the indoor temperature is often regulated within a narrow temperature range, resulting in excessive energy consumption. Expanding this temperature range promises substantial energy savings and may even benefit (metabolic and cardiovascular) health by stimulating human thermoregulation. However, thermal comfort and work performance may be jeopardized. One innovative solution to this challenge is the implementation of personal environmental control systems because it has shown great potential to enhance personal comfort and performance. Therefore, we explored this possible win-win situation: Using personal environmental control systems (personal comfort systems and personal lighting systems) combined with a relaxed indoor temperature range to realize a healthy, comfortable, productive, and energy-efficient office environment.



> ***Figure 1:*** *Designed personal comfort system including two ventilation fans), a heating desk, and a heating mat.*



> ***Figure 2:*** *Designed personal lighting system and its control interface*

We firstly designed a novel personal comfort system *(Figure 1)* that only warms the hands and feet in cold conditions and cools the head in warm conditions, followed by a laboratory test in 17–25°C. Our test results showed that the designed personal comfort system enhanced thermal comfort while retaining the healthy stimulation of mild cold to the body when warming the hands and feet in 17-21°C. Moreover, it boosted feelings of pleasure and arousal. No significant impact of the personal comfort system on cognitive performance was observed in mild cold conditions (17-21°C). However, it did enhance cognitive performance at 25°C when cooling the head, along with improved perceptions of air quality and mitigated eye strain.

Moreover, the personal lighting system *(Figure 2)* with adjustable correlated color temperature (CCT) may also address the challenges associated with expanding the indoor temperature range. Because the hue-heat hypothesis suggests that the visual experience of low CCT (more red/yellow colors) leads to a warmer thermal sensation than high CCT (more blue colors). Therefore, low CCT may improve thermal comfort compared to high CCT in cold and vice versa. We examined this hypothesis at 17°C with relatively longer exposure durations than in previously published studies. Our findings showed that CCT did not significantly impact thermal sensation but, unexpectedly, high CCT improved thermal comfort in mild cold, with limited influence on thermoregulatory responses. Moreover, cognitive performance, alertness, and arousal were notably enhanced under higher CCT. Given that non-visual mechanisms of light would imply that a higher CCT is related to higher arousal/alertness, these findings suggest a more important role of the non-visual mechanism in thermal comfort over long exposure durations.

Furthermore, we tested whether thermal comfort and cognitive performance can be improved via providing individual visual comfort using personal control of CCT (a personal lighting system). We found, while personal control of CCT successfully improved visual comfort and mitigated eye-related symptoms, it did not substantially affect thermal comfort or cognitive performance. Moreover, personal control of CCT sometimes improved alertness, decreased mental demand when performing tasks, and differentially affected cognitive performance depending on the task type.

Taken together, the outcomes of these experiments imply that we can lower the indoor temperature to mild (dynamic) cold in winter using personal environmental control systems (the designed personal comfort system with a high CCT lighting). This potentiates significant energy savings and may benefit (metabolic, cardiovascular and circadian) health in the long term. In addition, the designed personal environmental control systems successfully cater to individual preferences for their indoor environment. They also have shown potential in reducing eye-related discomfort, improving productivity, and increasing alertness, arousal, and pleasure in the workplace. Hence, the personal environmental control system offers a promising solution for the modern office to create a healthier, more comfortable, and energy-efficient indoor environment that also enhances overall productivity.

ILI host IEEE **Sustainable Smart Lighting World Conference 2024**

The exact date is not yet known, but end of 2024, ILI will be host to the 2024 edition of the IEEE Sustainable Smart Lighting World Conference (LS Series), which is returning to Brainport after 14 years. The conference aims to provide an excellent forum for science and engineering professionals, in both academia and industry, to share and exchange the latest progress on the Science and Technology of Lighting. There will not only be presentations by distinguished invited leading researchers, but also presentations and posters by talented early-stage researchers, as well as ample opportunities for networking and socializing.

In collaboration with IEEE, we are working on an attractive program for a wide range of professionals from universities, university medical centres, universities of applied sciences, RTOs such as TNO, PKI such as RIVM and industry and with a wide range of relevant topics.
As we already had to start with the preparation of this conference we decided to ‘skip’ this year’s ILIAD and will have ILIAD 2024 as start of next year’s conference.

HAROLD WEFFERS | OPERATIONAL MANAGER ILI

Light4Life Initiative

Over a year ago, we embarked on an initiative towards a proposal for a large national program focused on R&D and (technological) design for systems to enable Intelligent Lighting. Last year, we used the 2022 edition of ILIAD to announce this new initiative and to start working on the proposal for a large-scale program focused on R&D and (technological) innovation on Light & Lighting in preventing diseases and to encourage other universities, university medical centres, universities of applied sciences, RTOs, companies, etc. to join the initiative, first in the co-design (plan) of the program and later in the co-creation (execution) of the projects in the program.

This new initiative, coined *"Light4Life,"* was supposed to be focused on the R&D and (technological) innovation necessary to be able to achieve intelligent environments, featured with lighting, and probably extended with sound and haptics, that should enable improving the performance and well-being of humans.
We had three specific application domains in mind, being (1) caregivers, (2) patients, and (3) offices and schools. To be able to design and develop such intelligent environments, we would need three R&D domains, including the domain of (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.

We wanted to submit the proposal for the NWO NWA calls supporting research by consortia on relevant research questions of the National Science Agenda. However, this year, NWO changed the process related to the National Science Agenda dramatically. Instead of being a bottom-up process, now the proposal has to be aligned to the agendas of the NWA Route Management Teams and each year only half of the NWA Route Management Teams is offered an opportunity to identify a specific topic in their NWA Route... Regrettably, none of the nine NWA Route Management Teams invited to define their priority subjects for the 2023 call defined a topic that our proposal would be aligned (or even "alignable") to.

Consequently, we have to hope that in the 2024 call the Management Teams of the NWA Route Prevention and Health will identify a priority subject that we can align our proposal to, or look for other opportunities in terms of regional, national, European or transatlantic funding.

ILI Top Publications

Kronberg, V., Anthonissen, M. J. H., ten Thije Boonkkamp, J. H. M., & IJzerman, W. L. (2022). Two-Dimensional Freeform Reflector Design with a Scattering Surface. *arXiv, 2022, Article 2211.03629. https://doi.org/10.48550/arXiv.2211.03629*

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Visiting address
ATLAS 3.424
5612 AZ Eindhoven
The Netherlands

Postal address
P.O. Box 513
5600 MB Eindhoven

www.tue.nl/ili